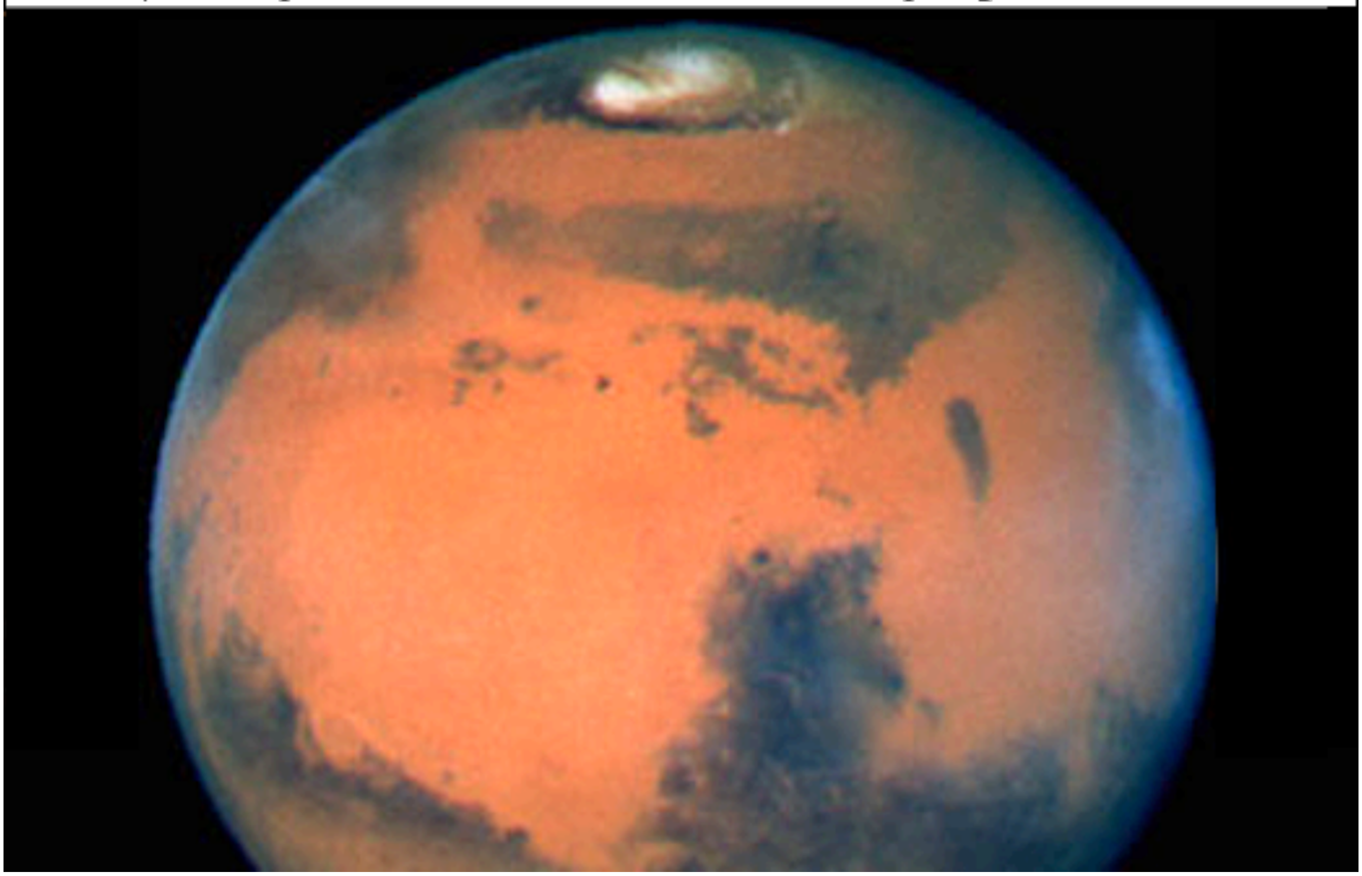
"Towards an Earth-Moon Economy – Developing Off-Planet Resources"

Moon Miners' Manifesto

India Quarterly Edition www.moonsociety.org/india/mmm-india/



Focus on Mars: India shifts focus from Moon to Mars as ISRO plans its first Mars Orbiter mission to launch in 2013

MAJOR ARTICLES in this issue - (Index on last page)

About The Moon Society - http://www,moonsociety.org

Our Vision says Who We Are - We envision a future in, which the free enterprise human economy has expanded to include settlements on the Moon and elsewhere, contributing products and services that will foster a better life for all humanity on Earth and beyond, inspiring our youth, and fostering hope in an open-ended positive future for humankind.

Moon Society Mission - Our Mission is to inspire and involve people every-where, and from all walks of life, in the effort to create an expanded Earth-Moon economy that will contribute solutions to the major problems that continue to challenge our home world.

Moon Society Strategy -We seek to address these goals through education, outreach to people of all ages, through contests & competitions, workshops, ground level research and technology experiments, private entrepreneurial ventures, analog research and other means. ***We collaborate with Mars-focused and other organizations*.**

About Moon Miners' Manifesto http://www.MoonMinersManifesto.com

MMM is published 10 times a year 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. International memberships are $35 US; $20 students, seniors – join online at: http://www.moonsociety.org/register/

MMM Classics: All the "non-time-sensitive 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. These issues are freely accessible, no username or password needed, at: www.moonsocietyorg/publications/mmm_classics/

Editors of MMM-India Quarterly:

Peter Kokh kokhmmm@aol.com - **David A. Dunlop** dunlop712@yahoo.com

Madhu Thangavelu thangavelu-girardey@cox.net

Pradeep Mohandas pradeep.mohandas@gmail.com - **Srivinas Laxman** moonmission.srinivas@gmail.com

About MMM-India Quarterly - http://www.moonsociety.org/india/mmm-india/

This publication was launched with the August 2008 issue. This issue begins our 3rd year. The Moon Society was founded as an International organization, but in has few members outside the United States, mostly solitary and unorganized.

Background - The Moon Society and The Planetary Society of Youth (TPSY) in India, http://www.youthplanetary.org/ in December 2003, put together a "Design a Mission to the Moon" category in TPSY's student design contest -- "A Mission to the Moon and Beyond." The contest was designed to help students learn about various objects in the solar system as they compete in the design of a mission. www.youthplanetary.org/moon_mission_contest.html

Why an MMM - India Quarterly?

India is a very populous country, and one in which, through the heritage of the British Raj, English is the almost universal medium of higher education. It is likely that English-fluent Indians outnumber English speakers in the United States. More books are published in English than in any other country. And – ***India has now gone to the Moon!***

We want to share with space-interested and space-enthused people in India, our vision of the possibilities for Exploration and Utilization of the Moon, development of lunar resources, not just to support a permanent population on the Moon, but to help better address chronic clean energy supply problems on Earth and to help slow and reverse our home planet's environ-mental degradation in the process. In short, we would like to share our glimpse of an emerging greater Earth-Moon Economy.

This vision was well-expressed by the former President of India, Dr. A. P. J. Abdul Kalam in a speech at The Symposium on "The Future of Space Exploration: Solutions to Earthly Problems" to mark the occasion of the 50th Anniversary of the dawn of Space Age, Boston University, Boston, MA, April 12, 2007. In this speech, Dr. Kalam made the point that to fully industrialize and become an equal partner in the future of our planet, India needs to access the unlimited clean undiluted solar energy available in space. We agree with this bold vision and want to share itwith the forward-looking people of India.

Free Access: MMM-India Quarterly issues are available as a free access pdf file, downloadable from the address above We encourage readers to share these files with others freely, and to use this publication to grow and cultivate wide-spread interest in the open-ended possibilities of space among the people of India, and to encourage the rise of additional citizen support space organizations within the country.

Indian Space News

Kutch village could become India's "window to Mars"

http://articles.timesofindia.indiatimes.com/2012-07-02/ahmedabad/32507547_1_rocks-kutch-village-mars-surface

AHMEDABAD: Even as NASA's latest multi-billion dollar Mars exploration rover — a robot called 'Curiosity' — is set to land on the neighbouring planet's surface in the next 34 days, an important discovery has been made at **Mata No Madh** — a small village nestled near **Bhuj** in **Kutch** district.

Even as Curiosity gets down to search for signs of habitability and collect rock and soil samples, scientists from the Dehradun-based Wadia Institute of Himalayan Geology (WIHG) have found a meter thick layer of hydrous sulphate rocks in this Kutch village quite similar to the ones found on Mars surface. These are called the calcium bearing mineral rocks that are rare on Earth.

So far, there were just three places in the world where these rocks were found. The discovery of same type of rocks in the desert here can play an important role ahead of India's Mars Mission. The scientists here are still trying to ascertain properties of the rock and whether it can support life in any form.

Hydrous sulphate deposits at Mata No Madh are predominantly made of calcium bearing Minamiite and another mineral called natro alunite. They are white to cream-yellow and reddish in colour, and extend for more than a kilometre on both sides of Mata No Madh on Lakhpat road. N V Siddaiah, a senior scientist with WIHG, who found these rocks along with a colleague Kishor Kumar, says: "The hydrous sulphates is result of reactions between volcanic gases and acidic hydrothermal solutions with volcanic ash or rock."

Ever since Nasa's first Mars mission found hydrous sulphates on the Red planet, the hunt for these rocks begun on Earth. On the globe, these rocks form part of the famous 'Mars Analouge' at the three other place. These places include Mt Schimkura in northeastern Japan, the volcanoes of southwest Turkey, and from volcanoes of the Cascade Range in the western US.

"Till the time India gets the technological ability for collecting samples on Mars, these Mars analogues present in the Deccan Volcanic Province (DVP) or the Himalayan stretch will be of tremendous help. We have been researching the rocks for two years," says Siddaiah.

"If we were to know whether Mars support's life, we will have to study the rock and soil samples while being in Martian atmosphere instead of bringing them on Earth. The Mata no Madh rocks are a ready reference for us geologists on earth," The discovery was published in Nature magazine a while ago.

MORE:

http://articles.timesofindia.indiatimes.com/2012-07-02/ahmedabad/32508120_1_red-planet-space-scientists-orbiters

AHMEDABAD: The hydrous sulphate rocks found in Mata No Madh village in Kutch district can be a boon for ISRO scientists who are planning a mission to the red planet expected to be kicked off in November 2013. "Till now space scientists have only gathered data from spectral images from orbiters to Mars to gauge the nature of the atmosphere. But these images may not be adequate in understanding whether life can sustain under such acidic conditions," says a senior scientist at Dehradun-based Wadia Institute of Himalayan Geology N S Siddaiah.

These Mata no Madh rocks have come into existence because of a similar volcanic activity as on Mars. These rocks can be a ready reference for us in understanding the red planet," he adds.

India's Mars Orbiter mission involves launching an orbiter around Mars using Polar Satellite Launch Vehicle-XL. This space explorer will be placed in an orbit of 500x80,000 km around Mars and will have a provision to carry nearly 25 kg of scientific payload on-board. An initial budget of Rs 125 crore has been prepared and awaits approval. The November 2013 is an appropriate time as the Mars' orbital dynamics makes it a good time to launch.

Below: a scene in Mata No Madh

Chandrayaan-1 Reports

Seismic signatures of the sonic boom during the launch of Chandrayaan-1

K. S. Prakasam*, S. S. Rai and G. S. Meena National Geophysical Research Institute (CSIR), Hyderabad, India

http://cs-test.ias.ac.in/cs/Volumes/102/01/0105.pdf

Chandrayaan-2 Updates

http://www.chandrayaan-i.com/index.php/chandrayaan-2/chandrayaan-2-updates/**141-chandrayaan-2-may-miss-the-scheduled-2013-take-off-date**.html

http://www.chandrayaan-i.com/index.php/chandrayaan-2/chandrayaan-2-when/1**40-chandrayaan-2-is-dealing-with-weight-issues.**html

http://www.chandrayaan-i.com/index.php/chandrayaan-2/chandrayaan-2-updates/**137-solar-flare-could-prove-to-be-chandrayaan-2-nemesis**.html

http://www.chandrayaan-i.com/index.php/chandrayaan-2/chandrayaan-2-updates/119-**chandrayaan-2-wont-have-much-space-for-foreign-payloads**.html

Mysore Hosts COSPAR 39

http://www.cospar2012india.org/Default.aspx

Narayana Murthy Centre of Excellence, Mysore (Mysuru), Karnataka, India - 14 - 22 July 2012
http://www.cospar2012india.org/Pages/1037-About-Mysore.aspx

COSPAR promotes scientific research in space, with an emphasis on the exchange of results, information and opinions. COSPAR assemblies attract more than 1,000 participating space researchers. Chairman Prof. U.R. Rao heads the local organizing committee. Scientific Assembly topics this year will include Lunar Science and Exploration, Issues in Education for Space Sciences and Teacher Training in Space Sciences and Astronomy. (quoted from Spaceage Publishing, Hawaii)

Approximately 100 meetings covering the fields of the Committee on Space Research (COSPAR) Scientific Commissions (SC) and Panels.

- SC A: The Earth's Surface, Meteorology and Climate
- SC B: The Earth-Moon System, Planets, and Small Bodies of the Solar System
- SC C: The Upper Atmospheres of the Earth and Planets Including Reference Atmospheres
- SC D: Space Plasmas in the Solar System, Including Planetary Magnetospheres
- SC E: Research in Astrophysics from Space
- SC F: Life Sciences as Related to Space
- SC G: Materials Sciences in Space
- SC H: Fundamental Physics in Space
- Panel on Satellite Dynamics (PSD)
- Panel on Scientific Ballooning (PSB)
- Panel on Potentially Environmentally Detrimental Activities in Space (PEDAS)
- Panel on Radiation Belt Environment Modelling (PRBEM)
- Panel on Space Weather (PSW)
- Panel on Planetary Protection (PPP)
- Panel on Capacity Building (PCB)
- Panel on Education (PE)
- Panel on Exploration (PEX)
- Special events: interdisciplinary lectures, round table, etc.

M3IQ Co-editor and Reporter Srinivas Laxman will be attending this event and he will report on the sessions and event in our next issue.

Earth2Orbit CEO, Dr. Susmita Mohanty, Talks To Asian Scientist Magazine

http://www.asianscientist.com/features/earth2orbit-ceo-susmita-mohanty/

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By Srinivas Laxman - July 6, 2012

We talked to Dr. Susmita Mohanty, CEO and co-founder of Earth2Orbit, India's first private space start-up. She shares with us her thoughts the commercial viability of India's space sector.

AsianScientist (Jul. 6, 2011) – Dr. Susmita Mohanty has a career that science afficionados can only dream of. On her Google Profile, she describes herself as a "Spaceship Designer + Entrepreneur"

Left: Dr. Susmita Mohanty - Right Masthead art from http://www.earth2orbit.com

A serial entrepreneur at heart, Dr. Mohanty founded MOONFRONT in San Francisco (2001), LIQUIFER in Vienna (2004), and is currently onto her third, as the co-founder and CEO of Earth2Orbit, India's first private space start-up. A member of the International Academy of Astronautics and the American Institute of Aeronautics and Astronautics, none other than the celebrated science fiction writer Arthur C. Clarke personally sponsored her education at the International Space University in France. Dr. Mohanty also has a PhD in Aerospace Architecture from Chalmers University of Technology in Sweden.

In 2005, Dr. Mohanty was honored in Washington, DC with the International Achievement Award for promoting international cooperation through entrepreneurial space ventures. She is the Space Policy Fellow for Gateway House, a Mumbai-based foreign policy think tank.

AsianScientist Magazine spoke with Dr. Susmita Mohanty at the American Center in New Delhi, after she gave a presentation on behalf of Earth2Orbit. We asked her for her thoughts on India's domestic and international space policy, and the commercial viability of the Indian space sector.

Industry Collaborations Are Necessary To Grow Space Sector

Looking ahead into the future, her vision for ISRO was for it to collaborate effectively with the private sector. India's space policy, which is largely focused on domestic needs, requires a major overhaul to allow for privatization of satellite and rocket manufacturing, she said.

"The long term goal should be for ISRO (Indian Space Research Organisation) to focus on R&D, and let the industry take over routine manufacturing activities. Plus go all out to support the industry such that it can compete with its international counterparts," she said.

Her views are echoed by ISRO officials, who also believe that the role of the private sector will considerably go up in the days ahead. Currently, the private sector does contribute towards India's space program, but in a small way. Some of the major industries which are partnering with ISRO are Godrej, Larsen and Toubro (L&T), and Walchandnager Industries.

Dr. Mohanty was also concerned about the hurdles for start-ups like hers in India.

Earth2Orbit was created with the vision of leading India into the world of private space enterprise, and the goal of her Mumbai-based organization is to revolutionize the way India's space industry conducts business and by doing so bring novel concepts, technologies and efficiencies to a legacy industry.

She said that politicians, bureaucrats and policy makers have to be persuaded to reduce regulatory hurdles and red tape, and to generate funding and incubatory support as available in western economies like the US and Europe.

ISRO Should Bid For International Contracts

According to Dr. Mohanty, India has a very accomplished government space program, and it should focus its efforts on international clients and companies.

"We are among a handful of nations that have the capability to build satellites and build rockets. The next logical step is to commercial ISRO's technological capabilities and compete in the global market," she said.

For this, she said, "We need to get the Indian industry involved in a big way, not just supply parts to ISRO, but go after international businesses. Most companies that currently cater to ISRO are not focused on space. Space is not their primary line of business."

However, she added that the industry will venture into the civilian space sector in a big way only when the government is willing to deregulate and create an environment that allows them to bid for international contracts and not limit themselves to serving ISRO's needs.

"ISRO contract volumes and margins are too low for them to bother," she said.

India should work towards a significant share of the global commercial space market, which she estimated to be worth more than US $150 billion a year.

"If India is to become a global player, we should try and capture at least a fifth of this market, if not more," she said.

Another hurdle she mentioned is that investor mindset in India is entirely focused on businesses which can bring a quick return on investment.

"Space businesses, unlike information technology or mobile telephony, take longer to break even and start making decent profits. We, therefore, need proactive support from the government. We need investors with vision and a greater appetite for risk,'' she explained.

More Dedicated Commercial Launches By India

All eyes are on India's upcoming launch of the 1,410 kg GSat-12 communication satellite on July 15 by the Polar Satellite Launch Vehicle (PSLV). The satellite will be used for societal applications such as tele-education, tele-medicine, village resource center operations and other communication services. The last time the rocket ferried a similar spacecraft was on September 12, 2002, when it placed in orbit India's first dedicated meteorological satellite, Metsat, which was renamed as Kalpana-1 in honor of Kalpana Chawla.

ISRO's PSLV, Dr. Mohanty said, was one of the most reliable rockets in its class and therefore in great demand for piggyback launches by foreign clients.

Over the last decade India has launched more than two dozen foreign payloads on board the PSLV.

"While the list of countries is spectacular, the total mass launched is modest, close to a single PSLV launch," she said.

Further, the PSLV has had only one dedicated commercial launch, that of an Italian satellite.

"India needs to aim for more dedicated commercial launches if it wants to become a serious global player," she added.

Old Competitors, New Markets

In an article published in *Gateway House*, a journal of the Indian Council on Global Relations, called "A Tale of Two Rockets", Dr. Mohanty said that the implication of the two Geo Synchronous Satellite Launch Vehicle (GSLV) failures of ISRO was huge. One failed in April and the other in December 2010.

"Every GSLV that fails slows down India's ambition to compete in the lucrative global commercial launch market – estimated to reach 12 billion dollars by 2018 – for heavy tonnage telecommunication satellites in the geostationary orbit, the kind launched by the GSLV," she said.

"While India has a capability, it also has powerful rivals – the French Ariane, the American Delta, the Chinese Long March and the Russian Soyuz – that have seen greater successes," she added.

Dr. Mohanty said that in addition to more developed launch markets like the US and Europe, India should focus on emerging markets in Asia, Africa, Latin America and the Middle East.

"It should leverage its growing trade ties with those regions and use bilateral relationship as the basis for new satellite and launch contracts. China seems to be doing this very effectively," she mused.

http://www.earth2orbit.com/ **Earth2Orbit** has offices in **Mumbai** and **San Francisco**

Elsewhere in Asia

Chinese National Space Agency

China's Shenzhou-9 with crew of 3 including 1st female "taikonaut" docks successfully with Tiangong-1 Space Laboratory - June 16-29

The three-member crew docked with and lived in the Tiangong 1 orbital module launched last year. During the flight, one crew member remained aboard Shenzhou 9 as a precautionary measure "in case of emergency" while the others entered Tiangong 1. The crew included Jing Haipeng, 45, the mission commander and a veteran astronaut, Liu Yang, 33, and the country's first woman taikonaut, Liu Wang, 43, who did the manual docking.

China completed its first space docking in November when the unmanned Shenzhou 8, launched September 29th, 2011 docked with the Tiangong 1 by remote control. The US and Soviet Union had pioneered space docking in the early 1960s. A new 60 tonne multi-module space station will oneday replace Tiangong-1. The target date is 2020. China has not been allowed by US law to participate in the 16-nation International Space Station. Many people in the US see this restriction based on political and military fears, as shortisighted policy. On the good side, other nations may join China's space station effort, and if the ISS mission is not extended in 2020, the new station will retain human presence in space.

Below: artist's conception of the docking; the crew inside Tiangong-1 ◘

Docking Report: http://www.asianscientist.com/topnews/shenzhou-9-docks-with-tiangong-1-space-station-2012/

Debriefing Report: http://www.asianscientist.com/topnews/shenzhou-9-debrief-mission-full-success-2012/

China's Space Plane ("Shenlong" Space Dragon) Program Advances

Sources: July 27, 2011 - http://www.strategycenter.net/research/pubID.253/pub_detail.asp

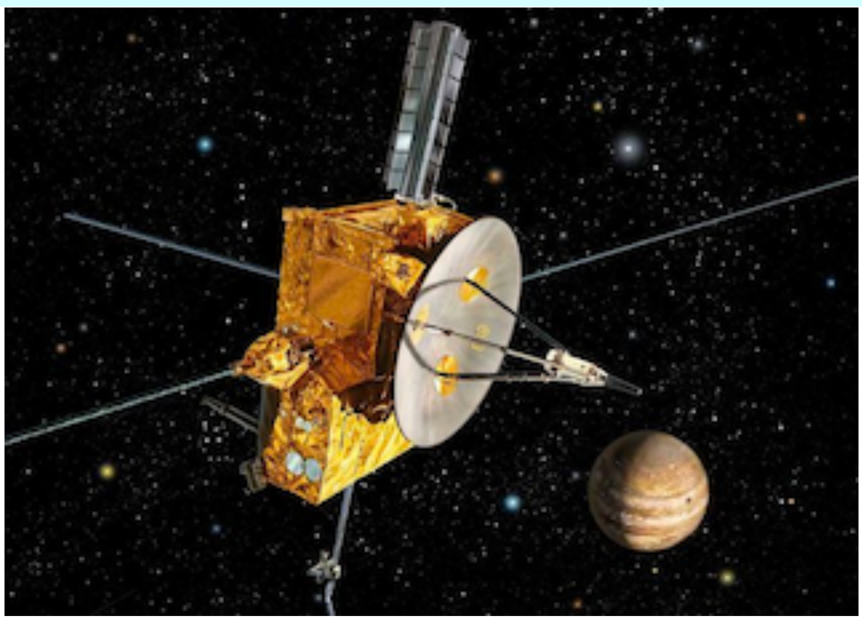
May 4, 2012 - http://www.andrewerickson.com/2012/05/**china-signpost-58-shenlong-divine-dragon-takes-flight-is-china-developing-its-first-spaceplane/**

Three US "Space Planes" - the US Air Force's unmanned X-37B (Lockheed Martin) and Boeing's X-51 WaveRider unmanned supersonic combustion ramjet (scramjet) demonstrator aircraft, plus Sierra Nevada's commercial manned DreamChaser are in various stages of development and testing. And now China is working on one also, with a test flight having been conducted in January of last year, 2011 as part of the 863 State High-Tech Development Plan. Shenlong appears to be quite small, but could still work with payload miniaturization.

Photo of Shenlong slung below launching plane between wheels

Full size image at http://www.china-defense-mashup.com/wp-content/uploads/2011/04/shenlong.jpg ◘

China will try again with its first Mars Mission



Above: Artist vision of ill-fated Yinghuo-1 - Sources:

www.csmonitor.com/Science/2011/1102/Could-China-s-first-space-kiss-lead-to-a-Mars-mission-with-US

http://zeenews.india.com/news/space/china-s-1st-interplanetary-probe-hits-mars-mission_753748.html

China's first Mars exploration probe, **Yinghuo-1** was launched on November 9, 2011 aboard a Ukraine Zenit launch vehicle. hitching a ride with Russia's Fobos-Grunt sample return spacecraft. But once in Earth orbit, the Russian Fregat upper stage failed to ignite its engines for the long journey to Mars. Both probes landed up in the ocean. Undaunted, China plans to launch a Yinghuo-2 on its own. Some have suggested China partner with the US instead, but that is less likely. The preliminary target date is just a year away, in late 2013. Windows to Mars open every 25+ months. The next window would be in early 2016. Chinese scientists aim at shedding light on how and why Mars' original water reserves disappeared. ◘

China will cooperate globally on its Space Station By Srinimas Laxaman

http://www.asianscientist.com/topnews/china-cooperate-globally-to-build-chinese-space-station-2020/

Japan Aerospace Exploration Agency JAXA

Japanese construction company Obayashi wants to build an elevator to space

Elevator would transport passengers to a station about a tenth the distance to the Moon

http://news.cnet.com/8301-17938_105-57383872-1/japan-plans-snail-paced-space-elevator-for-2050/

The elevator's cables would be built out of super-strong carbon nanotubes and stretch about 96,000 km, a quarter of the way to the Moon where it would be anchored to a heavy counterweight. The "station" itself would be located where the cable crosses Geo-Synchronous orbit about 38,000 km above Earth. There, the "space station" would have living quarters and lab facilities. Solar panels connected to the station would generate electricity that would be transmitted to the ground.

The Earth terminal would be a floating spaceport anchored to the ocean floor along the equator.

The ride to the GEO Station would be slow, taking a week at the snail pace of 200 kph.

The concept has been around for decades and is being pursued enthusiastically by a number of groups.

The challenge is that the tonnage of cargo and/or number of passengers per hour or per day that could make the trip, no matter how cheap the ticket, could never keep up with demand. And the Earth terminus might be in the path of hurricanes, cyclones, or typhoons. On the other hand, we would not have to deal with the buildup of rocket exhaust in the atmosphere, a potentially severe pollution problem as traffic grows. **M3IQ**

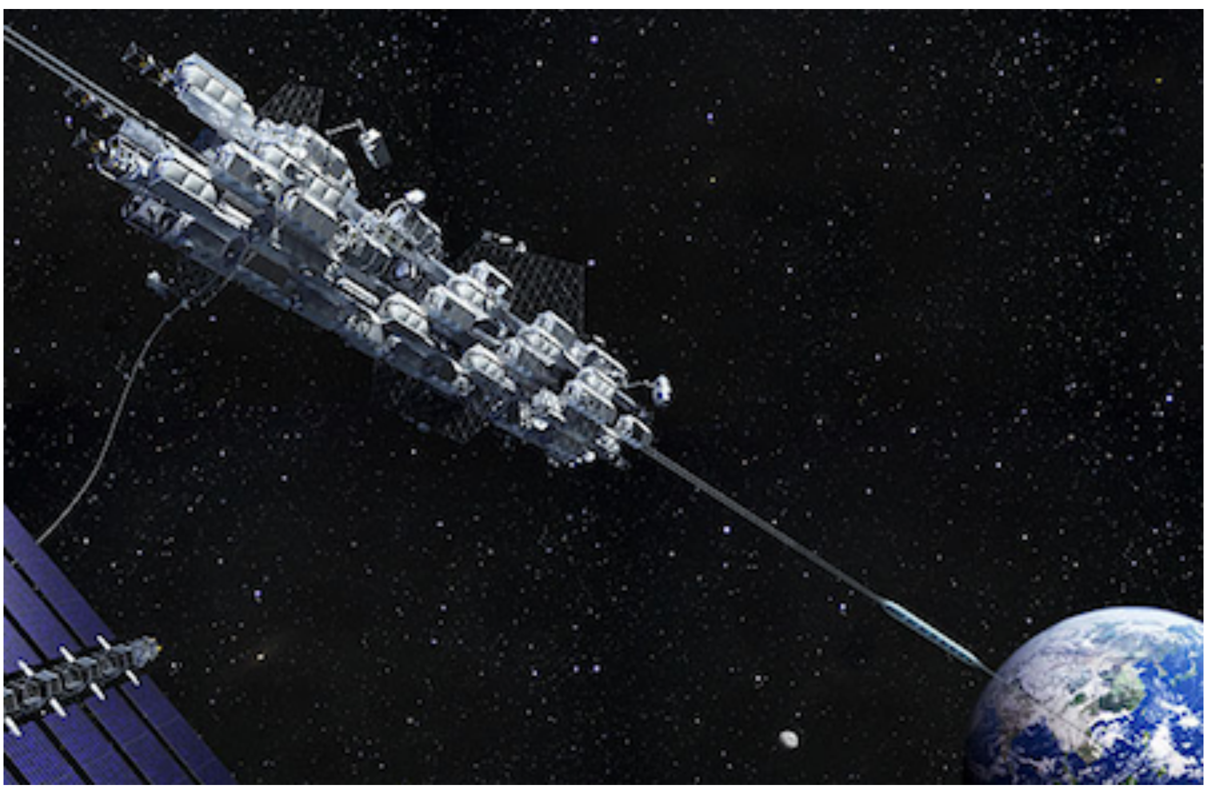


Illustration by Obayashi

More on Space Elevators: http://en.wikipedia.org/wiki/Space_elevator - http://www.liftport.com/

Russian
Space
Agency
ROSCOSMOS

Kazakhstan gives Russia the go-ahead for Baikonur launches

http://www.spacedaily.com/reports/Kazakhstan_gives_Russia_the_go_ahead_for_Baikonur_launches_999.html

June 18, 2012 - Disagreement over a new drop zone for the debris from Russian carrier rockets being launched from the Baikonur space center had delayed a number of launches. Since losing sovereignty over the site, Moscow had decided to build a new "Eastern" spaceport in the Amur region north of Manchuria (China).

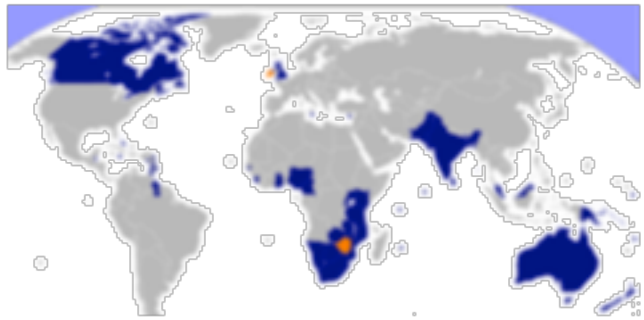
Progress on the "Vostochny" site has been slow and inaugural flights are still some years away. So reaching an agreement with Kazakhstan, no longer a "Soviet Republic" under Moscow's rule has been a priority. Kazakhstan had insisted that in order for the zone to be used the two sides must sign an additional agreement to the Baikonur lease deal, which has to be ratified by the Kazakh parliament. In the Kazakh's view, Russia was careless about littering the environment surrounding Baikonur.

Above: a Soyuz Capsule prior to being placed in its faring on a launch rocket.
See worker at lower left for and idea of scale.

Since the retirement of NASA's remaining 3 **Space Shuttles**, all astronauts have relied on the **Soyuz** for transportation to and form the International Space Station. It may be four more years before Space-X manned **Dragon crew capsule** (which can carry a crew of 7 vs. Soyuz' three) can take on part of this load.

The recent totally successful docking and return of a **Dragon cargo capsule** at ISS would indicate that this target goal will be met, if not beaten. Dragon will be the first "commercially provided" transport vehicle to space, breaking decades of monopoly by national space agencies. ◘

Elsewhere in the Commonwealth



UNITED KINGDOM

U.K. Space Agency To Build 4 Solar Orbiter Instruments

http://www.spacenews.com/civil/120621-**ukspaceagency-instruments-solar-orbiter.html**

June 21, 2012 - The United Kingdom will spend 11.5 million pounds (997 million rupees) to develop four of the 10 scientific instruments to fly aboard Europe's Solar Orbiter mission in 2017.

British institutes will take lead responsibility for development of

★a **magnetometer** to study the sun's magnetic field
★an **extreme ultraviolet imager** to examine the solar corona
★a **spectral imaging telescope** to image the solar disk
★a **solar wind analyzer**

SOUTH AFRICA & AUSTRALIA

SKA - World's Largest Radio Telescope, to be shared by Australia and South Africa

http://www.space.com/15883-worlds-largest-radio-telescope-ska-array.html

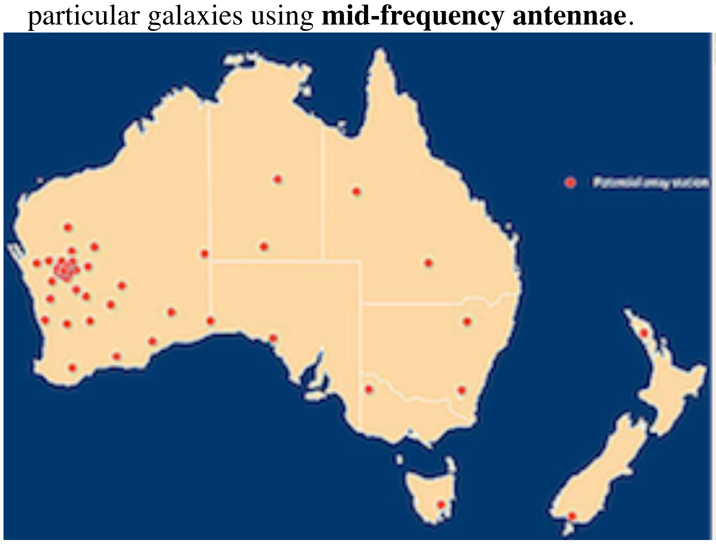
http://www.skatelescope.org/news/dual-site-agreed-square-kilometre-array-telescope/

http://www.smh.com.au/national/double-vision-a-worry-for-telescopescientists-20120526-1zbzt.html#ixzz1vzW2jlzA

http://www.timeslive.co.za/local/2012/05/26/ska-an-achievement-for-south-africa-africa-anc

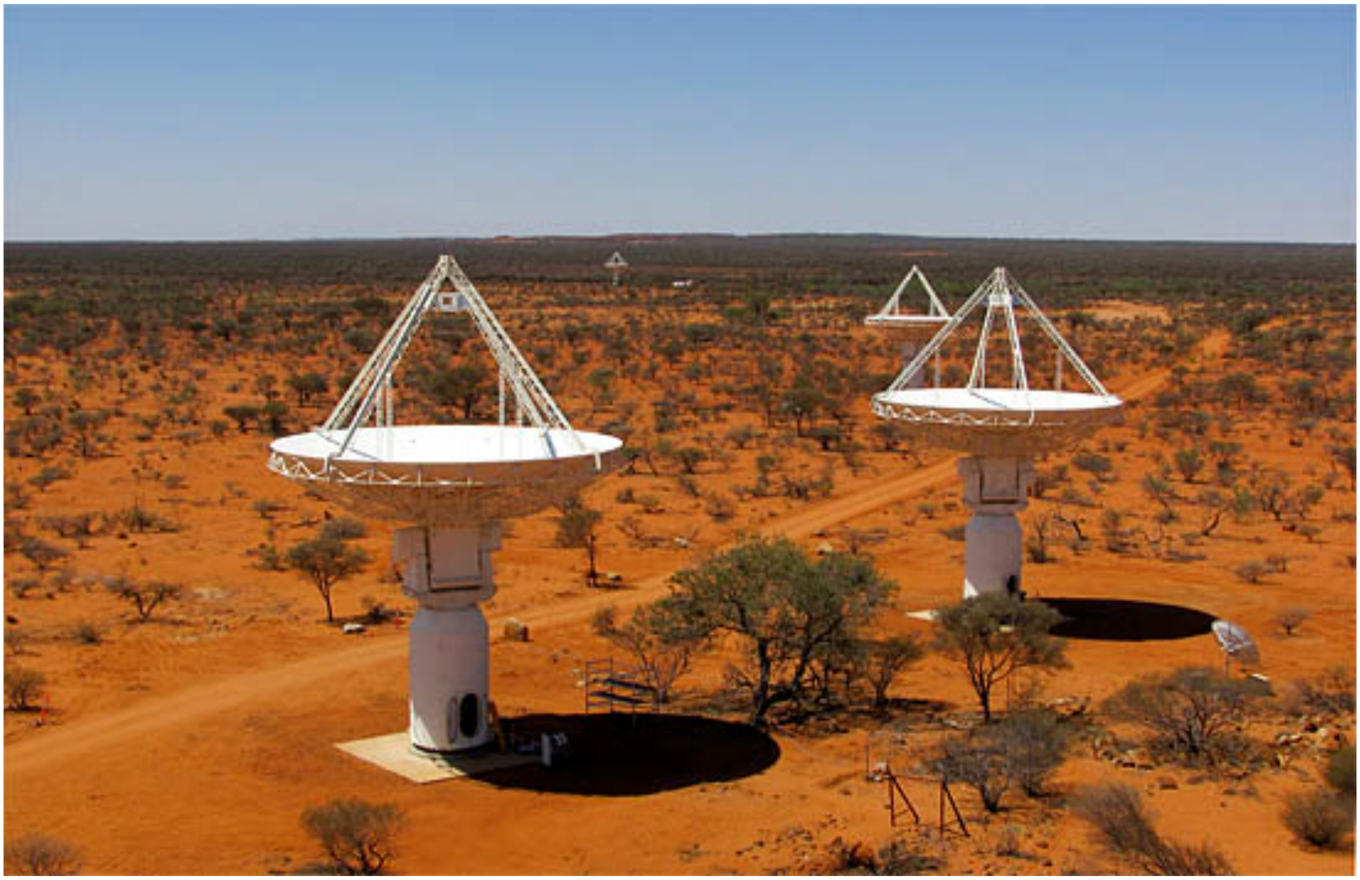
May 25, 2012: In Amsterdam, the SKA Organisation surprised everyone by a "split decision."

- **Australia** would be the base for the telescope's **low-frequency observations**, which will image the birth of the first stars in the universe using instruments built in the remote Murchison Shire of Western Australia, 600 km NE of Perth.
- A **South African base** in the Northern Cape will be involved in targeted observations, such as studying particular galaxies using **mid-frequency antennae**.



"The majority of SKA dishes in Phase I will be built in South Africa, combined with MeerKAT. Further SKA dishes will be added to the ASKAP array in Australia. All the dishes and the mid frequency aperture arrays for Phase II of the SKA will be built in Southern Africa while the low frequency aperture array antennas for Phase I and II will be built in Australia-New Zealand."

Source: http://www.asianscientist.com/topnews/square-kilometer-array-ska-telescope-2012/



Above: Some of CSIRO's new ASKAP antennas at the Murchison Radio-astronomy Observatory (MRO) in Western Australia

This unexpected compromise grew out of concern that both applicants had invested considerable amounts of money developing their plans and it did not seem right that one party should get nothing, the other everything. While both South Africa and Australia are relieved, there is some worry that there will be a problem combining and/or comparing data from the two systems. But there is ample time to work out solutions to any such problems. Both nations and the International SKA organisation itself, are to be congratulated by this "Indian Ocean" combination solution. Editor

Latest News on SKA - http://www.skatelescope.org/category/news/

★ http://www.skatelescope.org/news/**sweden-joins-the-ska-organisation/**

General Information: http://en.wikipedia.org/wiki/Square_Kilometre_Array

SKA
SQUARE KILOMETRE ARRAY

Elsewhere in the World

EUROPE-ESA

ESA team's Antarctic stay to mimic Mars mission

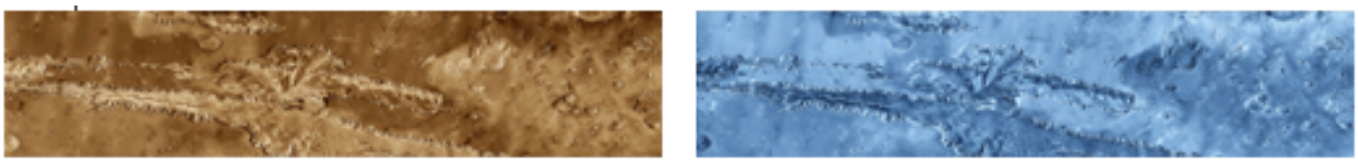
http://www.marsdaily.com/reports/Antarctic_stay_to_mimic_Mars_mission_999.html

ESA scientists will undergo four months of freezing darkness and isolation in Antarctica in preparation for a possible manned trip to Mar in an attempt to understand the affects and requirements of such a trip.

British, French and **Italian** scientists will stay 8 months a the **Concordia Research Station**, at "Dome C" high on the Antarctica plateau. Concordia is a joint French-Italian station.

The crew expects to suffer from low oxygen levels as well as isolation.

The extreme conditions in this part of Antarctica may be the closest here on Earth to what we can expect on Mars.The winter at Dome C is the harshest on Earth. Temperatures will drop below minus 80° C.



Mars' Valles Marineris, as it looks (left) and as it feels (right)

But unlike Mars, Antarctica's Dome C experiences four months of complete darkness during the local winter. The team expects that the hardships will be worth it if the research paves the way to sending people to Mars. ◘

SOUTH AMERICA

ESA Tests Out Rover In Chile Desert

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

June 18, 2012 - The Challenge for ESA: Develop a rover that could steer itself. Why? because to "teleoperate" a rover on Mars from a site on Earth means a time delay of from 6-40 minutes depending on where Mars is in it orbit to where Earth is. Even at the speed of light, signals traveling as much as 300 million kilometers take that long. Spirit and Opportunity have done much, but they could only crawl short distances each day at the end of a joy stick at NASA headquarters far far away on Earth. If a rover could steer itself and avoid obstacles long before controllers on Earth were aware of them, then the rover could cover much more ground each day, making significantly more observations and measurements with its various instruments.

"After six months, engineers on the StarTiger team created a fully autonomous vehicle capable of charting its own course through Chile's Atacama Desert.

"Their challenge was to demonstrate how a planetary rover – programmed with state-of-the-art software for autonomous navigation and making decisions – could traverse 6 km (3.7 miles) in a Mars-like environment and come back where it started," per ESA's Gianfranco Visentin.

ESA's ExoMars rover, due to land on Mars in **2018**, will have state-of-the-art autonomy.

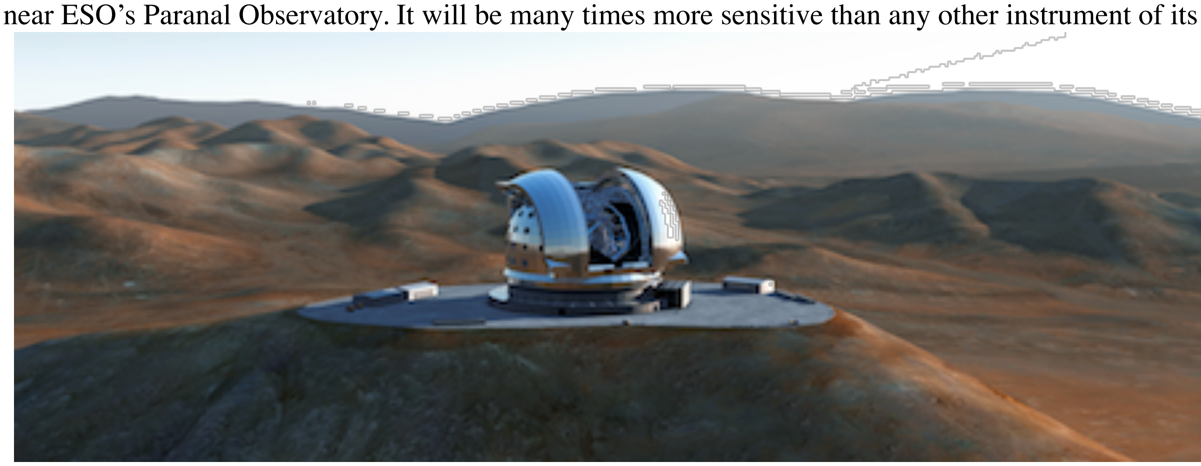
The test rover in the Atacama Desert in Northern Chile
http://bowshooter.blogspot.com/2012/06/**esa-exomars-tests-self-steering-rover.**html

More on ExoMars: http://exploration.esa.int/science-e/www/area/index.cfm?fareaid=118
http://en.wikipedia.org/wiki/ExoMars

ESA nears approval of World's Largest Telescope for Northern Chile

http://www.space.com/16115-worlds-largest-telescope-approval-eelt.html

June 11, 2012 - The **European Extremely Large Telescope** (E-ELT) has gained final approval from the scientific consortium backing the new observatory, the governing council of the European Southern Observatory. The E-ELT will be a **39-meter** segmented-mirror telescope sited atop a mountain called Cerro Armazones in northern Chile, near ESO's Paranal Observatory. It will be many times more sensitive than any other instrument of its kind.



The E-ELT will collect at least 12 times more light than today's largest optical telescopes, alowing astronomers to search for habitable planets around other stars. and to study the nature and distribution of dark matter. According to Isobel Hook of the University of Oxford, the UK's E-ELT project scientist, "Its unique combination of sharp imaging and huge light collecting area will allow us to observe some of the most exciting phenomena in the universe in much better detail."

Construction cannot begin until provisional votes from four more of the ESO's 15 member states have been confirmed and 90 percent of the required funding has been secured, expected to be about 1.083 billion euros. Construction could begin sometime this year, but the telescope may not be operational until the early 2020s.

UNITED STATES

Dawn of a new Commercial Space Era
Space-X Dragon Capsule - 1st Commercial Cargo Carrier docks with ISS
And later undocks and lands safely

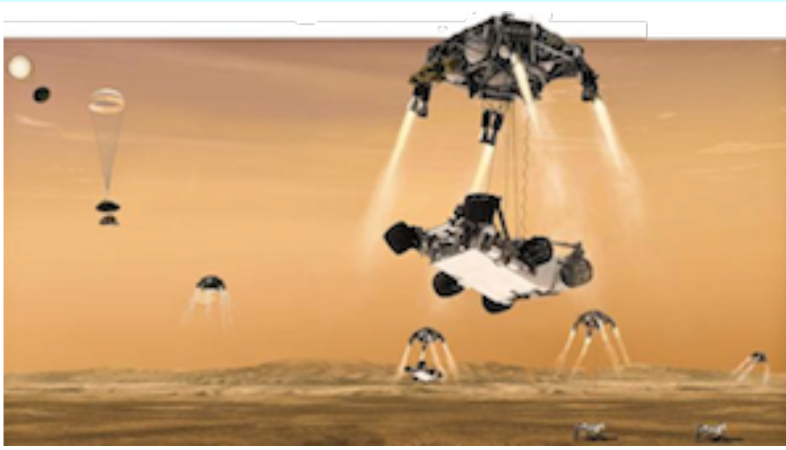

Historic Firsts: ISS Canadarm attaches to Space-X Dragon Cargo Capsule to guide it to docking port; Splashdown

http://www.space.com/15874-**private-dragon-capsule-space-station-arrival**.html
http://www.space.com/15832**-spacex-dragon-1st-station-flight-pictures**.html
http://www.space.com/15885-**spacex-dragon-capsule-station-astronauts**.html
http://www.space.com/15951-**spacex-praise-dragon-spacecraft-success.**html
http://www.space.com/15930-**spacex-dragon-capsule-future-spaceflights**.html
http://www.universetoday.com/95599/**a-banner-week-for-commercial-spaceflight/**#.T8p7jEoGAvg.facebook

Tuesday May 22nd, a Space-X Falcon-9 rocket successfully launched its Dragon Cargo Capsule on a flight to dock with the International Space Station. Previously, (dates) Space-X had successfully launched a Dragon capsule into orbit and then successfully returned to Earth. On that mission, docking with ISS was not involved.

Editorial comment by Peter Kokh: The significance of this feat is monumental. There are forces in the US Congress who oppose allowing Commercial companies to supply the space station. But this is the only path to drastic lowering of costs. Space agencies act as Holy Priesthoods guarding the door to space. "They should open the door, not be the door," as American activist Rick Tumlinson put it. Whether a similar transfer of control occurs in other countries is another question. Time will tell. ◘

NASA's Mars Science Lab "Curiosity" nears arrival at Mars on August 6th




Location where it will land - http://www.nasa.gov/mission_pages/msl/multimedia/pia15685.html
Video of landing procedure - http://www.nasa.gov/multimedia/videogallery/index.html?media_id=147675731
http://www.space.com/13689-nasa-amazing-mars-rover-curiosity-science.html
http://en.wikipedia.org/wiki/Mars_Science_Laboratory

NASA selects Sunita Williams, of Indian extraction (Gujarat), to command International Space Station Expedition 33

http://indiawest.com/news/5275-**astronaut-sunita-williams-heads-into-space-in-july**.html

http://www.space.com/16376-**preparing-to-command-the-iss-sunita-williams**-video.html

http://www.redorbit.com/news/space/1112644443/**sunita-williams-to-return-to-iss-as-commander-of-expedition-33/**

Sunita Williams is scheduled to take off July 14 from the Baikonur Cosmodrome in Kazakhstan with flight engineers Yuri Malenchenko of the Russian Federal Space Agency and Akihiko Hoshide of the Japan Aerospace Exploration Agency. Now 46, Williams will be a flight engineer on the station's Expedition 32 crew and become commander of Expedition 33 on its reaching the space station.

Williams and her colleagues will be aboard the station during an exceptionally busy period that includes two spacewalks; the arrival of Japanese, American commercial and Russian resupply vehicles; and an increasingly faster pace of scientific research.

She will be the third woman to command an ISS Expedition Crew, following Peggy Whitson and Pamela McCoy.

Three previous trips to ISS:

Sunita Williams made her first trip to the International Space Station (ISS) on crew SRS-115, aboard the shuttle *Discovery*, on December 9, 2006 and joined the Expedition 14 crew. In April 2007. Among the personal items Williams took with her to the ISS were a copy of the *Bhagavad Gita*, a small figurine of the Hindu deity Ganesha and some samosas.[12]

On the STS-116 mission, her second stay aboard ISS, she completed three spacewalks from the ISS on January 31, February 4, and February 9, 2007.

On her 3rd trip she served as a mission specialist with **STS-117**, and returned to Earth on June 22, 2007 aboard the shuttle *Atlantis* after a record total 195-day stay in space.

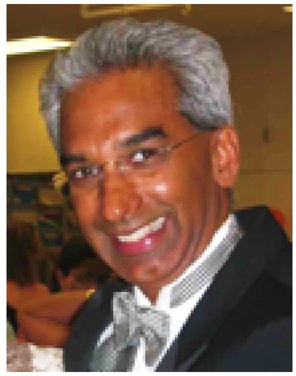
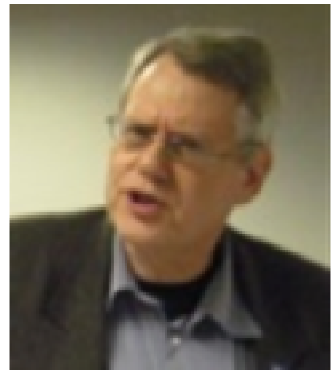
In September 2007, Williams visited India. She went to the Sabarmati Ashram, the ashram set up by Mahatma Gandhi in 1915, and her ancestral village Jhulasan in Gujarat. She was awarded the Sardar Vallabhbhai Patel Vishwa Pratibha Award by the World Gujarati Society[26], the first person of Indian origin who is not an Indian citizen to be presented the award.

http://indiawest.com/news/5275-astronaut-sunita-williams-heads-into-space-in-july.html



More on Sunita Williams: http://en.wikipedia.org/wiki/Sunita_Williams ◘

MMM-India Quarterly Editors

L>R: Peter Kokh - kokhmmm@aol.com - http://www.lunarpedia.org/index.php?title=Peter_Kokh
Moon Society Secretary - Editor Moon Miners' Manifesto - Milwaukee, Wisconsin US
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 - 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 - Green Bay, Wisconsin US

L>R: Pradeep Mohandes - pradeepmohandas@gmail.com - Mumbai - Formerly President of SESDS India
Srinivas Laxman - moonshotindia@gmail.com - Mumbai

COMMUNITY - 3 M3IQ EDITORS RENDEZVOUS IN MINNEAPOLIS, MN, USA

By Dave Dunlop

The M3IQ Editors Group

The Moon Miner's Manifesto India Quarterly is a publication produced by five editors spread across the globe. Both Peter Kokh and I live in Wisconsin separated by 115miles (185 km), Peter in Milwaukee and I in Green Bay. Madhu Thangavelu lives in the Los Angeles California area where he teaches in the Viterbo School of Engineering School of Architecture at the University of Southern California (USC.) Pradeep Mohandas and **Srinivas Laxman** live in the Mumbai metropolitan region in India. Our contacts are for the most part by e-mail as we communicate about forthcoming issues and contribute news and articles, and sometimes we connect by Skype.

I had had the pleasure of meeting Madhu a couple of years back when he graciously invited me to his home when I visited the Los Angeles area. Peter had met him some years earlier. However neither Peter of I have been to India and neither of us had met Pradeep or Srinivas face to face. This May however, we learned that Srinivas was visiting the US and would be meeting some family members in the Minneapolis area. I was traveling from the Western US back toward Green Bay and could come through Minneapolis heading East; and Peter could take the bus up to Minneapolis from Milwaukee heading West. So with a little coordination of our schedules we had a face to face meeting for the first time of three of the five editors of M3IQ on May 9th and shared an enjoyable time having breakfast together and discussing a wide range of issues.

L>R: Dave Dunlop, Srinivas Laxman, Peter Kokh

Chandrayaan II Planning

Srinivas told us that planning was moving forward for the Chandrayaan II mission and that seven instruments had been selected for that mission. The launch of Chandrayaan II however has been set back by an ISRO launch failure and by the desire to insure that those problems had been overcome with a couple of successful launches before this second lunar mission flies. The Russian launch failure of the Phobos II mission has raised similar delays on the Russian side. So it seems that the Chandrayaan II/Resurs Mission may be delayed until 2014 at the earliest. It is of course frustrating to have these delays and no doubt many are impatient with the process and this no doubt puts the ISRO under more public pressure.

For those who are impatient with this process I would recall the words of John F. Kennedy who said **"We go to the Moon not because it is easy but because it is hard."** Forty years after Apollo, there may be the tendency to think that it has become easy to go to the Moon with the prior history of successful missions plus the great advances made in computers, engineering design and materials. Many may think. "Going to the Moon? Well, it is no longer pioneering, now it is just engineering."

Some "Grey Hair" Editorial Perspectives

It is instructive to look at both the high tempo of attempted lunar missions for the US and the Soviet Union and to note that both programs suffered failure after failure in the attempts to get things reliably launched, to navigate successfully in cislunar space, and to land on the lunar surface. Those engineers who went through that learning curve are for the most part now long gone. It is foolish to underestimate the learning curve as more nations take up the challenge of returning to the Moon. That history made the success of Chandrayaan I more formidable in retrospect. On the very first Indian mission it was overwhelmingly successful in meetings its scientific objectives. Its shortened mission life by contrast with the many scientific successes seems rather trivial to this US observer although some in India were critical and in my opinion unnecessarily so. From attending many lunar science conferences I can say that those US scientists who participated in Chandrayaan-I see the mission as an unqualified success and a high point their careers. I hope that ISRO and Roscosmos can do it again with Chandrayaan II/Lunar Resurs!

Mars Next

We also talked about the high priority parallel drive to develop an Indian Mars mission. This is generating a high level of excitement and a sense of the strategic importance of Mars to ISRO's plans as an advanced space faring nation. We learned that there may be some sense of emerging rivalry between the Lunar and Mars teams within ISRO. Here again the US experience is a cautionary tale. The conflict between destinations has been internally divisive in the competition for what always seems like limited resources.

This competition often divides Lunar advocates from Mars advocates and this competition has been an impediment to American progress because of pendulum swings in the fashion of destinations and priorities. The road to Mars is also littered with the history of many mission failures. We also go to Mars not because it is easy but because it is hard, very hard. For the Moon Society The Moon is the best, closest, and most economical on-ramp to Mars. Mars is a destination and destiny that we fully embrace.

We learned from Srinivas that ISRO Dr. G. Murty(?) of the Physical Research Laboratory is leading these Moon and Mars initiatives and that the Sanskrit word for Mars is Mangal! So we salute ISRO's mission to Mangal! We hope that if the new mission is named Mangal I that is has many successors!

Lessons Learned and New Challenges

Those who expect unblemished success in the space business are naive and forget that it remains a difficult and a high risk business. It is not only a technical exercise but also an exercise in political will.

Not only did India succeed with it first lunar mission but it did so with the added complications of working with many international partners. That is also a testimony to the ISRO's skillful management of the multinational teams who learned to work together and whose instruments produced a rich harvest of new information. Where there are failures, delays, and frustrations it is always tempting to lay the blame on one's partners and find scapegoats. ISRO's management is to be commended for managing this human equation brilliantly.

One of my favorite U-Tube video clips is that of Dr. Abdul Kalam describing his first launch of India first significant launcher. He said, "I was responsible and gave the "ok for launch" and then watched as the rocket then proceeded to fly into the Bay of Bengal." From that terrible moment of failure he expected as the person accountable to perhaps lose his job and career but instead he received a vote of confidence and the encouragement to continue with his team to successfully reach their objectives. What a great story of the need to appreciate that we learn from mistakes and especially so at the very moment of failures."

In retrospect the first decade of this millennium saw an amazing success rate for the lunar orbiter missions of Europe, then Japan, then China, then India and then the US. What a string of successful missions! I would caution those who expect a similar record in the increased challenge of landing on the lunar surface, and surviving the harsh conditions of the lunar environment to temper their optimism a bit.

That is a lesson that may be learned again as many nations now aspire to return to the lunar surface and that of Mars. Only the naive will expect unblemished and early success. *At a political level the funding of back-up missions and the willingness to commit to "test programs" rather than single mission efforts is one of lessons that can be learned from the early US and Soviet eras and their success*. A recent fortune cookie I got proclaimed: "Good judgment comes from experience. Experience comes from bad judgment."

Summer Drama in August

In the US for sure, many "hearts will be in their throats" in early August as the Mars Science Lab Mission enters the Martian atmosphere and the new landing systems meets it first test in targeting and landing the "Curiosity" rover in Gusev crater. It is a cliché that such moments define either the thrill of victory or the agony of defeat but they also define the national resolve to master the difficult, to step up to both the technical and political challenges and pay the price of opening the new frontier. Will this system work and a new flood of exciting areology and perhaps news hints of Martian life be revealed? Or, will we witness the expenditure of $2 Billion on a new smoking hole on the Martian surface? This is the Opera of the Space Movement!

More News Perspectives

Srinivas recommended that we read the ISRO annual report as a source of a wealth of information. He also recommended a book "Martian Summer by Andrew Kessler. We also noted the continuing progress and the increasing numbers of exo-planets discovered. Another new development was the announcement of Planetary Resources of its ambitious plans to discover and assay Near Earth Asteroids, NEAs.

ISRO Leadership

Srinivas also noted that ISRO Director K. Radhakrishnan attended the Heads of Space Agency Meeting in Vienna and that India is working closely with other countries on the Global Exploration Roadmap as we also later learned from our visit at the Indian Embassy with ISRO's Washington representative Mr. Vivek Singh and from the ISRO participation in the Global Exploration Conference in Washington. In the aftermath of President Obama's trip to New Delhi and meeting with Prime Minister Singh, Srinivas expects strengthened space cooperation between India and the US. ISRO has received increase financial support and we expect progress on a broad range of efforts in rocket development, manned space flight, a vigorous commercial and scientific satellite program, and international collaboration, as well as continued progress on both Moon and Mars initiatives.

Our breakfast meeting. although lasting two and a half hours, seemed to fly by in ten minutes. It was wonderful to have this rare chance to meet face to face, to work together and chat as friends observing the world with editors' eyes. We also had a chance to meet some of Srinivas' family members who came back to our restaurant meeting place to pick him up. **DD**

Community - My experiences running a space organisation in India

By Pradeep Mohandas

I am only 26 years old. However I've had experience in being a part of four space organisations. This article goes through my personal experiences in all four organisations and my present position with respect to them. Then I move forward and share experiences that I think will be helpful to others who are planning to start their own space organisations. These are suggestions and I urge you to take them with appropriate help and advise from experts in the field.

My first experience of running a space organisation in India was when I started the Indian chapter of the Students for the Exploration and Development of Space (SEDS). Then, as a student, the first thing I got was friction whether as a student I wanted to run something like this. However, since there were other clubs like the Mechanical Engineering Students Association (MESA) and Institute of Electrical and Electronics Engineers (IEEE), I had some precedent to follow and state as an example. Following this, the effort to sustain a long distance relationship with other members on a fragile and relatively expensive internet connection was a challenge. However, I am happy to say that this effort was quite successful in that it resulted in an organisation with more than one thousand members spread over 5-6 Universities with more colleges and universities expressing their interest and intent to sign up. This was a place where I was totally hands-on and in-control. As time passed and I neared graduation, I loosened my reins and allowed more people to take part in the operations of the organisation before running an election and slowly stepping out completely from the picture. I wanted SEDS to have its own agenda inspired by the thinking and ideas of the students and not run by an individual, who was not a real stake holder.

My second experience was getting in touch with an international body of students and young professionals in what is today the Space Generation Advisory Council (SGAC). This was a lively and fun organisation when I joined in with a very active mailing list. I was part of this organisation as National Point of Contact for India between 2009 to 2011. It was a time when this organisation transitioned to some organisational architecture and introduced more structure into its functioning. At the time, I did not like it too much and felt bureaucracy had taken over the functioning of the organisation instead of a lively project minded and open atmosphere that prevailed before it. Closer to 2011, I understood the various pressures that were pushing the organisation towards this structure. I withdrew temporarily from it to pursue running a Wikipedia conference in India. I have since returned to the organisation (subscribed to its mailing list).

My third experience has been meeting with Raghunandan Kumar, who runs the Planetary Society, India out of Hyderabad. I basically helped him out plan some technical projects and provided some technical feedback and answered questions related to rockets and satellites when he needed help understanding some of the technicalities. He remains firmly rooted in his home city of Hyderabad in Andhra Pradesh and has shown interest in expanding to other parts of the country but has not taken the critical step for implementing it. He too remains firmly in control of the Planetary Society. We remain friends and I still continue to help him with Planetary Society, India.

My fourth experience was starting a post-SEDS organisation (for me) in India. This happened in the shape of the Moon Society. I found more bureaucratic friction here than before. There were chartered accountants and lawyers involved and there was frustration that things were not moving forward and many of the executive committee members felt the need to move on with things as the buzz around Chandrayaan mission died down in India. I felt the need to have a more general space organisation like SEDS for adults than a percieved specific organisation like the Moon Society. We decided to wind down the Moon Society as an organisation, kept it alive virtually as a Facebook group and decided to see where that leads us.

Based on these experiences, I have a few guidelines on how to move towards setting up a space organisation in India, if you ever plan to. No matter what the aim of your non-profit is going to be - specific (like the Moon Society, Mars Society etc.) or general (like the National Space Society, Planetary Society etc.), I would suggest building it virtually. Start a google group or facebook page. Start sharing news, hold discussions online, build relationships with people. Get phone numbers. Move some conversations to the phone with people you trust (use appropriate measures for your personal safety when meeting strangers from the Internet). Start building a core group of people who are involved. Try to do an offline meeting of these core group of people. If they are not in one geographical location, try Skype or Google Hangout or Facebook video.

Resist the urge to immediately register an organisation. Work together in doing an event like SpaceUp (a barcamp for space lovers) or a star party for a night. Participate in a few competitions on an individual basis but use the name of the group to promote yourselves. Start building a following. Only at this stage seek help in starting a space organisation. In India, this involves help from a Chartered Accountant and a lawyer basically and 11 individuals. It's best if the same core group involved in conducting the various activities step forward. Take help, do the registration process slowly, understand the law. Get an accountant to do the accounts regularly. Hire a consultant who can help you with various tax stuff (like tax deductions on donations) and on communications with the Registrar of Societies.

In decision making in activities of the society, strive for consensus. There will be politicking, be ready for this. There will be threats to the existence of the organisation from people who may have other intentions. Keep the working transparent, allow people to ask questions, answer them publicly. Seek ways to become more open. Hold meetings as often as possible even if only 2-3 people turn up. Allow new members or non-members to attend this meeting. Record their email id or contact information. Get in touch with them and see if they are interested and involve them in activities. I know, being a founding member, you will have an emotional attachment to this organisation. The more pragmatic you are in approaching the running of the organisation, the easier for you it will be. Always keep yourselves above the organisation. Don't make personal sacrifices for the organisation beyond a point. Make sure your wife is not going to leave you or that you're going to drop out of college just because of this organisation. Involve more people in running and administration of the organisation to make this easier and possible.

Last up, do as many activities as you can as an organisation. Project based organisations seem to work best in my opinion, but feel free to go with activities and meetups if that works for you. Enjoy doing this. At any stage, if anything does not work out, be ready to bail out. Don't push too hard to make your dreams everyone's reality. It takes time. Give it a rest and try again after sometime. Pushing through things works in the corporate world, not in the non-profit world.

These are just my ideas, you are free to follow them or do things your way. Please do share your learnings so that others may gain from your experience. **PM**

COMMUNITY - NSS SPACE SETTLEMENT DESIGN TEAM AT ISDC PARTICIPANTS NSS OPEN FORUM AND PLAN TO FORM NSS STUDENT CHAPTERS

By Dave Dunlop

At the International Space Development Conference held in Washington D.C. May 24th through 28th over 270 students came from 10 countries to participate in the Space Settlement Design Competition sponsored jointly by NASA, lead by Dr. Al Globus of NASA AMES, and Lynne Zielinski, NSS VP for Education. These teams met with a variety of National Space Society Board members and heard presentations on topics such as Space Solar Power Satellites, the problems of space debris, the need for more attention to the threat represented by Near Earth Asteroids, and the new opportunities for opening the frontier because of lower cost access to space. A dramatic opening of the ISDC Plenary Session was a speech by Dr. Charles Bolden, NASA Administrator who addressed the meeting even as the Space-X Dragon capsule was docking with the International Space Station, shown live on large TV screens behind him.

Students displayed their posters in an exhibit hall dominated their work which showed a great deal of imagination, background research, and skills in presentation. As Chair of the International Committee I also hosted a Student Open Forum, along with members of the NSS Board of Directors from the Membership, Web, Chapters, and Education Committees. Students were invited to address two question at the Open forum. First, what practical steps can you see in your on country in the application of space technologies to important national issues. Second, how can the NSS organization assist you in addressing these concerns as a space advocacy organization?

On Sunday morning over 150 students jammed into the conference room that was set aside with standing room only to with representatives from each team invited present their statements. NSS board were gratified to see this level of interest from both the student teams and their teachers and team mentors. I have appended a synopsis of these comments at the end of this article.

Students expressed excitement to be part of this diverse conference but also expressed in interest that NSS meeting such as the ISDC be held in other areas of the world. We encouraged students to participate in forming chapters in conjunction with their schools and many of the teachers at this forum who had participated at the ISDC Conference Competition also offered their assistance in this regard.

NSS also anticipates the development of some new unique components to its education program with opportunities to conduct experiments on the International Space Station and to win O-G flight opportunities.

As a result of this Open Forum the NSS has begun to streamline its process for enrolling new student members and the formation of student chapters at a sponsoring school. Some 10 to 12 groups expressed interest in forming new student chapters. Planning is already underway for the NSS Space Settlement Design Contest and Education Track at the 2013 Conference in San Diego and we look forward to expanded participation next year building on the success of the 2012 ISDC.

Student Open Forum Appendix

Present were some 50-100 students in teams from Bulgaria, India, Romania, Singapore, and the US:

Some of the ideas suggested included:

- NSS should hold more international meetings and expand our international partnerships!
- ISDCs are a good idea and we should have more of them across the world.
- Facebook is not enough and direct interpersonal contacts are important!
- We might find an affiliate organization in the Bulgarian Astronomical Society which engages people.

Suggested Google Floss.

- NSS should be much more global and should address issues that affect all humanity such as opening up the resources of space and asteroid mining.
- NSS might use the human and intellectual resources in Singapore, which might also be a good place for an international conference.
- We could do a better job of advertising and sharing information about the design contest..
- NSS should try to integrate its members into schools and conduct workshops, and have ambassadors.
- We should address issues such as Life Support systems and asteroids.
- A teacher in India who has attended ISDC with students in 2009, 2010, 2011, 2012 suggested that we provide a letter of recognition to Dr. Abdul Kalam.
- From a student who had attended Space Camp in Huntsville: NSS should develop a Space Camp in India (Ronnie Lajoie indicated he would pursue this with Space Camp personnel in Huntsville)
- NSS is not reaching teachers and guidance counselors.
- Not enough outreach.
- More NSS Ambassadors.
- I learned more in three days working on the Space Settlement Design Contest than in a month in school
- NSS might have some practical workshops.
- Paul Werbos spoke about the Research Experience for Teachers program of National Science Foundation.
- Do something to promote protection of the Earth! Why not a design contest do to this.

  (Lynne Zielinski challenged this student to work with her toward this end)
- NSS could have student debates on Space Issues
- NSS could publish a magazine on space settlement design.
- We had an offer to assist NSS in its web committee from Paul Sudahkar.
- We had an offer to assist our NSS Kalam delegation to India from Mrs. G.R. Vasantha, a teacher whose teams have won 5 prizes)

COMMUNITY - A NATIONAL SPACE SOCIETY MEETING WITH THE ISRO COUNSELOR FOR SPACE AT THE INDIAN EMBASSY, WASHINGTON, DC, USA

By David Dunlop

After the recent International Space Development Conference (ISDC) in Washington D.C., along with fellow NSS BOD member Lynne Zielinski, I had the pleasure of meeting Mr. Vivek Singh, Counselor of Space for the Indian Space Research organization at the Indian Embassy. This was my chance to meet Mr. Singh for the first time. We have enjoyed the collaboration of ISRO in making presentations at prior ISDCs but this was to the best of my knowledge the first time any NSS representatives had met at the Indian Embassy.

NSS Educational Activities

One reason for our visit was to talk about the high level of participation in the NSS Space Settlement Design Contest from India. Lynne Zielinski noted that at this year's ISDC over 100 students from India attended. Singh gave us some practical advice in facilitating the visa issues that involve our participants in the future. We invited him to participate in the ISDC 2013 conference to speak to about ISRO future space activities and to meet the many enthusiastic participants that compete on space settlement design from both India and other countries.

He also invited us to work collaboratively with the newly established **India Institute of Space Science Technology** which will be in charge of ISRO educational initiatives. We noted some exciting new educational opportunities that have been presented to the NSS involving experimentation on the International Space Station for one, and also opportunities for participation on Zero-G flights. Mr. Singh also noted that there is a student exchange program established from the IISST to Cal Tech every year.

India's International Role in Space Development Planning

Mr. Singh had commitments this year working with a high level ISRO delegation that was attending the Global Space Exploration Conference, which was meeting simultaneously as the ISDC. India as a major space-faring nation has been a participant in the Space Exploration Roadmap effort with 12 other nations looking at developing collaborative efforts on topics such as some standards for common architectures that will advance goals such as the exploration of the Moon with robotic systems, technologies such as development of space tugs, and the capacity to repair and extend the life of existing satellites, and the development of refueling capacity. We expect more news as efforts to develop specific collaborations continue.

NSS Kalam Initiative

We also noted with pride that India's former President Dr. Abdul Kalam had addressed the ISDC during the 2010 Chicago Conference and that we have been working with his office on the NSS-Kalam initiative to promote international collaboration on the topic of Space Based Solar Power [SBSP] since a joint Press Conference in the fall of that year. In 2011 Dr. Kalam addressed electronically a meeting of the China Energy and Environment Summit in Beijing and proposed a global knowledge platform for SBSP. An NSS Delegation, of which I was also a part, attended CEES also and spoke in this meeting about NSS support for global SBSP, where Chinese interest in this technology was a major focus.

A significant step forward occurred in Paris March of 2012 when a Global Space Solar Power Working Group was established by the International Academy of Astronautics. Dr. John Mankins, Dr. Feng Hsu, and NSS Director Mark Hopkins attended this meeting.

At this year’s ISDC, the SBSP track with NASA sponsorship provided an update on future SBSP designs and anticipated research and development. We anticipate an NSS delegation going to India in 2012 to meet with Dr. Kalam. We are pleased to see international support from NSS affiliate Space Canada, and from Japanese researchers such a Dr. Nobu Kaya and were glad to have an opportunity to brief Mr. Singh on these activities.

University of Luna Award on behalf of the Moon Society

Finally, I had the honor of Presenting the University of Luna award from the Moon Society to ISRO for its discovery of a lunar lava tube skylight by the Chandrayaan I lunar mission. This discovery provides a chance for further discovery of the geologic forces that produced lunar lava tubes and of samples of materials from the lunar interior that date back 2 to 3 billion years. Lavatubes may represent natural environments that can be useful in providing sheltered volume from harmful radiation on the lunar surface and a more stable and benign thermal environment as well for human and industrial equipment.

We were privileged to have the generous time commitment of Mr. Singh who represents the ISRO in consultation with all the nations of the Western Hemisphere and look forward to working with him in the future and to provide M3IQ readers with updated news. **DD**

COMMUNITY - MOON? MARS? ASTEROIDS? WHERE SHOULD HUMANS HEAD FIRST?

The "Triway" to Space

By Peter Kokh and Al Anzaldua

For several months, we have been working on a paper about destinations for Human Space Exploration. This project started when Al approached Peter, saying that he was impressed by his **"Triway" Presentation**.

http://www.moonsociety.org/presentations/ppt/ or http://www.moonsociety.org/presentations/pdf/

We decided to turn this into a paper for publication and widespread dissemination among the various space enthusiast groups. This paper has now been published by Space Review, and has received very positive reviews.

http://www.thespacereview.com/article/2078/1 - The full text follows

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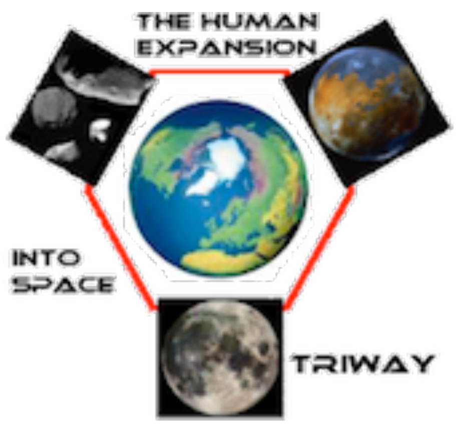


The Triway into Space Declaration

By Peter Kokh* and Al Anzaldua**

* National Space Society, Moon Society, Mars Society, Lunar Reclamation Society, Planetary Society, OpenLuna.org

** National Space Society, Tucson L5 Space Society, Moon Society, Planetary Society, Mars Society

"There is no surer way to give the budget cutters—and there are plenty of them out there—a reason to go after the planetary program than to project an appearance of disunity, disarray, disagreement as to what we should be doing. We must speak as one voice."

Steve Squires, as quoted by Jeff Foust in *The Space Review* article, "Fighting for Mars," March 26, 2012.

In the space advocacy community there has been a "**tri-polarization:**" **some advocates interested only in the Moon, others only in Mars, still others only in asteroids.**

- The **Moon-focused** contingent is convinced that the Moon's proximity and resources could lead to clean, space-based solar power and a platform to develop the rest of the solar system.
- The **Mars-focused** contingent is keen on seeing that the planet becomes a "second basket" into which to place humanity's eggs.
- The **asteroid-focused** contingent is concerned with planetary defense and the extraction of asteroidal resources.

The three groups are sometimes dismissive and even antagonistic towards each other, leading to a confused message to our media and elected officials, which in turn leads to an apathetic public and limited, undependable funding. Although all three groups have the long-term survival and prosperity of humanity as their primary motivation, their disunity impedes human expansion into the solar system and imperils long-term human survival.

What is lacking is an exciting, comprehensive, and *integrated* space-development vision and action, satisfying the primal urge to explore and including the emerging private-sector companies. Such a compelling and integrated approach would go well towards engaging government officials and the public in a productive way. An approach to space development that integrates each of the major destinations, a "Triway" approach, and collaboration based on such an approach, we suggest is more sensible than bashing natural allies and squabbling over limited funding. An integrated, public/private Triway expansion into space will facilitate not only to our long-term survival, but a prosperous and advanced human civilization throughout our solar system - and someday beyond.

Integrated Pathway to Three Solar System Destinations and Their Orbital Spaces

The potential unity and integration of all three destinations is more easily glimpsed within the context of the orbital spaces that approach or surround them. These include highly eccentric Earth orbits (HEEO) approaching Earth-Moon L1 (EML1) and potential orbits connected to Langrangian libration points. If one includes Mars's orbiting moons, Phobos and Deimos, a more holistic picture emerges for possible infrastructure development of the inner solar system. As a rule, efforts to develop or settle the three main solar system destinations should always be seen within the context of the potential orbital spaces that connect them to each other and other destinations.

Potential Synergies through Triway Research and Development

Pursuing each of these space-expansion goals separately can blind the activist to the synergies and savings that can come from pursuing one goal with the other two in mind. Only if all three space-activist groups appreciate and promote a unified, integrated vision of human expansion into space--with technologies and missions congruent with that vision, can it be a "win-win-win." The fact that this synergy is vital for the survival of Earth and mankind should itself be a powerful incentive.

Similar transportation and habitat module/ life-support technologies will be needed for all three space destinations. These technologies might include: 1) modular bio-regenerative, life-support structures and technologies; 2) multi-use spacesuit and vehicle development; 3) mining, processing, and construction technologies; 4) modular and robotic factory systems; and 5) small "pocket" hospitals. More specifically, we suggest that the space advocacy community promote the following infrastructure projects and political efforts with an eye toward reaching all three destinations as quickly as possible:

1. Government policies that mandate and promote continued private-sector efforts to develop fully and rapidly reusable launch and shuttle spacecraft systems to drastically drive down the cost of space transportation.
2. Evolution of the International Space Station (ISS) into a platform for building human-safe staging, fueling, and processing stations to be put in various Earth, lunar, and Earth-Moon libration orbits.
3. Evolution of the ISS into a platform for testing rotational artificial-gravity systems to determine the minimum amount of g-force needed to maintain health in various terrestrial plants, insects, amphibians, reptiles, and small mammals.
4. Evolution of the ISS into a platform for testing bio-regenerative life-support systems within small habitats (sometimes termed enclosed mini-ecosystems or biospheres)[1] for animals and humans.
5. A crash program to test various materials and their combinations to shield against cosmic radiation.
6. Public-private partnerships to build space-based solar satellites in geosynchronous Earth orbit (GSO) and possibly on the Moon to provide energy on Earth.
7. The step-wise construction of industrial parks on the Moon and within human-safe stations populating Earth-cis/trans-lunar orbits.

The Benefits of Triway Trade

The Moon, Mars, and asteroids all have significant natural resources, and the economies of each will grow immeasurably if they are trading partners. Adding services, intellectual property, and other human resources into the mix is sure to enhance such trade. Phobos and Deimos pioneers could bring useful skills to Mars, lunar, and asteroid crews and vice versa.

Because of the delta-V characteristics of the inner solar system, materials and products produced on the Moon or at cis-trans-lunar locations could be shipped to markets in HEEO, GSO, and low Earth orbit (LEO) or to Mars plus its moons (Mars PhD) at a cost lower than similar products shipped out of Earth's much deeper gravity well. On the other hand, products made from minerals or volatile compounds *uncommon on the Moon* could also be shipped from Deimos or near-Earth asteroids to the Moon or Earth orbits at significant cost savings compared to shipping them from Earth. Moon/cis-Moon/Earth-orbit trade could enhance both Moon and Mars frontier efforts and vice versa.

Because closed-loop bio-regenerative systems to recycle nutrients, vital gases, and water will allow humans to live long-term, not only on Mars, but also on the Moon, in large asteroids, and in orbiting work sites or habitats, testing of these systems in space, even on a small scale, should begin as soon as possible.

Let us now look closely at the three traditional space-expansion goals with a more detailed and integrative eye:

Lunar Resources for a Solar System Economy

"Isn't the Moon resource-poor?" ask the Mars and asteroid activists skeptically. Triway advocates will remind them that *solar system location* is a natural resource (just three days travel to reach the Moon) and that the Moon's regolith also offers oxygen, iron, titanium, magnesium, thorium, silicate, KREEP (potassium, rare-Earth elements, and phosphorous), and polar-crater water-ice – just what we need to make metal alloys, glass, glass composites, concrete, and ceramics, all potentially exportable to construction sites in LEO and GSO at significant savings over equivalent products from Earth's surface. Combined with complementary asteroidal and Mars PhD resources, lunar resources will help support a space-faring civilization throughout the solar system.

Lunar resources could facilitate the fabrication of solar power satellites for Earth and other astral bodies. Solar power satellites receive sunlight undiminished by Earth's atmosphere 24/7 and can beam the converted energy to rectennas on Earth by microwaves or lasers. A lot of material will be needed to build them, *but it will cost 1/20th of the propellant to obtain the needed materials from the Moon than from Earth* because of the Moon's lesser gravity. As an alternative, encased lunar materials could also be catapulted via maglev launchers off the Moon's surface to be caught by catcher vehicles in a halo orbit at Earth-Moon L2 (EML2), 40,000 miles above the lunar surface. From there it would take only a velocity change of 9 m/sec to reach a processing site in a 2:1 Earth-Moon resonant orbit with an apogee of 200,000 miles and a perigee of 100,000 miles. A bit more delta-V could achieve a site in HEEO.

Already Helium-3 is being used in so many medical and security technologies that shortages are appearing. Moreover, nuclear physicists foresee a day when we will have the technological expertise sufficient to use Helium-3 in fusion reactors without significant radioactive waste products. *One* shuttle external tank full of liquid He-3 would be enough to power the United States for a year. When the first fusion plant comes on line, Helium-3 will suddenly become a very high-demand, very high-priced commodity. The good news is that there is enough helium -3 in the upper 2 yards/meters of moondust to bring the whole world up to our standard of living and keep it there for a thousand years. A Triway infrastructure, utilizing the Moon's libration points and resonating vehicles in HEEO, will help deliver Helium-3 to the Earth and other solar system destinations.

Human Settlement of Mars

The fact that the Moon is deficient in some critical resources could well become the foundation of a successful effort to settle Mars. It is difficult to conceive of anything that could be produced on Mars (or on its two moonlets), which could not also be produced on Earth at considerably less expense. And Mars is too far, and journeys there and back too long to support a significant tourist trade. But without trade of some kind, the cost of creating a Martian frontier would not long be supported by terrestrial governments or corporations, leaving only legendary ruins. As it happens, however, there are many raw materials and products that a Mars PhD economy could likely export to the Moon, such as volatiles, salts, and metals like copper, chromium, cobalt, mercury, zinc, and silver. Such complementary resources from Mars PhD would facilitate a wider and more sophisticated provision of building materials and products from lunar and cis-Moon settlements to Earth orbits, expanding the already economically significant "gross economic product" of LEO and GEO.

Mars is in many ways the most "Earth-like" planet in our solar system. Its total land surface of Mars is equal to total land surface of Earth, and its day is only a bit longer than ours. Because Earth plants and animals evolved in a 24-hour day/night cycle, the similar day/night cycle of Mars will contribute to the health of plants, animals, and humans. Mars apparently also has an abundance of water locked up in permafrost and underground aquifers. The planet also has four seasons like Earth, and its year (called a Sol) is nearly twice as long as Earth's.

Although recent experiments on the International Space Station indicate that at least some plants can be raised in zero G, animals are another matter. At 38% Earth gravity, Mars *possibly* has sufficient gravity to keep Earth plants and animals healthy over the long term--even upon their return to Earth.[2]

Mars has only a thin atmosphere of mostly CO2, providing insufficient protection from cosmic radiation, including UV, and solar flares. As on the Moon, the first long-term settlers will therefore have to live in strong-shelled bio-regenerative habitats below five meters of soil and with light reflected down from the surface and complemented artificially. Technology for such encapsulated living developed for Moon settlement will therefore be helpful on Mars, and vice versa.

We in the space community should give the exploration and study of Phobos and Deimos the highest priority. Phobos and Deimos appear to be carbonaceous and might therefore contain below-surface water, as well as myriad other natural resources commonly found in carbonaceous asteroids. Both moons could be used as platforms to study Mars telerobotically in near real time. Exploring and studying Phobos and Deimos, both robotically and with humans, will help generate methodologies and technologies for dealing with both Mars and the asteroids. Phobos and Deimos could also eventually be used as fueling way-stations to-and-from orbiting asteroids and other solar system sites. Mars PhD, along with carbonaceous asteroids, could also conceivably supply water for propellant and life support to water-poor solar system sites. Mars PhD has sufficient natural resources at hand to someday survive cutoff of support from Earth and therefore fulfill a "lifeboat" function.

As mentioned above, space pioneers living and working on (or in) the Moon, Mars, asteroids, or in rotating habitats in various orbits around planetary bodies or Lagrangian points, will have to remain mostly within small enclosed "mini-biospheres," ecosystems, or other bio-regenerative systems located either underground or inside dense structures to protect from cosmic radiation. A yet undetermined number will have to live in habitats, rotating to produce artificial gravity. Meanwhile, any environmental technologies and processes developed on extraterrestrial planetary bodies or inside rotating habitats, out of necessity, could be adapted to help those remaining on Earth to better preserve our precious environment for generations to follow.

[2] If we don't test humans under various levels of artificial-gravity in space before settling the Moon and Mars, the real experience of humans will settle the issue of how much gravity humans need to stay healthy. It may turn out that solar system pioneers from the asteroids, Moon, and Mars will have to spend at least some time within rotating, artificial gravity structures to regain or maintain healthy bones, muscles, and immune systems.

Deflection and Mining of Asteroids for Safety and Profit

Asteroid activists are quick to point out that near-Earth asteroids (NEAs) and comets are not only possible threats, they are also *reserves of raw materials* essential to our growing material needs. Among the resources asteroids can provide, depending on their type, are 1) elemental carbon; 2) mineral-bound water; 3) iron, nickel, and other construction metals; 4) precious metals, such as gold, silver, platinum group metals; and 5) internally, volatiles like hydrocarbons and ices of water, ammonia, and nitrogen. All these may be vital imports for a solar system economy, including Earth's, as Earth's finite resources become more costly to extract and if aerocapture techniques become widely utilized.

As suggested by John S. Lewis in his 1996 book, *Mining the Sky*, some HEEOs make very attractive staging areas of the transfer of asteroidal and lunar resources because they approach EML1 and then come as close as 1000 km to Earth at perigee. Other less eccentric orbits in the Earth-Moon system, some resonating conveniently between Earth and Moon, are possible as well.

Asteroid-deflection methods in need of testing include gravity tugs; spot-heating by mirrors or lasers; striking with impactors; and attaching reflective material, mass drivers, rocket motors, or solar sails. The idea of deflection with a nuclear explosion seems fraught with danger as well as unpredictable results. Although 90% of NEAs larger than 1 km in diameter have been found, perhaps a million much smaller but still-dangerous NEAs have not been identified. These smaller bodies strike the Earth much more often. For instance, 40 meter diameter Tunguska-sized object will strike the Earth an estimated average of every 100 to 200 years.

At the earliest opportunity, we should 1) choose asteroids on the basis of which pose the greatest threat and resource opportunity; 2) systematically track them; 3) characterize the asteroids as to their internal cohesiveness, resource composition, and structure; then 4) develop and test methods of deflection and resource extraction. Carbonaceous near-Earth asteroid 1999 RQ 36, a 575 meter diameter body that crosses Earth's orbit every year, fits the bill neatly by being both threatening and resource-rich. Fortunately, NASA in June 2011 funded the robotic Osiris-REx mission to RQ 36. After launching in 2016, the Osiris-REx spacecraft is scheduled to encounter RQ 36 in 2019, study it, and bring a sample back to Earth in 2023.

The Role of Private-Sector Space Companies in a Comprehensive Triway Approach

The settlement of our solar system will likely be facilitated by private-sector space entrepreneurs involved in the endeavor, ideally in partnership with government. Fortunately, over the past few years, well-funded private companies such as Space X, Virgin Galactic, Bigelow Aerospace, Blue Origin, XCor Aerospace, Stratolaunch, and others have entered the space market and the price of getting into orbit is already dropping. Beyond more X-prizes, sponsorship by non-space private companies would also boost space development. While advertisements on space vehicles and other promotional activity may offend some traditionalists, sponsors like Google could promote their own businesses while they help defray development and launch costs.

Space X founder Elon Musk has expressed interest in producing multi-purpose (i.e. "Triway," without using the word) vehicles and missions for Earth orbits and deep space. Both Elon Musk and Stratolaunch founder Paul Allen have announced that their companies intend to produce, within a few years, fully and rapidly reusable launch vehicles that might drive the cost per kilogram to LEO and beyond down by one order of magnitude or more. If that happens, space tourism, science, technology and commerce will likely surge, changing the direction and goals of humanity forever. A multi-planet, spacefaring civilization will be in our grasp. And a comprehensive, integrated Triway space activism will support that effort.

A "Triway" Call to Action

In this time of scarce governmental funding, it is more important than ever to consider comprehensive, integrated missions and technologies that facilitate reaching all three major destinations. As soon as possible, the major private and public space development players, including advocacy groups, should meet with one another to collaborate on unified, integrated Triway strategies and missions. Organizing a conference specifically for such a purpose would be a good first step. Meanwhile, there is no reason why each group should not keep its own principle focus, while recognizing the validity of the others and playing mutually supporting roles.

If we do that, the people, the media, the Congress, and the Administration will get the message: *"They do have our act together, and they have a compelling agenda that makes sense for humanity's future."* That would provide a "common ground" basis for budget priorities, providing strong incentive to developing technologies and equipment that supports all three branches of the Triway into Space.

In conclusion:

- **Whereas,** in the space advocacy community there has been a "tri-polarization": some interested primarily in the Moon, others primarily in Mars, still others primarily in asteroids;
- **Whereas,** this tri-polarization and lack of an exciting, integrated space-development vision from the space-advocacy community has led to a confused message to the media and our elected officials, fostering a space-apathetic public and lack of support from elected officials, thus impeding human expansion into the solar system and imperiling humanity's long-term survival;
- **Whereas,** ***all three groups have essentially the same motivation, the long-term survival and prosperity of humanity;***
- **Whereas,** efforts towards all three goals can be complementary and mutually supporting with shared technologies and methodologies, and therefore *all* deserve humankind's priority attention;
- **Whereas,** funding only by governments is not sufficient or dependable enough to create a solar system economy, and private-sector space companies have emerged recently, showing the promise of much lower space mission costs;
- **Therefore**, we declare that the time has come for the three camps to put away their differences and put forth a unified, integrated, public/private space-development plan for the benefit of the U.S. Congress, the general public, and all of humanity. We coin such an integrated effort towards the three main space destinations the **Triway into Space** ("Triway").

The authors wish to thank David Brandt-Ericksen and Ben Nault for editing suggestions related to this article.

PK/AA

The Moon Society: Mars is in our "Field of View"

By Peter Kokh [a Moon Society brochure first printed in 2004]

[The writer, while President of the Moon Society (2004-2011), is also a dedicated member of the Mars Society]

The Moon Society is focused on the Moon, of course. But for lunar settlement to be truly viable, the Moon will need to tap resources it lacks in economically accessible abundance: industrially strategic metals such as copper, zinc, silver, platinum, and gold; and perhaps carbon and nitrogen-rich volatiles. The Moon also needs markets for its products other than Earth.

"Mars first" supporters are quick to point out the resource-challenged poverty of the Moon. That established fact turns out to be irrelevant. Japan too, lacked many industrially strategic resources: coal, oil, iron ore, and more. So it went out and developed "markets" in resource-rich areas of the Pacific Rim, becoming rich and prosperous in the process. Japan is the model for the Moon. Our satellite does, however, start with **the three most important resources of all -- "location, location, location"** -- the Moon has it, and Mars does not. The Moon will become "the Japan" of the Inner Solar System.

But the story does not end here. Greater Mars (with Phobos and Deimos) is a potential market for goods manufactured on the Moon, but, more importantly, a potential source of volatiles and strategic metals that can be shipped to the Moon for far less fuel cost than up out of Earth's deep gravity well. It is in the Moon's interest to promote the opening of "Mars PhD", not eventually, but without delay, apace with the opening of the Moon.

But it is also in the best interests of the future Martian frontier to have the lunar frontier develop side by side. Why? When it come to products that Mars could market to customers on Earth, Mars has no resources in abundance that are scarce on Earth. Tourism? Who will be willing to take two to three years out of their life for a round trip jaunt to Mars, when most of that time will be spent coming and going?

However, Mars does have potential exports needed on the Lunar Frontier. In fact, without the Moon in the picture, it will be exceedingly difficult to establish any believable "Economic Case for Mars." An Earth-Moon-Mars economy could work.

The Moon has three potential product areas that might be developed for direct sale to customers on Earth: microwaved-power, helium-3, and tourism. But beyond that, any item that lunar industries develop for local, lunar, consumption, should be marketable to "inspace markets" -- such as Low Earth Orbit industrial parks and tourist facilities -- at a cost advantage over equivalent products produced on Earth, given the 23:1 fuel savings advantage.

Again, what the lunar economy will be able to produce, and the extent to which it will be able to diversify, will be limited without cheaper sources of lunar-deficient materials than from Earth's deep gravity well. Here is the opening for a Mars-Phobos-Deimos economy.

Mars will also benefit from immigration of Moon-seasoned pioneers. For experienced Lunans, Mars will be "a walk-in-the-park." ALunan recruit will be worth as much on Mars as many recruits direct from Earth.

Simply because of distance and frequency of launch windows, the lunar frontier will initially develop faster than the Martian one. Made-on-Luna equipment and supplies will be shipped to Mars at considerable fuel cost savings, allowing Martian

hard currency credits to go farther, helping to insulate the Martian frontier from a cut off or cut back of support by benefactor governments and corporations on Earth - support that might be interrupted

at any time.. Whichever world you personally would rather pioneer, it remains all but certain that the Lunar and Martian Frontiers will have an significantly better chance of successful development, each more quickly reaching viability should

support from Earth dwindle slowly or be abruptly interrupted, together than separately.

It is more constructive to see Moon and Mars as natural partners, than as "us or them" rivals. Well-intentioned enthusiasts who buy into the "Moon or Mars" debate, not only deceive themselves, but work for the failure of both initiatives. Can we afford to open both frontiers? Let's rephrase the question: Can we afford to pick just one if it entails certain failure?

The Moon Society calls for the opening of both frontiers simultaneously, with new equipment (e.g. mining, processing, manufacturing; transport) and systems (pocket hospitals, air and water recycling, biospheric, etc.) for use on both worlds, tested on the Moon first, where rescue, resupply, repair are easy.

This will provide a triple benefit for Mars

1. New equipment will arrive on Mars with a much higher confidence and assured reliability level for use in a location where rescue and or resupply can be months or years away.
2. Development of such equipment and systems can be charged to the cost of opening the Moon, greatly reducing the incremental cost of opening Mars.
3. With new, debugged equipment from the Moon will come persons familiar with its use, proven pioneers, not untested romantics from Earth.

Similarities between Moon & Mars

• Neither world has a breathable atmosphere - we must establish self-contained mini-biospheres on both to house and support our outposts and settlements. There is no one-size fits all biosphere approach. "Modular biospherics" is the best approach, providing primary waste treatment at the point of source, to allow our biosphere encradled settlements to grow without trouble.

• Neither world is well protected from "the cosmic elements" - cosmic rays, solar flares, solar ultraviolet, etc. While Mars has significant protection from the incessant micrometeorite rain than the Moon, it is much more exposed than Earth, with our much thicker atmosphere. Outdoor surface activities such as construction will be hazardous duty when prolonged. Construction and assembly methods which minimize man-hours spent on the surface will be at a premium.

• Both worlds experience very cold temperatures. Lubricants and fuels and materials which hold up under those conditions are needed on both . The Moon has extreme heating to deal with as well, but to a lesser degree, so do Phobos and Deimos, also without atmospheric heat sinks.

• Both worlds have dust management problems. Is fine dust on Mars as intrusive and abrasive as that on the Moon? Not sure. But dust control measures are needed on both frontiers.

• Safe, reliable modular nuclear power units, add-a-unit-as-needed, will be a big benefit on both frontiers. Both worlds have solar power access, the Moon much more so than Mars. And Mars,.with little reason for optimism, may have some geothermal hot spots that can be tapped.

• If a treaty banning shipment of nuclear fuels through Earth's atmosphere were ever enacted, fuel for nuclear power plant units, and for nuclear propulsion rockets, can tap substantial Thorium deposits on the Moon, using fast breeder technology

to process this into fissionable U-233. Such a lunar industry would benefit both frontiers.

• Both worlds are without road networks - infrastructure is expensive, labor intensive - on both we'll need pressurized all terrain vehicles, that can travel fairly fast of boulder strewn stretches.

• Lavatubes for ready made shelter are expected to abound on both worlds, for settlements, warehousing, industrial parks, etc. Construction inside them benefits from substantial in place regolith shielding. Workers can use light weight, light duty, unhardened space suits, and need not worry about "outdoor radiation exposure times."

• Areas of subsurface ice , or frozen soil, are expected to exist on both worlds

• Both worlds are more economically challenged by themselves than if they trade goods and services and work together to develop other "in space markets" to further the rise of an interplanetary economy that could withstand interruption of

support from Earth. Mars, Phobos & Deimos will be cheaper sources than Earth for things the lunar frontier cannot provide for itself, while the development of markets on Earth for these same

• items is unlikely. And the Moon can probably supply the Martian frontier with some items at a lower expense than they can be shipped from Earth. The Economic Case for Mars, presently mostly wishful thinking, gains a boost from the Moon being a customer. The reverse is also true.

• The hardships and challenges of life on the lunar and Martian frontiers will bear many similarities, along with obvious differences.

• **The pioneers will have left behind much, forsaking Earth for a fresh start on a new world.**

The ability to go outdoors without a spacesuit Many outdoor forms of recreation.
An ever increasing variety of consumer goods
Many food and beverage specialties
Many hobbies, even indoor ones, that cannot be supported on the frontier, at least not yet.
The endless list of tourist destinations
A very rich and diversified biosphere
Endless occupational options and opportunities

• They will be chasing similar dreams, a chance

to pioneer a pristine, unspoiled world
to be in on the beginnings, on the ground floor
to start over, fresh, and try new ways of living
to rise to the top rather than be lost in the pile
to find oneself, to be all that one can be
to appreciate more deeply what life is all about.
to pioneer new ways to be human
to take a barren world and make it fertile
#to learn to be "at home" in a setting where no one could ever have felt "at home" before
#to help spread humanity and life to the stars

• They will face similar challenges, having to

make do with different resources and tools
make substitutions for unavailable materials
make do without when substitutions won't do
respect alien, mindless dangers of the frontier
express one's artistic creativity in new ways
accept fewer change of scenery options
raise children where they have never been raised before, without access to all the variety of Old Earth they will surely learn too mush about.
develop new sports for new gravity levels

• They must be made of the same "right stuff"

resourceful,s, ingenuous, creative, adaptable
willing to make sacrifices
willing to try new ways to do old things
accepting the frontier as "home" soul-deep

Yes there are differences between the Moon and Mars, differences that do matter. Some equipment and systems will be unique and special to one frontier or the other. But that should not keep us from working to identify and maximize

equipment and systems that can be standardized, at least in part, for use in both locations, saving finite money and funds for other vital expenditures.

Robert Zubrin's view that equipment sent to the Moon that is analogous to what will be needed on Mars, should be designed to work on Mars from the start, has considerable merit. Such a constraint would work to guarantee that we do indeed continue on to Mars, something vital to the long range viability of Lunar Settlement. This suggestion may be received grudgingly

by many Moon-enthusiasts, but we all need to take the long view.

The Moon Society sees the Mars Society not as a rival, but as a logical partner working to realize this vision.

If some things get tested on the Moon first, that initial delay will greatly speed-up the pace at which the Martian Frontier successfully develops over the long run. But we have to work at it, to guarantee that both frontiers open and develop apace.

Patience? Not exactly. Aggressively industrious patience, yes! Impatience gets quicker results, to be sure, but far more often than not, those results are flawed and soon lead to failure.

So let us both, the Moon Society and the Mars Society, work together, cooperating and collaborating, helping each other achieve a shared,brighter, open-ended future. Yes, the Moon Society is focused on the opening of the Lunar Frontier. But Mars loom large in our Field of View. It is in this spirit, and with this hope, that the Moon Society cosponsored Mars Convention 2004 and will hopefully continue to cosponsor these events.

This vision is just the beginning. In time humanity will call all the Solar System home, and have begun to reach for the Stars! A pdf file version of this brochure can be found at:
www.moonsociety.org/spreadtheword/pdf/mars.pdf

OTHER Relevant Moon Society Publications: see http://www.moonsociety.org/mars/
Collected Mars-related articles from the first 20 years of Moon Miners' Manifesto

http://www.moonsociety.org/publications/mmm_themes/mmmc_Mars1.pdf - 56 pages
http://www.moonsociety.org/publications/mmm_themes/mmmc_Mars2.pdf - 68 pages

Moon Society - Mars Society: Collaboration & Joint Project Areas

By Peter Kokh

FUTURE ROBOTIC PROBES

Push development of instruments to map near subsurface voids (lavatubes). Such instruments can be test flown in Earth orbit where ground truth is in hand to calibrate the readings. We suspect these in shield volcanoes (Olympus Mons, and the three Tharsis Ridge volcanoes, Arsia, Pavonis, and Ascraeus) on Mars, and in lava sheet flows (maria) on both worlds.

- A **radar "flashbulb" impactor** with two parts which would "telescope" on impact, creating a signal illuminating subsurface voids within 8 kilometers, the signal to be received by an orbiter overhead.
- The Moon Society is proposing to run a **"Lavatube Track"** at the National Space Society's **2013 International Space Development Conference** in San Diego, California to be held the last weekend of May. We hope to secure co-sponsorship of this track by the Mars Society
- Joint **publication of a volume of papers on the exploration and use of lavatubes.**
- **If the extended GRAIL mission detects voids below the Moon's surface, fly a similar 2-probe low altitude survey over Mars**
- **At promising skylight sites** on both worlds, **fly a "lavatube skylight explorer" type mission** http://www.moonsociety.org/competitions/engineering/

FUTURE LONG DURATION CREW TRIPS/STAYS TO/ON MOON AND MARS

Simulations of "Fractional" Gravity at Mars (3/8 normal) and Moon (1/6) normal levels

- We know from experience on MIR and on the international Space Station that astronauts returning from 6 months, even a year or more, in zero (micro) gravity experience considerable physical and physiological impairment and weakness and that it takes them some time to return to near-normal. This affects muscle tone, physiological processes, even vision.
- Some have jumped to the conclusion that humans require full Earth-normal gravity for long term or permanent relocation. A human Mars round trip would last 2 or more years. This is an illogical leap. No one has experienced "fractional gravity" - e.g. on the Moon - for more than a week.
- A minimal rotating facility at the International Space Station could determine if astronauts should be provided Mars-level gravity on the 6-9 month trip to Mars, so that when they arrive, they are not too weak to set up their base or to explore. If they stay on the planet a year or more, and then have a 9 month trip back to Earth, we need them to return healthy
- Similarly, we need to determine if humans can stay on the Moon for long periods (even indefinitely) without serious physiological consequences.
- NASA has no plans to experiment along these line: nor does any other space agency.
- For a human Mars Expedition, providing artificial gravity could totally alter spaceship design

OTHER TECHNOLOGY DEVELOPMENT PROJECTS

Technologies to "mine" Mars' Atmosphere for more vital materials than just Methane. Can we land equipment that will produce a stockpile of propane, polyethylene, and other useful compounds?

Development of "3D Printing Technologies that can use Mars dust and/or Moon dust instead of special plastic powders so that small unforeseen items can be manufactured on Moon or Mars when needed. The more substances we can "mine from the Mars atmosphere" (see pre-landing project # just above) the more potential feedstocks we will have for 3D printing.

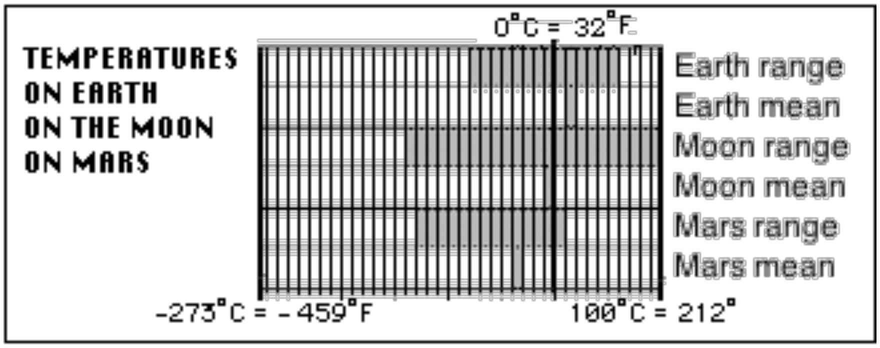
Development of Compact Pocket Hospitals for unforeseen medical emergencies

Development of Biospheric Technologies that more completely recycle waste air and water in a trouble-free way. The priority should be given to "modular biospheric systems"- for example systems for each habitat or activity module with a toilet so that as the physical modular complex grows, the modular biosphere systems will grow apace. Living wall systems are also suitable for this approach.

Development of Robonaut/Avatar robotic technologies so that remotely guided non-human crews that do not need life-support can set up outposts and have everything in running order before humans arrive

 # Development of compact "suit-locks" to replace air-wasting "air-locks." NASA has been working on this 2-decades old concept for one of its recent pressurized rover units. Not only does such a technology conserve air, it greatly lessons the tracking inside the habitat of troublesome moondust and/or marsdust.

A UNITED PUBLIC POSTURE - Instead of "Moon First" or "Mars First" postures, both Societies should embrace **the "Triway" approach** [see above] prioritizing development of technologies needed for all human space destinations. **PK**



PK

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Monitor AsianScientist Magazine Daily for up to the minute space reports by Srinivas Laxman
http://www.asianscientist.com/

The Quest for Lunar-Deficient Elements (LDEs): A Task for Future Lunan Engineers and Scientists

By Dave Dietzler, Moon Society St. Louis

Editor's Foreword

Many people interested in further exploration of the Moon, manned or unmanned, but exploration only, are interested in scientific information only. But there can be no argument that far more science can and will be done if there are permanent human outposts on the Moon, and the more such outposts in more locations, the better. But the cost of a multitude of outposts can be brought down drastically if we first learn how to use local lunar materials ("In situ" or "on location" "resource utilization") out of which to build expansion modules and furnishings.

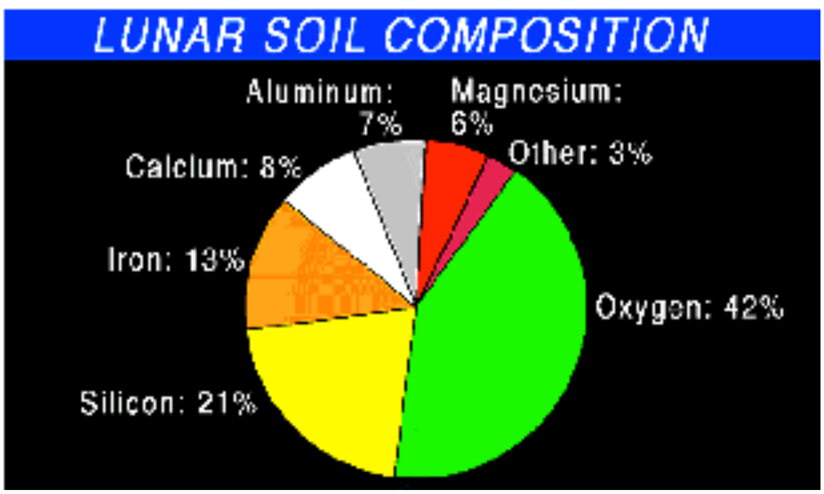
That, of course, then lays the grounds for industrial settlements with permanent populations, which in turn will yield even more scientific information. In that light, those who want scientific information only, "shoot themselves in the foot" so to speak.

This article looks at the possibilities starting with the essentials: what elements will we have to work with, and in what abundance or scarcity.

Available Lunar Elements

The Moon has an abundance of O2, Si, Fe, Ca, Al, Mg and Ti. It has minor amounts of Mn (0.174%), Cr (0.264%), Na (0.290%), K (0.113%), P (0.066%) and S (0.125%) based on average maria samples. Potassium and phosphorus are more abundant in KREEP with K2O at 0.2 - 2% and P2O5 at 0.3 - 2%. There are only traces of important metals like copper (14.4 ppm), zinc (23.4 ppm), zirconium (311 ppm), and vandadium (114 ppm). Halogens like chlorine (25.6 ppm) and fluorine (174 ppm) that could be used for some major element extraction processes like the electrolytic production of aluminum are also rare

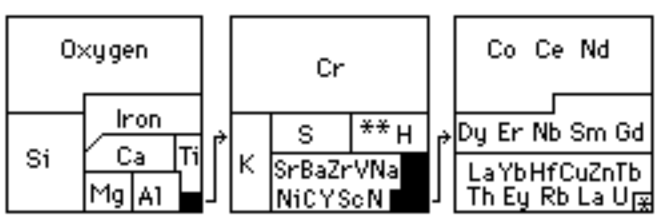
The Moon: "Pie in the Sky! But, oh, what a great recipe!



Courtesy Space Studies Institute: http://ssi.org/assets/images/slide06.jpg

The Moon has in abundance, all the elements that we need for basic building and manufacturing materials: concrete, ceramics, glass, fiberglass, glass-glass composites, and the four "engineering metals" - iron, aluminum, magnesium, and titanium.

What else?



3-panel chart by Peter Kokh

It's "easier" to extract elements that are in higher concentrations. With luck, it might be possible to concentrate trace elements and make their extraction more plausible. In the process of extracting major elements we might concentrate minor and trace elements in the "slag" and this "slag" would then be an enriched source of LDEs (Lunar Deficient Elements).

There are also traces of hydrogen, helium, carbon and nitrogen in the regolith. Strangely enough we seem to have more hopes for extracting those solar wind implanted gases than many of the other rare elements listed above because getting them is only a matter of using robot miners to shovel through massive amounts of regolith and roast out the solar wind implanted volatiles. Carbon is a solid with a very high sublimation point but it reacts with other elements during the roast and comes off as CO, CO_2 and CH_4. The machines to mine the solar wind implanted volatiles will be rather complex and command my respect, but the basic concept is simple. The polar ices might also yield a bounty of light elements.

Uses for Less Abundant Elements

The best alloys of aluminum use copper and the best alloys of magnesium use zinc. Zirconium can be used to make high temperature alumina crucibles for smelters and molds for vacuum casting titanium. Vanadium along with aluminum is used for the workhorse titanium alloy Ti-6-4. Chlorine and fluorine are needed for electrolytic aluminum extraction processes and chlorine is needed to make electrolyte for FFC cells to extract titanium and other metals. Sodium is a plant growth stimulant and also the main ingredient in lye, NaOH. Potassium and phosphorus are necessary plant nutrients and so is nitrogen. Sulfur is needed for sulfuric acid.

Simple roasting of regolith at 900-1200 C. will boil out about 30% of the Na and K and about 90% of the sulfur. I suspect that these elements will boil out of the melt as impurities in oxygen during magma electrolysis too if this finds any use on the Moon.

Nickel once seemed like a demon, but most of the nickel is present in meteoric iron particles that can be extracted by magnetic processes by robots that sift thru large areas of regolith. This nickel which composes 5 to 10% of the meteoric iron can be separated with CO gas--the Mond process. It might also be possible to use pyrolitic and electromagnetic methods to separate the nickel. Nickel can be used as a catalyst for shifting CO and H_2 to methane and it can also be used to make carbonless maraging steel. Nickel doesn't seem to be a problem, although the nitty-gritty details of designing and building the equipment for processing it out will keep future Lunan engineers and scientists busy enough!!

Lunan Engineering without LDEs

In the absence of so many technical elements on the Moon we have suggested using "second best" alloys like aluminum with a little magnesium and magnesium with a little aluminum and just designing machines with thicker, heavier parts to get the strength required. In the low gravity of the Moon a heavier machine might not be such a problem. Alloys are used not just to make stronger metals but also to save money. If a little copper can make aluminum so strong that we don't need as much of it for a part we can save money. On the Moon, however, that copper might be so expensive that it is cheaper to use two or three times as much aluminum for a part!!

Another reason we use alloys is to make aircraft light enough to fly. We won't be building airplanes on the Moon but someday we will want to build spacecraft and this will demand lightweight materials. Once again, the gravity of the Moon is so low that heavier spacecraft and low performance fuels just might work for sub-orbital rockets at least. Also, lower gravity means that we don't need as much structural strength for many things like supports for solar furnace reflectors and crucibles. We might just use plain iron for things like that. Since there are no high winds on the Moon and earthquakes are infrequent and of low intensity, lunar structures can be built with less robustness than their terrestrial counterparts and pure iron, aluminum, magnesium and ceramic materials can be applied in ways that would make a Terran engineer struggling in the deep gravity well of Earth shudder!!

Imports

Still, we search for ways to obtain LDEs (Lunar Deficient Elements). If we can't get them from the Moon we must import them. Since chlorine and fluorine might have major industrial uses on the Moon we would import metals in salt form like copper chloride, zinc chloride, etc. These could be electrolyzed to free up the halogens and get the pure metals. This means we can ship up halogens in plastic bags full of salts instead of heavy tanks full of supercold liquid Cl and/or F.

Impacts?

When we believed that the copper, nickel and other metals at Sudbury, Canada, came from a giant meteor impact, we hoped to find a similar impact on the Moon, but this came to nought when it was concluded that the metals there had upwelled from the Earth's mantle, after the impact had cracked the crust below. The possibility of a low velocity grazing meteor impact on the Moon and a subsequent deposit of iron, nickel, PGMs and other metals still exists. This would be an act of Divine Providence and although searching for such an anomaly with orbiting spacecraft is probably worthwhile I wouldn't bet much money on it.

Volcanic Glass?

There might still be enrichments of "strategic" metals on the Moon. From From: "Lunar Pyroclastic Deposits and the Origin of the Moon" by Harrison H. Schmitt at < http://www.lpi.usra.edu/decadal/leag/DecadalOrigin.pdf > we read:

"Volatiles associated with coatings on beads of both orange and green glasses are enriched over associated basalts by factors greater than 100 in Cl, F, Br, Zn, Ge, Cd, Tl, and Ag and by factors greater than 10 in Pb, Ga, Sb, Bi, In, Au, Ni, Se, Te, and Cu (Wasson et al 1976; Krähenbühl 1980; Meyer 1989)."

Certainly, 100X enrichments in chlorine, fluorine and zinc and 10X enrichments in copper just might make those pyroclastic glasses worth mining. How to extract the metals and halogens? Perhaps simple roasting in the vacuum will work. It would seem that chlorine and fluorine should boil out if enough heat is applied, but then again they might be so tightly bound chemically with other elements that this doesn't happen. It should be possible to mine up large tonnages of pyroclastic glass on or just below the lunar surface. The presence of rare elements entices me. What if we dug into the volcanic dyke of a low volcanic dome or vent where glass beads were spewed out and hacked or blasted into it? Would we find enrichments of rare elements with industrial uses on the Moon?

"Amalgamation?"

The thought crossed my mind once that molten sodium, potassium, phosphorus or sulfur might dissolve up rare elements. My reasoning was that these elements can be obtained by roasting regolith and that they have low melting points, so it wouldn't take a lot of energy to make liquids of them. Water won't dissolve the oxides and silicates in regolith but molten Na, K, P and S might react with and dissolve things in unpredictable ways. Mercury amalgams are used to extract gold from ores. What if "amalgams" or alloys of Na, K, P, S and some of the elements we are interested in like zinc and copper form? Or zirconium and vanadium?

After some searching i found this: < http://home.us.archive.org/stream/nasa_techdoc_19830003839/19830003839_djvu.txt >

Back in 1980, Dr. David Criswell and several other authors proposed something to that effect. They said," Immiscible fluids (iron, silicon, sulfides, etc.) can be circulated through magmas to take out over 30 minor elements. Some of these schemes would mimic the natural processes which were presumed to have operated on the moon to produce observed separations of trace and minor elements in lunar basalts." This quote comes from page 12 of chapter 1 and there is more detail in chapter 3 where they discuss mixing molten regolith with molten iron, silicon, sulfur or phosphorus. As the magma is cooled and partially solidified some elements remain in the melt and are concentrated. I leave it up to chemical engineers, metallurgists and geologists to pursue this further. If these processes were applied to lunar volcanic glass beads we have to wonder if an even greater bounty would result.

Liquid Iron and/or Silicon?

Ferrosilicon can be obtained by magma electrolysis. It might also be possible to get iron and silicon separately by serial magma electrolysis. More research is called for. We have to wonder what other elements would dissolve into the iron and silicon? Would this concentrate them and make them easier to extract? Silicon can be zone refined and this would be facilitated by low lunar gravity and free vacuum. Other elements extracted during electrolysis would be concentrated in the ends of silicon rods after zone refining. These might then be extracted by acid leaching and other methods. Iron could be melted with a flux of calcium aluminate obtained by roasting anorthite at 2000 C. to absorb and concentrate impurities consisting of desired elements. Then we'd have to find ways to extract those elements from the slag. Whether all this would be worthwhile compared to the cost of imports i know not, but when imports cost thousands of dollars per pound any way to get elements on the Moon from the Moon is worth studying.

We can pre-condition or beneficiate regolith magnetically to get the meteoric iron fines and electrostatically to remove ilmenite and separate other minerals. Once the free iron and ilmenite was safely separated we could use more powerful magnetic separations to remove all iron bearing minerals and this would result in a mix with higher concentrations of minor and trace elements by a small fraction. We could do more.

Acid Leaching etc.

It should be possible to make sulfuric acid on the Moon from lunar sulfur, oxygen, hydrogen and catalysts. If we leach regolith that has been purified by magnetically extracting iron bearing minerals including chromite and ilmenite and roast out most of the sulfur, sodium and potassium we will get a solution of aluminum and magnesium sulfates mostly. The insoluble silica and barely soluble $CaSO_4$ won't go thru the filter. The sulfates could be roasted to oxides and processed further. It might be possible to separate the sulfates or oxides electrostatically to concentrate minor and trace elements. Perhaps during the boiling down of the sulfate solution the major salts will precipitate out and leave the trace sulfate salts in a concentrated solution.

Halogenation and Volatilization?

What would happen if we treated the oxides from with chlorine or fluorine? Would it be possible to boil off some chlorides or fluorides? At atmospheric pressure, uranium hexafluoride sublimes at 56.5 C. That's not even as hot as boiling water. What other substances could be roasted out? There has been some work done on reprocessing nuclear fuel by volatilizing chlorides. See: http://en.wikipedia.org/wiki/User:JWB/Chloride_volatility

Miscellaneous Ideas

If we dissolved these sulfate or chloride salts in water could we use plastic filters like the ones used experimentally to extract uranium from sea water to remove minor and trace elements? Zeolites can be made by steaming lunar regolith and there has been some discussion of agriculture in zeolites. Zeolites can also function as molecular sieves that allow some ions through their micropores but not others. Could we make zeolites on the Moon, pack them in columns made of basalt or glass, and filter out some of the rare elements in aqueous salt solutions?

Summary

We will have to process megatons of regolith or pyroclastic glass to get useful amounts of trace elements be it done by vacuum roasting, electrostatic separation, mixing with molten metals, acid leaching and/or ion exchange. The cost of doing this might not be justified when compared to the cost of imports, especially if those imports are coming from settlements on Mars. Eventually we must "cut the cord" with Earth out of the assumption that imports from Earth will always be expensive.

Author's Note: I am not an expert. I am merely a speculator. I write this with the hope that others will pursue the path to knowledge in greater detail and even earn themselves some advanced degrees and patents. - **Dave Dietzler**

Lunar Materials for Solar Power Satellites

By Dave Dietzler, Moon Society St. Louis

A Rough Assessment

In 2050 the global demand for energy is projected to be about 60TW at present rates of growth. Since that is power mostly from combustion two thirds becomes waste heat. If everything goes electrical including transportation, heating, industry, etc. we will need about 20TWe since electric motors and heaters are so efficient. We would need 1000 powersats rated at 20GWe each to supply this demand. In truth there will still be the use of combustion and energy demands will probably increase beyond 2050. Airplanes, locomotives and ships will still probably use hydrocarbon fuels and their CO_2 emissions will not induce significant global warming, especially if vast areas of desert have been irrigated. Population growth might stabilize before or after 2050. There's no way to tell. Even if population growth stabilizes at 9 to 12 billion people in 2050 the demand for energy due to rising living standards might increase. So even 1000 powersats could not fulfill all energy demands and we would still see some fossil fuel burning, fission, and lots of wind, wave, tide, hydro, biofuel, ground based solar....unless thermonuclear fusion becomes the number one power source of the future.

If we are to build 1000 powersats from 2050 to 2100 then we better start soon. We now have 38 years to land a base on the Moon, do the research and proving at an International Lunar Research Park, mine the Moon, start materials production, expand the base(s), build mag-lev mass launchers and space cargo tugs, build the powersat construction space stations and start building the powersats. If we are to build 1000 powersats at 50,000 to 100,000 tons each then we need 50 million to 100 million tons of metal mostly Al and Mg and since these two combined amass about 10% of the regolith we need to mine 500 million to one billion tons of regolith or 10 million to 20 million tons a year and process out one to two million tons of Al and Mg a year and launch it into space.

This is an enormous challenge. Beyond early research outposts that we might see in the next decade we must land thousands of tons of cargo, sometimes called the industrial "seed," just to get started bootstrapping up industrial settlements on the scale needed to do the job. We can dispense with visions of large orbital space colonies and predict the use of teleoperated robots to do most of the work. Powersats will probably not be composed of giant fields of silicon but rather giant lightweight reflectors that concentrate solar energy on high efficiency gallium based solar panels rocketed up from Earth. Transmitting dishes will be built of lunar materials and microwave generators will be built of a combination of lunar and terrestrial materials.

Requirements for the Ideal Process

One of the challenges we face is the extraction of metals from lunar regolith on a vast scale. The ideal process for extracting metals and oxygen from lunar regolith would use no chemical reagents from Earth—only chemical reagents available on the Moon. That would limit us to hydrogen, water, sulfur, sulfuric acid and possibly sodium, potassium and phosphorus. Specific substances might dissolve easily in molten Na and/or K or sulfur thereby making extractions possible but no research has been done into this that I am aware of. Sodium and potassium can be reacted with water to form caustic hydroxides. Carbon and nitrogen are very rare but some carbon could be used if it is recycled by shifting CO and CO2 generated during smelting to CH4 and thermolyzing that at 900 C. at least. The ideal process would not rely on equipment made of exotic materials not available on the Moon like Teflon, copper, stainless steel, platinum, thoria and other ceramics like hafnium oxide. It would rely heavily on lunar sourced materials like basalt, glass, cement and meteoric iron-nickel. The equipment would be simple, robust and "Moon makeable" from raw and extracted materials. The ideal process would rely on solar energy as much as is possible and electricity rather than chemical processing. It is highly doubtful that we will ever have a process for refining regolith that does not rely in part on imports from Earth. The key to success will be maximizing the use of lunar sourced materials.

Silicon and Solar Panels

Dr. Peter Schubert has proposed a patented system amassing about 6 metric tons that can produce 64 tons of doped silicon, along with aluminum and glass, enough to make 15.9MWe worth of thin film solar panels every year with solar illumination 70% of the time as at a polar location[1]. The system does not require any chemical reagents from Earth but it is made of exotic materials not available on the Moon so we cannot replicate the entire system on the Moon, but only part of it. If we launched 50 of these Lunar Dust Roasters-All Isotope Separators and Solar Panel Factories to the Moon, or 300 tons of them as part of the several thousand ton industrial seed then we could produce almost 800 MWe worth of solar panels a year and build up to 8GWe worth of power in ten years. We would produce about 3200 tons of silicon a year. This is a far cry from the one to two million tons of aluminum every year we'd need to produce for a massive powersat building program, so we will need to build large aluminum smelters on the Moon. Since lunar aluminum production might require 20MWh per ton we could produce 1.75 million tons of aluminum every year with 8GWe of power available 50% of the time.

Iron and Steel

One of the most accessible lunar resources is meteoric iron-nickel fines found in the regolith all over the Moon at a concentration of about 0.5% These could be harvested by robot rovers that use low intensity magnetic separators. From a square kilometer mined to a depth of one meter 10,000 tons of iron-nickel could be obtained. Some of this could be used for low stress parts like indoor fittings and some could be converted to steel simply by packing iron rods or bars in carbon powder and bringing them to red heat and holding them there for several days while the carbon dissolves into the iron. Furnaces could be made on the Moon from basalt or ceramic bricks. Carbon could come from polar ice mining or from volatiles mining. Most steel contains 0.15% to 1% carbon though it can contain up to 2% carbon. Cast iron contains about 3.5% carbon. Since steel contains only a small amount of carbon a large amount of steel can be produced with a small amount of carbon. Carbonless maraging steel can be made from iron containing 20% to 25% nickel with small amounts of aluminum, titanium and cobalt. It seems that several thousand tons of steel to build regolith mining machines on the Moon is a reasonable goal. The Moon could yield enough carbon to produce steel in the quantities necessary without endangering the carbon budget for biospheres since several thousand tons of mining machines should be able to move millions of tons of regolith every year. The presence of nickel and a trace of cobalt in the meteoric fines will make the steel tougher and no oxygen that could degrade the lunar vacuum will be released by tapping this resource.

Materials from Heat

Solar wind implanted hydrogen, carbon, nitrogen, helium and small amounts of other noble gases can be obtained by mining and roasting millions of tons of regolith. Sodium, potassium and sulfur can be boiled out of regolith at 900 to 1200 C. About 90% of the sulfur will boil out and about 30% of the K and Na. [2] Cast and sintered basalt products can be made by heating mare regolith. Cast basalt resists 96% sulfuric acid solutions and 30% caustic solutions and has high chloride resistance. Highland regolith can be heated to form glass and there is also native glass in the regolith that could be extracted electrostatically. [3] Cement can be made by heating highland regolith over 1500+ C. to drive off silica and MgO to enrich the lime and alumina content. Concrete could be a major construction material on the Moon. Concrete lunar habitat has been designed [4].

Heat can be supplied by solar furnaces. Solar furnaces have the advantage that no complex electrical equipment is needed but aiming reflectors is necessary and window fouling is an issue. Solar furnaces that can reach 1500 to 2000 C. necessary to make cement would be imported at first and later aluminized Mylar dishes would be replaced with sheet aluminum or magnesium dishes. Crucibles could be made of alumina lined iron supported by concrete or basalt blocks after materials production on the Moon has progressed far enough. Alumina can be ground fine, mixed with NaOH and cast in a plaster mold to make crucibles. See ref. 6. Interlocking alumina bricks could also be cast, assembled and welded together with electron beams to make large crucibles. Some imported zirconia would make the alumina ceramic more resistant to heat and cracking.

Magma Electrolysis

This process is very simple in principle and it might be possible to build magma electrolysis cells from basalt bricks, regolith for insulation and a pure silica or alumina cell lining. Rather than use platinum electrodes ceramic electrodes that become conductive at high temperatures might be used. These ceramics are composed of elements available on the Moon. They have high enough melting points to endure the 1400-1600 C. temperatures of molten magma but they must be tested for high temperature electrical conductivity and resistance to dissolution in the melt.

Oxides) Al2NiO4 2200 K, Cr2MgO4 2200 K, Al2O3 2300 K, NiAl2O4 2350 K, Ca3TiO5 2350 K, MgAl2O4 2350 K, CaCr2O4 2400 K, Cr2O3 2500 K, CaO 2800 K, MgO 3100 K

See: http://www.moonminer.org/9701.html and http://www.moonminer.org/10201.html

Of course, it will require the capacity to extract these elements from lunar regolith to make these ceramics. Also, the electrodes and regolith would have to be preheated with iron aluminide heating elements perhaps so that the ceramics become conductive.

Magma electrolysis will produce oxygen, ferrosilicon and slag. It might be possible to use serial electrolysis to obtain iron and silicon separately. If not, then ferrosilicon could be sprayed thru a nozzle while still molten to form a spray of particles that cool by radiation in the vacuum. How to separate the iron and silicon? High silicon alloy iron resists H2SO4 so I seriously doubt that acid leaching could get the iron. Iron is attacked by acids but not by bases. If we leached the ferrosilicon in a solution of hot concentrated NaOH we could produce large quantities of sodium silicate, but this seems like a lot to do just for iron and sodium silicate! **Perhaps the best thing to do with powdered FeSi would be to use it for a low performance rocket fuel.** It can also be used to reduce magnesia to obtain magnesium metal.

Acid Leaching and Aluminum

Sulfuric acid can be made from lunar water, sulfur and oxygen. Vanadium pentoxide is usually used as a catalyst but lunar available SiO2*Al2O3 and Fe2O3 can also be used [5]. Iron containing about 14% silicon can be produced on the Moon to make acid leaching vats and associated plumbing. Iron-silicon alloy is not very weldable so parts made from it would have to be sand cast in pressurized lunar foundries. Cast basalt also resists attack by sulfuric acid and might be used for H2SO4 handling devices.

During magma electrolysis Na,K and P would be deoxidized and might boil out of the melt with the oxygen. These could be filtered and condensed out. They would oxidize and form sodium and potassium oxides and phosphate. Sulfur would boil out and form SO2 and perhaps H2S.

The slag from magma electrolysis will contain oxides, spinel and silicates (since not all silicon is deoxidized) of calcium, magnesium, aluminum and titanium. If we pretreat the regolith by electrostatic separation we could remove ilmenite and process it separately to get titanium dioxide ceramic material and titanium metal.

The slag from magma electrolysis would then consist mostly of Ca, Mg, Al compounds, mostly oxides, spinel and silicates. It could be ground to a powder and then be leached in hot sulfuric acid to extract Mg and Al sulfates. Since silicon does not react with H_2SO_4 and $CaSO_4$ is barely soluble in water the SiO_2 and $CaSO_4$ would be filtered out. These could have other uses. Silicon dioxide is the basic stuff of glass and calcium sulfate is plaster; it's also a cement ingredient used to retard setting time.

Magnesium and aluminum sulfates could be calcined at about 1100 C to drive off sulfur oxides and oxides of Mg and Al will remain. Alumina will be useful as a ceramic for making crucibles and furnaces and large scale mining and refining will demand large qtys. of this material. Since MgO sublimates in the vacuum at about 1900 K perhaps these could be separated by roasting in a solar furnace [6]. Electrostatic separation is also possible and would use less energy. It should be possible to mix MgO with ferrosilicon and CaO obtained by calcining $CaSO_4$ and apply heat under vacuum to reduce the Mg which will boil off and be condensed. It might be possible to mix the Al_2O_3 with SiO_2 and use solar carbothermal reduction to obtain an Al-Si alloy that can be further purified by cooling the molten mixture to below 1000 C. to condense out the silicon then the aluminum could be further purified by zone refining [7]. All carbon would be recycled. Since leakage is inevitable and expansion is desired, more carbon could come from mining enormous quantities of regolith for solar wind implanted volatiles and polar ices.

See: **http://www.moonminer.org/8301.html**

If solar carbothermal reduction of alumina proves to be impractical then we will have to import chlorine in salt form and carbon electrodes made of graphite bonded with pitch. Alumina would be carbochlorinated and the $AlCl_3$ electrolyzed in a flux of LiCl and NaCl and the chlorine and carbon recycled. The electrodes would last for years unlike electrodes in cryolite [8]. Thus, aluminum could also be a costly commodity on the Moon due to the cost of imports for its production. Equipment for handling chlorine might be made of titanium since this metal has excellent chloride corrosion resistance. Cast basalt also has excellent chloride resistance. Aluminum can also be zone refined to a high degree of purity. Zone refining of Al and Si might concentrate trace elements and make their extraction more feasible.

It might also be possible to place purified anorthite in FFC cells to obtain silicon, aluminum and calcium[9]. Another possibility is the high temperature roasting of purified anorthite at up to 2000 C. in solar or electric furnaces to get calcium aluminate, $CaAlO_4$, and deoxidize that in FFC cells to get calcium and aluminum[10]. Inert electrodes made of tin oxide and chlorine in salt form to get $CaCl_2$ electrolyte for FFC cells would be upported from Earth. The cells could be made of alumina blocks.

Some will argue that magma electrolysis requires very high temperatures and produces little of value besides oxygen. I feel that FeSi will be of value for large scale magnesium production and we can also use it to make sodium silicate and rocket fuel to spare hydrogen supplies. The slag could be used for concrete aggregate but I feel that it would make a good feedstock for aluminum and magnesium production via acid leaching. Some will argue that acid leaching requires water and that this is like extracting metals with liquid gold. What if there is a leak? That would be catastrophic. There are other waterless processes but these rely on imported hydroflouric acid, fluorine, lithium flouride, chloride salts and exotic materials like tin oxide. Given the cost of imports it looks like we are using elements as valuable as gold to extract elements that we'd otherwise have to pay a price equal to their weight in gold for to import! Better to pay for some imports and recycle them rigorously! It might also be argued that solar carbothermal production of aluminum requires carbon recycling so where's the benefit compared to importing some cryolite and recycling the carbon electrodes as they burn up? My thought is that it will be “easier” to recycle carbon powder from CO than it will be to make pitch and mix it with carbon powder and bake new electrodes. Alumina can also be reduced with CH_4 at lower temperatures than with plain carbon and the resultant hydrogen and carbon monoxide could be shifted back to methane without thermolyzing it to carbon, a very energy intensive process. See: http://opensourceecology.org/wiki/Metal_Refining?title=Metal_Refining

Some final objections might be made regarding the use of alumina for furnace crucibles. Alumina is useful up to 1600 C. and melts at 2000 C. How would we reach temperatures of 2000 C. ? We must consider some kind of cooling system for the crucibles that uses SO_2 perhaps for coolant and large space radiators. Another possibility is the use of oversized crucibles in which the ceramic crucible is insulated from the melt pool by unheated material. This would require ladling out the heated material. While we couldn't get the whole crucible so hot that it fills with molten material we could let the stuff in the melt pool cool down and solidify then use a robot to remove it. Wouldn't hot methane reduce an alumina crucible? Perhaps we could line it with titania. Mine is not the last word when it comes to lunar materials processing. Far from it.

Chemistry is not the supreme challenge. Building an aluminum industry on the Moon that rivals the aluminum industry of the USA, which produced about 1.78 million metric tons of this metal in 2010 is! This would mean the construction of numerous mining and industrial settlements on the Moon along with power infrastructure. It appears we can make the solar panels and it would be wise to construct a circum-lunar power grid for constant power rather than shutting down production at night. Years, even decades, of bootstrapping would be required before the first powersats could even be built. Enormous electrolysis cells and acid leaching vats, giant solar furnaces and more would be needed. Dozens of aluminum refineries where hundreds of thousands of tons of metal were produced every year at each of them would have to be built. Some magnesium and silicon would also be produced in mass quantities to alloy the aluminum. The magnitude of the job is so great that many will dismiss it outright. Even if we could surmount the architectural and engineering challenges, where would the money come from? I can only guess that an international government-private business partnership would have to be formed. Certainly, the price of space launches would have to come down lower than that offered by SpaceX even. Big government-big business partnerships built the railroads and the interstate highway system.

Asteroids?

Perhaps the Moon is not the best source of materials for building powersats. Asteroids could supply iron-nickel and carbon for steel. Given the limited resources of the Moon, only low strength alloys of aluminum and magnesium are possible. Steels with higher specific strength therefore lightweight powersats are possible. Rust and corrosion will not be a problem in the vacuum. Perhaps the Moon will serve as a springboard to near Earth objects including metallic asteroids, carbonaceous chondrite asteroids and old comets rich in organics. It might be best to devote lunar materials to the construction and fueling of large robotic asteroid mining ships that haul small asteroids or loads of materials back to high Earth orbit. Building such ships would not require nearly as much lunar materials production and industrial development and harnessing asteroids might be much more productive than launching megatons of metal from the surface of the Moon every year.

FOOTNOTES:

1) **Solar Panels from Lunar Regolith** Peter J. Schubert, Ph.D., P.E. Packer Engineering, Inc., Naperville, IL

2) http://www.nss.org/settlement/moon/library/1980-HandbookOfLunarMaterials.pdf pg. 115

3) http://www.highfrontier.org/Archive/Jt/Koelle%20PILOT%20PRODUCTION%20at%20the%20MOONBASE%202015.pdf pg. 12

4) **Cement and Concrete.** Gene Corley and Larry A. Haskin.|
http://www.nss.org/settlement/nasa/spaceresvol3/cemncon1.htm

5) http://en.wikisource.org/wiki/Advanced_Automation_for_Space_Missions/Appendix_5E section 5E.2 "Supporting Reagents"

6) http://en.wikisource.org/wiki/Advanced_Automation_for_Space_Missions/Appendix_5F section 5F.3 "Refractories"

7) Jean P. Murray, Engineering Division, Colorado School of Mines
Solar Production of Aluminum by Direct Reduction of Ore to AL-SI Alloy
http://www.kenes.com/Ises.Abstracts/Htm/0450.htm

8) http://settlement.arc.nasa.gov/spaceres/V-5.html Alcoa Electrolysis Process "**Extraction Processes for the Production of Aluminum, Titanium, Iron, Magnesium, and Oxygen for Nonterrestrial Sources**"
D. Bhogeswara Rao, U.V. Choundry, T.E. Erstfeld, R.J. Williams and Y.A. Yang

9) **The Electrochemical Production of Oxygen and Metal via the FFC-Cambridge Process.**
K. C. Tripuraneni Kilby1a, L. Centeno1, G. Doughty2, S. Mucklejohn2, and D. J. Fray1b
http://www.lpi.usra.edu/meetings/roundtable2006/pdf/tripuraneni.pdf

10) Rudolf Keller and David B. Stofesky of EMEC Consultants
"**Selective Evaporation of Lunar Oxide Components**" reported in **Space Manufacturing: 10 Pathways to the High Frontier**: Proceedings of the Twelfth SSI-Princeton Conference May 4-7, 1995; pg.

D. Dietzler

Space Resources, inc.:
A Game Changing "Disruptive" and Strategically-Focused Organization

By David Dunlop

Space Resources Inc. held a press conference in Seattle, April 24th, attended by many of its founders. Its ambitions are to bring utilization of space based resources into the global economy. Most of the discussion was focusing on the discovery, assay, and movement of potentially useful and valuable asteroids into cislunar space.

At first glance, this might be simply dismissed as grandiose and unrealistic but upon careful hearing it is clear that this challenging purpose has been the subject of a great deal of thought, research, and business development effort to date. The team that Space Resources has accomplished a lot individually and collectively. It is a talent pool with a formidable track record and future ambitions to match. The strategic vision expressed is in sharp contrast to the more diffuse activities of NASA and the other national space agencies in important ways:

It focuses on *what can be accomplished by small agile teams* rather than large bureaucracies. It was stated that the Space Resources team which has been working for a couple of years has only a couple dozen engineers at present and will remain at that level. It's strategy is to identify and use the most creative talent possible as opposed to supporting a "standing army" which consumes capital resources whether progress is made or not.

It uses **LEO as a relatively inexpensive test bed for technology development** for it's 100 series. It espouses a 'design a little build a little" philosophy which projects learning from mistakes and making evolutionary improvements with a test program approach similar to that used by the early Apollo program era in it Ranger and Surveyor. and lunar orbiter programs. It is expressly not afraid of taking risks and conversely expects to learn from failures associated with an aggressive test program.

It will *go beyond LEO using telescopes to discover a large fraction of Near Earth Asteroids and select the most likely targets for further exploration* for it's 200 series. By positioning telescopes in orbits on the opposite side of the Sun from Earth and a bit closer in it will be able to discover and explore a much larger fraction of the potential NEO asteroid population than can be done from the Earth. Perhaps 1% of this population is known at present and perhaps 70% can be identified from telescopes beyond LEO as proposed by Space Resources.

It will use *"swarms" of small relatively inexpensive spacecraft (at the single digit million cost level* to assay the potentially most economically valuable useful targets for it's 300 series. It will use "an assembly line" production philosophy to support a low cost paradigm of operations based on design commonalities and large production numbers in contrast to a "one off" space mission design philosophy. A "Swarm of perhaps as many as 10 to 12 small spacecraft will be targeted on "asteroids of interest" and that will also increase the potential for return of useful results as opposed to a lone spacecraft - a single point of failure for a mission. These spacecraft will be launched as secondary payloads on rockets with another primary mission. This philosophy expresses and embraces the new paradigm of small low cost Hitchhiker spacecraft that I wrote about in M3IQ 314.

Its Exploration and Assay program will reflect **potential market demand for raw materials on Earth and in cislunar space:** An important emphasis was placed on **water and the production of oxygen** as a product for both fuel and life support. **Metals** were another focus for discovery and utilization: Asteroids rich in nickel-**iron** are a target. Alumino-Silicate materials may also be plentiful. **Platinum group metals** (PGMs) were also discussed as a valuable industrial commodity. Another essential element is **silicon** for photovoltaic cells.

Perhaps what was only hinted at and left inexplicit in the Space Resources presentation was the relationship of their ambition to bring asteroidal resources to the demand for clean energy on Earth. *Large volumes of metal and propellant will be the essential commodities for the construction of large space solar power satellites.*

Also not mentioned in detail was the process of production for these finished material from the "raw" Asteroids. The movement of asteroids proximate to the Earth will take considerable periods of time. Deriving propellants from the asteroids to be moved both will enable movement closer to earth markets but also potentially beneficiate the remaining materials.

There is no production experience in space processing asteroidal materials so there is both much to be learned and demonstrated. The purpose of Space Resources to paraphrase Paul Spudis is: to learn to find and use essential off asteroidal materials in the further expansion of the Earth's economic system.

Demand for propellants is fundamental to all the other ambitions and plans for the economic development of cislunar space and that is why water ice is an appropriate first commodity in this model of development.

Its development program is open to additional partnerships and therefore global in scope. This is also acknowledgment that to fulfill this ambition significant additional investments will be needed. This program is closely tied to an educational strategy. The program will first influence by competing for the best engineering and design talent. \ Second, the science and applied science requirements for finding, characterizing asteroids of high potential value will engage the talents of many doing research at universities. A high tech high school is also part of the model that is being developed.

The market strategy of Planetary Resources is a long term proposition. The value of something is determined only by what someone will actually pay for it. The laws of supply and demand apply. As demand for metals and energy increases the competition for scarce and diminishing supplies will push the price point up. It is clear that the solar system contains vast amounts of materials potentially useful on Earth, but it is not clear when the price people are willing to pay for them will equal the cost and risk associated with processing materials and bringing them back to cislunar space where the markets exist. A high value asteroid might have it's material very gradually keeping up prices based on market scarcity. Alternatively its owners might flood the market and drop prices thereby eliminating high priced competition and establishing a monopoly on strategic materials in world markets. I have used the phrase “strategically disruptive” to describe the Planetary Resources for several reasons.

Rights of Discovery

First, it proposes creating a private program of discovery for a whole class of objects, NEO asteroids, and then “cherry picking” that tiny fraction that have maximum value. In a way this is reminiscent of the competition between Craig Ventor and the Federal and International Human Genome Project. The idea that the human genome could become the private property by right of discovery was the subject of an intense an continuing battle between “collective rights” to natural resources and the doctrine of private rights established by invention, discovery, and by reason of investments which brought the potential wealth to a point of market realization.

NASA's recent WISE mission was a mission of asteroid discovery directed toward the main belt and even toward the population of Jovian asteroids. This not so different in ambition as the ambition of Planetary Resources to more fully enumerate the NEO population and identify a variety of subclasses of high potential value. Does NASA and has NASA forgone an important responsibility and practical obligation to do the same thing. Can the same question be raised equally in relation to other national space agencies?

Rights of Assay and Economic Characterization and Demonstration

This second stage of assay and characterization and even demonstration of production processes is further preemptive of collective claims to these resources where in a practical sense a mining claim has been established.

The third step is the actual movement of the asteroid into cislunar space. Is any permit needed from any governmental authority? Is any regulation about the conditions and risk of such movement in place to address the potential that the movement of such objects could jeopardize the Earth?

Rights of Possession by movement

At first glance, it might seem a pretentious and premature ambition to think about discovering, assaying, and then moving asteroids to cislunar space but perhaps just the initial improbability is also a negotiating ploy. Most of the other space faring powers have signed on to a vision of lunar exploration and development beginning with programs of sending lunar landers in the next few years, then creating a robotic village to pioneer technology needed to utilize lunar resources and live and work on the lunar surface.

Rights of Preemption

The surface of the Moon is already in play on the use of potentially highly valuable real estate such are areas of extended illumination, polar areas with a less extreme temperature range, and areas where a significant amount of surface ice can be cost efficiently recovered from areas with a temperature below 106Kelvin. While no national claims of ownership are permitted in the basis Outer Space Treaty, the issues of utilization rights, shared access to limited or scarce and essential resources, rights of utilization by means of investment, are the degree to which exclusive use or even restricted use can be permitted are all issues begging for resolution. By turning toward asteroids when everyone else is focusing on the Moon, Planetary Resources may hope to establish a legal precedent for its activities and right of utilization and control of "assayed, characterized, and transport controlled" asteroids even as some parallel pragmatic agreements are being forged between competing national interests on the lunar surface.

Planetary Resources may be in a position of the Oklahoma “sooners,” trying to get a head start while everyone else seems distracted by the much closed and the potentially cheaper resources the Moon represents. Planetary Resources and its potential partners seem to want to “get there firstest with the mostest.” If the Moon is subject to plans to divvy up its scarce prime resources and prime locations among competing nations then bargains struck on that deal would likely roll over to claims on asteroids.

Rights by Fait Accompli and **Rights of control of market supply**

The obligation of an open sale as a means of satisfying the Outer Space Treaty?

It may well be that the rights of all mankind to these asteroid resources is in the last analysis an offering for sale to all by those who can find, assay, invest, move, and produce those resources. Will price be the only arbiter of such sales? Will essential resources priced out of reach of poor nations will claims of equal access remain? Will access to markets via tariff provide a means of moderating a winner take all market mechanism? (or) will claims of equal access remain**?**

D. Dunlop

Potential for Broader Use of Lidar Guidance Systems Designed for ISS

By Dave Dunlop

An article published in **Aviation Week** January 12, 2012 about NASA's Vision Navigation System (VNS) suggests broader applications of this lidar sensor system than just a docking mechanism originally designed for the Orion vehicle. (1) Howard Hu, manager of the Orion system performance at

Johnson Space Center is quoted as saying that the VNS "provides a 3D image of the target." "It's not like a picture, but it gives you a 3-D image, and it's fantastic in how it can replicate, because it gives you that surface differentiation." The lidar systems range for the ISS is impressive resolving features from as far as 5.7 km (3.5) to a close as 7 meter (35 ft.).

The systems is described as an advanced flash lidar that lit up the space station 30 times a second with bursts of laser light. Based on the differential strength of light reflections from various surfaces the systems algorithms can construct a 3-D images.

Hu is also quoted as saying, "We're looking at hazard avoidance for lunar landing." "If you want to avoid a particular bad spot as you get closer to the surface of the Moon, the lander can flash the lidar, and it gives you an image, and it can discern big boulders, big craters, things like that, and that allows you to steer yourself kind of like a target vehicle, to the surface and land safely." Lockheed Martin is testing this lidar system at it's Space Operations System against mock-ups of a planetary surface for use in a mission that could fly to an asteroid.

The article also indicates that this system will be flight tested before commercial crew vehicles begin flying to the ISS in 2017.

I think that there are other potential uses of this instrument:

(1) This might include the potential of hyper-spectral imaging with the spectrum of this lidar to characterize the composition of the materials illuminated by surface reflectance. This might have applications for example in the assay of asteroids or of planetary surfaces.

A If this lidar was used for surface navigation on a rover for example, it might also be assaying the terrain path of the rover.

B It's ability to images things at a distance might gives us an ability to assay a distant crater wall several miles away and hundreds of feet below the surface rim and therefore otherwise inaccessible.

C Similarly the central peaks of various craters might be studied remotely and their clues to subsurface composition revealed.

D Analysis in the interior of a lava tube could be done by imaging the entire interior surface including physically inaccessible walls and ceiling surfaces.

E If the VNS lidar could differentiate surfaces based on the level of ice content it might also assay areas of a permanently shadowed lunar polar crater from the sunlight rim of the crater where solar power can maintain the rover operations. The ability to map the ice abundances at a distance in these difficult cyro-environments will be important in planning further direct sampling activities.

F Early rovers will have limited on board power supplies and therefore operational limits in these ultra low temperature conditions. Laser power transmission potential to mining and sampling vehicles from sunlit crater rim locations may also be another related operational capability that can be mapped with the VNS system or something very similar.

Some of these suggested uses may be limited by the size and mass of the VNS system and it's own power requirements. Initial systems may require lander rover missions in the multi-hundred million mission cost range. The miniaturization potential of these systems will unlock a more cost effective survey capability using ultra low temperature and ultra-low power electronics. Scaling down the mass, volume, and power and cost requirements of these sensor platforms will really open the door to wide spread exploration of the Moon.

This is the as yet unrealized potential of the "LunarCube" paradigm suggested by Dr. Pamela Clark of NASA Goddard, Catholic University, and Flexure Engineering. This is an area where the NASA Office of Chief Technologist can make highly strategic investments that will advance commercial exploration and mission costs in the single or low double digit cost range.

Notes:

(1) http://www.aviationweek.com/Article.aspx?id=/article-xml/AW_01_09_2012_p44-409156.xml

The Strategic Competition for the Moon and the Role of Space Stations
Strategic Differences Between the US and Other Countries in Space Exploration

By Dave Dunlop

At the recent Global Space Exploration Conference in Washington in May the differences between the United States and other space faring nations which worked together to develop the Global Exploration Roadmap that was released in the Fall of 2011 was notable. (1) For other nations the collaborative development of a lunar exploration initiative is seen as the logical first priority in building an infrastructure which will then advance to the exploration of Mars. For the US the first priority is the development of equipment that will take a crew on a mission to a near Earth asteroid as a precursor to the longer term requirements of a Mars mission. The NASA plan is to build a large scale launcher larger than the Apollo era Saturn V by 2022 as well as a crew vehicle which has the capabilities of long duration flight beyond the LEO missions typically needed to access the International Space Station.

Criticism of NASA's Strategic Priorities Under the Obama Administration

(1) Critics of NASA's strategy believe that the high operational cost ($2 billion per flight) and long term of development of the Senate Launch System will doom this initiative to failure because of unsustainable economics and politics and result in another NASA unproductive development boondoggle.

(2) The recent success of Space-X and its Falcon 9 system also undercut the need for massive government investment in a long and expensive development of a heavy lift vehicle. The Falcon 9 Heavy is expected to debut in about only a year. Space X has also projected the development of a Falcon 9 Super Heavy.

(3) An additional criticism of the SLS launcher development is that a space architecture based on development of space refueling depots in LEO, and L1 or L2 would provide an infrastructure which would enable the suite of existing international launchers to undertake a variety of missions beyond LEO without a massive launcher and the associated investment and time delay. NASA is also investing in the development of cryogenic fuel storage and transfer technology as part of its current technology development budget. This innovation in transportation capabilities beyond LEO would permit a collaborative and redundant approach to both lunar surface access and exploration, a potential market for in situ lunar fuel production to fuel depots, and the advance of an infrastructure production capabilities well beyond the ISS including construction in GEO. NASA is clearly on the right track here with its orbital refueling technology development.

(4) The NASA developed Crew vehicle Orion which has long duration capabilities may also be an unneeded government investment. Private companies such as Bigelow or Excalibur Almaz may provide an alternative commercial capacity for long duration habitation facilities in LEO, Lagrange points, on the lunar surface, and further out in deep space.

(5) The rationale for a long duration mission to a Near Earth asteroid could just as well be applied to a long duration crew mission performed in cislunar space where the opportunities exist for crew rescue in case of equipment malfunction. A test of a long duration crew habitation vehicle that could also perform exploration duties on the lunar surface using crew telepresence would be a constructive program. This would make a crew working with lunar surface robotic equipment an early use of a crewed facility at L1 or L2 along with it fueling depot role. The potential for the loss of a crew in deep space for the purpose of visiting an asteroid seems to me to be both an unacceptable and unnecessary risk. This risk is specially inappropriate when companies such as Planetary Resources are promoting a low risk program of both discovering and assaying Near Earth Asteroids for their economic development potential with small low cost cube satellite scale robotic vehicles.

A more central criticism of NASA's current priority I have is that it is fundamental to a sustainable program of space development that the coalition of nations that has built the ISS remain a cooperative foundation for further development. The US would appear to be putting this political foundation and its own leadership of the enterprise in play by taking a divergent path than the one favored by its current partners and this at a time of shared economic vulnerability in the US, Europe, and Japan.

Chinese Strategic Independence

Further complicating this picture of international strategic differences is the strategic role of the Chinese. The Chinese although participating in some of the discussions involved in the Global Exploration Roadmap were not signatories. They however have indicated in their own strategic plan for space development that they also have a strategic commitment to lunar robotic exploration and a human return to the Moon. The Chinese also have started the development of their own space station initiative with a projected completion date of 2020. They have already started the courtship of other countries as participants in their new space station.

“Dueling” Space Stations

The ISS coalition succeeded in completing the ISS in August 2011 with the last flight of the Space Shuttle and its logistic support is now a matter of shared access by Russian Soyuz and Progress, European ATV, Japanese HTV, and the Space-X Falcon9-Dragon vehicles. The Antares-Cygnus vehicle is scheduled to test its capacity to deliver cargo later this year. There is a US commitment to the ISS which extends to 2020 and its international partners have made clear their commitment to maintain their components beyond 2020.

2020 is the same time that the Chinese project completion of their own new space station which at 60 tons is projected to be significantly smaller than the ISS as currently envisaged. Yet the ISS will have operated for 10 years and the Chinese station will have an opportunity to incorporate new technology.

If some of the ISS current partners also assist the Chinese with the development of their new station there could be significant improvements and some sense of International Space Station Version 2.0 versus a International Chinese Space Station Version 3.0.

The Utility of the ISS

Some critics of the ISS say that the ISS is not contributing to research issues that are central to further human exploration and its work is of limited usefulness. Since this facility has only just been completed it seems quite premature to judge the usefulness of this facility when it has only been fully manned so recently. The expense and the long time it took to develop the ISS are however justifications that the facility justify its continued operation and address its critics by performing substantive research.

In the most recent issue of MMM, # 265, Peter Kokh has proposed a research roles for the ISS that are central to its future strategic usefulness as a prototype for a Mars ship.

(1) In this role the ISS would demonstrate an ability to provide a CELSS for several months without resupply. The ability to survive long periods without resupply is critical for remote human bases. Unforeseen interruptions of the supply chain make this necessary and essential in planning for expansion into deep space.

(2) It is also necessary to research the effect of both Lunar and Martian gravity levels as a precursor to long term human assignments on the Lunar and Martian surface.

(3) The problem of radiation protection during long duration space flight is another problem that needs to be addressed if long duration flights to Mars and the asteroids are to be practical and of routine operations in cislunar space that are unprotected by the Earth's magnetic field.

(4) The issue of productive use of crew time on long duration flights is another issue Peter has raised that focus on the long periods of transit as opposed to the use of crew time on arrival at a lunar or Mars destination.

There are at least two salient points that can be made with these criticisms. The first is to look at the capabilities of the ISS as currently configured relative to its ability to conduct the research suggested above. It is likely that either significant additions to the existing ISS would be needed or alternatively a new space station could address these issues if the comparative analysis showed that latter to be a more cost effective investment. New commercial stations might be at the frontier of research in this regard.

The Development Potential of the Chinese Space Station

The second is to look at the capabilities of the proposed Chinese space station which is early in it planning. It may well be that as this design evolves and as other nations become part of this new endeavor that these essential long term research topics will be central to the strategic role envisioned for the Chinese space station and its anticipated international partners.

(1) The high degree of self sufficiency for the CELSS systems would also be an appropriate design goal for human facilities on the lunar surface.

(2) Lunar gravity levels could be tested in the new space station as an immediate precursor to the design of facilities for a lunar surface base. and of nations or commercial organizations that envision long duration facilities on the lunar surface.

(3) A Chinese space station could also provide prototype radiation protection not only for LEO operations but also for cislunar human transportation nodes located at L1, or L2 or GEO in association with refueling operations, telepresence operations on the lunar surface, or construction in GEO. This would reduce the risk of human operations in cislunar space as well as function as an on-ramp to Mars capabilities.

(4) Crew operations in cislunar space can be diversified to include telepresence, construction, astronomical and heliophysical observations, and Earth observations.

These functions if embraced by a new international coalition would be directly relevant to many of the lunar exploration and development goals of nations participating in the Global Exploration Roadmap and supporting lunar surface exploration as the first priority for international collaboration.

Those participating with a Chinese space station with these strategic goals and gaining operation experience with the Chinese station would also be well positioned to continue this collaboration on the lunar surface. This could also place China as a partner central to this new lunar operational systems capability. This would be a clear signal of the increasing economic and technological strength of the Chinese space program and of strategic importance of Chinese space program in reaching beyond LEO.

Russia could function as a key strategic partner with the new Chinese space station as it did when the ISS was started. It could provide the redundancy in depth its proven logistics system or both construction and operations. Roscosmos has vast experience in training foreign astronauts and joint missions operations. Russia also has many natural resources which China can pay for and which can support an expanded effort in space in Russia and justify the extensive expenditures of the new launch facilities in Siberia. Russian participation would also likely provide encouragement for other interested countries in the Pacific rim such as S. Korea. S Korea is also investing in its capacity to be a space faring power and has also collaborated on its launcher development program with the Russians.

A Commercial "Third Way"

A third strategic consideration is the role of commercial space stations and companies that aspire to function on the lunar surface and access in situ lunar resources for long duration commercial activities such as fuel production. A middle path with both US, Chinese, and other international partners may evolve as commercial investment becomes a factor of dominant consideration for the national space budgets of participating countries.

A "Fourth Way" Program of Development"

Another consideration is the growing interest in space based solar power production. Increased international cooperation is also something that is also driven more by commercial investment than sustaining government investments. Massive investments in space energy production facilities and in the access to space construction materials from lunar and asteroid resources is also a significant strategic consideration in the further evolution of the cislunar space economy. The ISS has by far the largest in space solar array in space. It has been suggested as a site for prototype solar power beaming experiment and systems development. This is another area where the intersection of both the technology research community and of commercial interest and investment may provide a strategic role in growth for the ISS.

A key question is whether the ISS remains a work in progress. A forward leaning program of strong collaboration internationally aimed directly at the Moon, expanding space transportation infrastructure, promoting space based solar power development, and functioning as an on-ramp to Mars and the asteroids is what is needed. NASA's current priorities on asteroid missions and Mars seem to me to put the strategic cart before the horse. As a work in progress I would also hope to see the ISS also expanding its international partnerships including India. ISRO as a major new partners with interest in a manned program, its own more robust launch system, and a program of lunar and mars missions in the works would add momentum. Australia was along with China an abstention from the Global Exploration Roadmap. I would hope the talents and energy of that Commonwealth country would also join the program.

The ISS as a Strategic Keystone

The arguments presented here would suggest that the current US space policy focused first on asteroid and then to Mars is significantly flawed and lacks the strategic strength that a cislunar development model would provide in collaboration with its current international partners. The use of the ISS for research goals more aligned with lunar and Mars development would help to maintain both the relevance of the ISS as a research facility but also keep international partners centered around common goals. They are interested in investment in its research work as part of applications directly enabling lunar surface exploration and extending human presence on the lunar surface. Commercial investment in cislunar space operations is another key strategic consideration. The use of the ISS as a spring board for private investments in CELSS applications for the Moon, Mars and deep space is also central as a way of learning more about gravitational biology. Its use also for space based solar power systems development is yet another area where both international partners and commercial investment can occur. We need clean energy for the Earth and we need sustainable power on Mars and at the asteroids.

A Chinese Space "Stimulus Program"

Chinese competition with the ISS in the development of their own international space station is an unfolding drama. China has a clear opportunity to focus on some some key strategic priorities which permit them to assume a central role in lunar surface collaboration.

(1) The development of international partnership agreements with the new Chinese space station will be one early indicator of competitive success.
(2) The focus of the research program they are proposing with their new space station is another indicator of their ambition and progress. If they perform significant work on CELSS, micro gravity conditions, radiation protection, and space solar power then they will have made a strong challenge of the relevance their station to what is being done on the ISS.

(3) Their openness to international commercial investments and partners is another indicator of the competitive strength of their space station program.
(4) The modification and expansion of their initial 60 ton space station design is another physical measure of their program development and intentions. I would predict that if their partnerships grow, the Chinese space station design will also be a work in progress.

I wish the Chinese well in their space station endeavor on its own merits, and also as a means of energizing the international space community in a peaceful but none the less vigorous competition to rapidly develop the potential of the global cislunar Economy.

Nostalgia for the Rapid Progress a Space Race

Since the Cold war ended the US space program has received an ever diminished share of US government resources for its NASA programs. The visions of "2001 a Space Odyssey" remain far from fulfilled after almost two generations of effort. A new space race may reinvigorate the US commitment. The growing role of private investments will also propel this era of expanding human presence off the surface of the Earth along with the pas de deux with the Chinese described above. This new space race is one of "frenemies" where both competition and collaboration are matters of both national and international ambitions and pragmatic economics. As a young person during the years of the US Soviet Moon race I was unprepared after Apollo for the slow pace of progress during the shuttle era and of the International Space Station program. To cling to the excitement and drama of the cold war competition may seem nostalgic but in my opinion the world and the fate of humanity needing space based resources can no longer wait for a space development program in the doldrums. I welcome an era when an ethos of "Gentlemen, start your engines" again prevails. This time however there will be plenty of women in the fray of competition and the appearance of China's first woman taigonaut underscores that positive social change.

Footnote: 1. The Space Exploration Roadmap http://www.**globalspaceexploration.org** **DD**

The New Space Station Race Heats Up

By David Dunlop

Excalibur Almaz press release and announcement made by Art Dula at the ISDC 2012
http://www.excaliburalmaz.com/pdf/052712EALPR.pdf

TEXT: **Excalibur Almaz announces lunar and deep space mission capability**

DOUGLAS, ISLE OF MAN, May 27, 2012

Excalibur Almaz Limited (EA) CEO, Art Dula, announced today at the National Space Society's International Space Development Conference (ISDC) in Washington D.C. bold plans to reach farther than any other manned-space mission has traveled in recent years. In unveiling his company's lunar and deep space mission capability, Mr. Dula took another step toward achieving the next giant leap in space exploration and creating an affordable commercial space program.

"Excalibur Almaz's approach is to leverage the billions of dollars of past investment by governments of spacefaring nations and apply advanced technology on an as needed basis to develop a space architecture that provides efficient access to space for commercialization, research and exploration," said Mr. Dula.

As competition mounts in the new space race, Excalibur Almaz benefits from its high degree of technical readiness. This advantage includes already achieving nine successful Reusable Return Vehicle (RRV) Capsule flights, reentries and soft landings with one RRV being flight-tested three times in space and one RRV staying in orbit attached to a Salyut Space Station for 175 days. Numerous other ground and flight tests have also been performed on Excalibur Almaz's RRV Capsules with each RRV expected to be reusable for up to 15 spaceflights.

EA's large Salyut-type space stations are equivalent to modules flown in space on every space station since 1972. The Salyut-type modules on the Salyut-7 Space Station, Russian MIR Space Station and the Zarya module currently on the International Space Station have been proven during many thousands of hours on orbit.

END

It is clear that Art Dula and the rest of his colleagues at Excalibur Almaz have not been sleeping. This Isle of Mann based company has been part of the new commercial space movement for some time but in my perception has not generated the level of press attention of new space companies such as Virgin Galactic or Space-X. They chose the recent 2012 International Space Development Conference held this year in Washington, DC, US as the forum to make their announcement.

The ambitions and eclectic strategy of their technology selection is genuinely international in scope. This company aims at aggressive solutions to the problems of cost reduction and a sense of a credible near term technological capability to do so.

Recently, the Global Space Exploration Conference (also held in Washington) revealed a public consensus among non US space faring powers that the Moon was a first priority destination and program objective that most other countries support. In contrast the US is focused on manned missions to a Near Earth Asteroid and a program focus on Mars. In the past America was *the* essential space nation and its leadership was the "make or break" component of projects of the scope of a manned Moon program or the International Space Station.

Now, a company like Excalibur Almaz with its reliance on Russian launchers and flight-tested and proven unused manned Soyuz capsules and Salyut (station) modules might provide both a commercial and a non-US capability to move forward if the US turns it back on this international interest in returning to the Moon. Excalibur Almaz is interested in proving that an international market exists for LEO stations as well as a space-experience tourism market for trips to low Earth orbit and non-landing trips around the Moon and back.

If Excalibur Almaz would gain the ability to launch its hardware on the Falcon 9 (as well as on Russian launch vehicles) it would further broaden its launch and operational base. It would position itself as a head to head competitor to the Bigelow Company which also aspires to launch a private space station, with the new Boeing CST100 manned capsule providing crew access, and use its inflatable design for human exploration beyond on both Atlas V and Falcon 9 launcher families.

Questions about the strength of the global economy create a cloud for these companies that want to pioneer commercial initiatives, but only reinforce the requirements that they have an innovative way to decrease costs on the one hand and increase access to space on the other.

ISS was at long last completed with the last flight of the Shuttle in 2011. (Further additions cannot be ruled out, however.) Within the next decade we could see it joined in LEO by Excalibur Almaz and Bigelow stations as well as a new and quite possibly also internationalized Chinese space station. This international space station race seems to have developed without much press attention. Excalibur Almaz has now given us a heads up. **DD**

LINKS:

http://excaliburalmaz.com/ - http://excaliburalmaz.com/0001_Overview.html

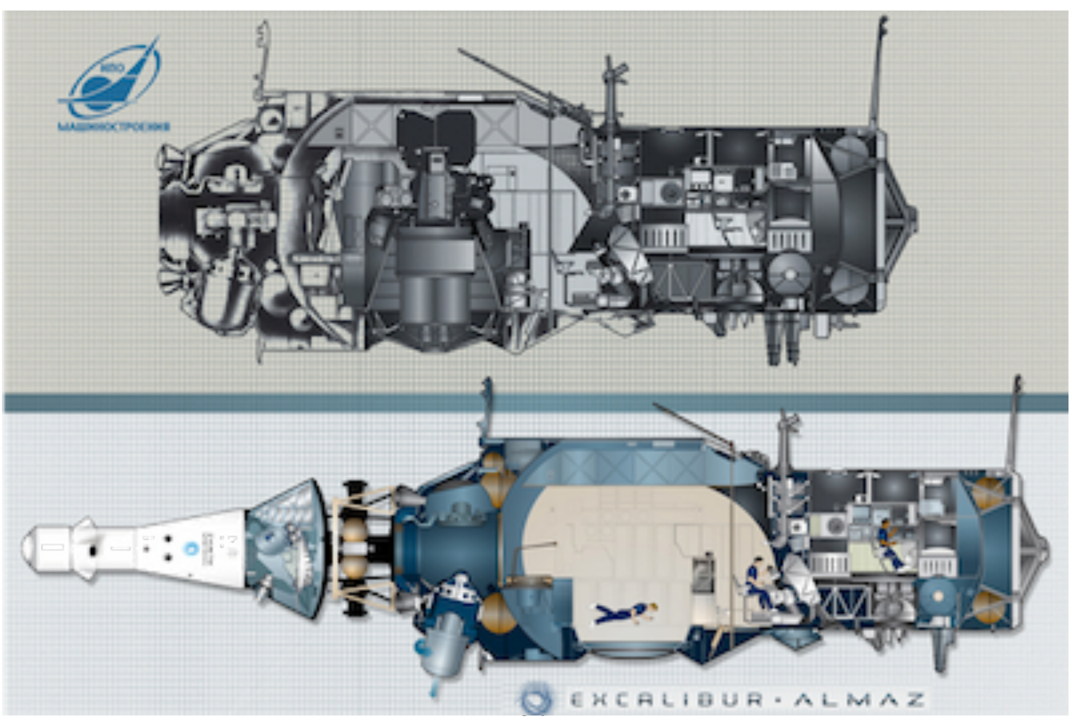
http://excaliburalmaz.com/0300_investors.html

http://excaliburalmaz.com/0200_Services.html

http://excaliburalmaz.com/0401_Press.html (Press Releases)

IMAGES:

http://www.google.com/search?num=10&hl=en&site=imghp&tbm=isch&source=hp&q=Excalibur+Almaz



A U.S. Department of Space?

A Proposed "Sea-Change" in the Way The Government Promotes Space

By Madhu Thangavelu

A few weeks ago the hatch opened into the interior of the Space Exploration Technologies (SpaceX) Dragon capsule, and crew members from the international space station (ISS) unloaded cargo from the first private spacecraft docked at station. The crew noted that upon entering Dragon, it smelled like the interior of a new car. I don't recall any such comment when logistics crafts built and serviced by multinational and defense corporations of other ISS partner nations docked with station for the first time.

Once unloaded, Dragon returned to Earth precisely on target in the Pacific near Baja California. NASA Administrator Charles Bolden noted that a new era in space activity had begun.

It is rightly SpaceX's time to shine. With a fraction of a fraction of the resources that governments and partner nations employ to create and support space missions, this small, can-do company in Southern California has made giant strides into a domain that was the monopoly of government-run space agencies of sovereign nations. A small business running out of a warehouse near Los Angeles is now able to support ISS logistics! Such are the true signs of progress in advancing life, liberty and the pursuit of happiness.

This "first mover" advantage should go a long way to establish SpaceX as the leader in private, commercial space activity. However, several small companies also are lining up hardware and operational flight plans. They include Virgin Galactic, Orbital Sciences, Blue Origin, XCOR, Bigelow Aerospace, Sierra Nevada Corp. and, most recently, Paul Allen's new consortium to build and service an air-launched orbital vehicle called Stratolaunch.

NASA has been asked to do too much with too little for too long, and in keeping with the erratic budget trims and fixes, the agency's vision has been badly warped over time. A clear vision is crucial for success. In the Kennedy directive to reach for the Moon, the choice of words articulating the vision were very clear. The NASA vision of today is nebulous and seems to pay lip service, catering to do all things for everyone.

NASA projects, by virtue of their one-of-a-kind, never-tried-before nature, must have open-ended budgets. But the agency has a history of being told by Congress to build projects with budgets that are insufficient, or worse, budgets that follow a rowdy on-again off-again cycle rather than a steady flow of funds.

Visions and ideas are precious, irrespective of their origin. They help planners to choose between options to shape the way forward. NASA has been accused of the "not invented here" syndrome that seems to affect large agencies. However, it is good to see NASA fielding out visionary architecture studies to universities through programs like the NASA Institute for Advanced Concepts. It would be much better if all visionary studies were done that way.

Recent visions include a U.S. Air Force study to put up solar-powered satellites to bolster U.S. and global energy security, a Massachusetts Institute of Technology report that seeks to reinvigorate human spaceflight through renewed international collaboration, and a California Institute of Technology report on accessing the asteroid belt for resources. Large defense contractors like Boeing and Lockheed Martin also have proposed new concepts, such as orbital fuel depots and technology test bed missions to the Moon.

Government space projects, or programs (as they are more aptly called), are about building and maintaining very large and expensive infrastructures. Proposed projects include planetary defense infrastructures, orbital debris mitigation systems, climate change and pollution monitoring programs, large GPS and defense-related constellations and assets, and manned lunar, asteroid and Mars missions. Private space projects, like space tourism and ISS logistics support, cost orders of magnitude less.

Since the scope and budgets are very different, it goes without saying that the processes and mindset behind government and private space programs are very different as well. Government space programs have always been about national pride and international prestige, much like those evolving in China, India, and Russia today, not to mention government jobs. It is not an economic matter as much as a policy-related one. The returns have been expected in broad international collaboration and results have been meant to steer and align administration policy to gain advantage in statecraft, both domestic and globally. Private space activity, on the other hand, is all about the profit-minded entrepreneur.

However, in the current economic climate, it is perhaps necessary to merge these philosophies and operate using synergies of both the public and private sector.

U.S. President Barack Obama is looking at restructuring his Cabinet to fit the needs of the 21st century, and perhaps now is the time to consider a U.S. Department of Space that can play a vital role in international policy. Besides helping to build up the infrastructure of friendly nations, align the projects and goals of various spacefaring nations and assist in global projects such as international manned missions and space debris mitigation, a Department of Space also would help to coordinate the activities of fledgling private space companies, which have a history of being squashed as NASA protects its charter and monopoly.

A range of options are available, from asking NASA to play the role of global coordinator to proposing a completely new organization and charter for space activity. NASA could, in theory, create a new division to coordinate such activity, evolving and extending the ISS model of international collaboration, but such activity would clearly distract resources and personnel from NASA's leading-edge space technology and mission charter, and detract from the agency's core competence. The creation of a U.S. Department of Space, however, might balance these two poles. And the private space sector could use a moderating, synergizing body between it and the government space sector.

Even before the imminent advent of routine suborbital space tourism flights by Virgin Galactic and others, the Federal Aviation Administration is involved, studying the potential impact and safety on airline traffic. As commercial spaceflight comes of age, we can expect the Department of Commerce, National Oceanic and Atmospheric Administration and Occupational Safety and Health Administration to become important players as well. And the State Department already has played a notorious role in suppressing space commerce under the International Traffic in Arms Regulations and Missile Technology Control Regime.

NASA may not be able to handle all these auxiliary functions that will be thrust upon it soon without radical changes to the agency's charter. It is perhaps better for the agency to stay close to its original charter, as the administrator has indicated, and provide leadership in its area of core competency: high-risk technology development and deep-space, endurance-class manned missions to destinations beyond Earth orbit.

A Department of Space must not be misconstrued as a threat to break up NASA or split up its stretched budget. Nor should it be portrayed as a stealthy effort by the Department of Defense (DoD) to exert influence globally.

A University of Southern California team project from last fall presented a case that the Department of Space should operate at a budget level of some $60 billion, consistent with other departments, of which NASA should have $20 billion to build, test and fly daring, leading-edge technology missions into deep space. An additional $40 billion is suggested for the department to handle all the coordination functions among large global infrastructure development projects, NASA and other partner nation agencies, and the private sector.

Government and private space activities are both necessary to keep the space industry in good competitive shape. Just as the Human Genome Project was accelerated by Celera Genomics, a small biotech company, large government-sponsored space programs can benefit from small space companies, acting as catalysts for quick results.

Large space infrastructure development projects that cannot be initiated or created by private investors alone, such as space solar power, orbital debris mitigation, fuel depots, interplanetary missions or even large space based observatories, remain the domain of NASA and the government. However, servicing these large systems, once put in place, could be a healthy sector for private participation in the near future.

The role of the Department of Space must be one of coordination between government and private space activity. Can NASA aspire to change its deeply ingrained culture and become such an entity? If we look at the history of failed private space efforts, the answer is no.

Should the 21st century creation and maintenance of national security infrastructure depend on obsolete DoD practices and a few established sole source suppliers, or should it be spread out over a much larger and more competitive commercial sector, including small business? If civil jobs protection is the goal, we might stay with status quo (though it is clearly unsustainable), but if true jobs expansion is what we seek, we might want a much more vigorous overhaul that includes the private sector at the core of all formulation plans.

New information and manufacturing technologies now clearly favor the latter, from both the agility and economic points of view. It is possible for small companies to innovate and field systems at a fraction of the cost and overhead of larger corporations. The same strategy that produced design results for complex protein folding methods in biology by presenting the problem to be solved over the Internet to a wide audience is now being probed to enhance and create national security projects. “Crowd sourcing” is seen as the next level of sophistication for designing and building complex systems, including space systems.

Human space activity remains a special endeavor that is able to bring the finest minds together in peaceful projects of progressive development. Spacefaring nations that once aimed their nuclear arsenals at each other have joined forces to support the buildup and operations of ISS. The next stage in this development is handing over the reins to global commerce and economic development.

Space remains the ultimate frontier. Among all spacefaring nations today, the U.S., with a Constitution that resonates with the freedom of mankind, is best suited for expanding activities. Can U.S. space policy be reshaped to encompass a globally inclusive, civilian paradigm? Can the U.S. shepherd the spacefaring nations of the world in undertaking visionary space infrastructure development projects? The answer for speeding up progress may lie in the creation of a U.S. Department of Space to combine the energies of the government space programs of the world and coordinate the various private space projects as well as assist in the pursuit of excellence in progressive, peaceful space activities. **MT**

USC Architecture School Moon Studio team: Profs. Anders Carlson, Neil Leach and Madhu Thangavelu at right; tall student third from left is Frankie Sharpe III

Touring an Apollo Moon Landing Site - A Design Proposal

By Frankie Sharpe, student of M3IQ Co-editor Madhu Thangavelu

Editor’s Forward

Tourists on the Moon? Right now, that seems a way off. Yet even now, there are two companies ready to take tourists on a “no landing” tour of the Moon, looping around the farside of the Moon. Both Space Adventures and Excalibur Almaz are ready to fly two tourists at a time out to the Moon, loop around the farside, and return to Earth. When? In both cases the ticket price per person is US $150,000,000. Space Adventures has one person signed up, waiting for the second. Excalibur Almaz has no reservations as of now.

But tourists “on” the Moon seems a bit further off, and should be more expensive as it involves a craft that can land on the Moon and take off. And further down the road, it will involve construction of facilities on the Moon where tourists can stay and from which they can make overland excursions.

Before this day dawns, we will want global accord on environmental protection standards. On this subject, download and read our paper “**National Parks on the Moon**”

http://www.moonsociety.org/publications/papers/NationalParkSystem.pdf

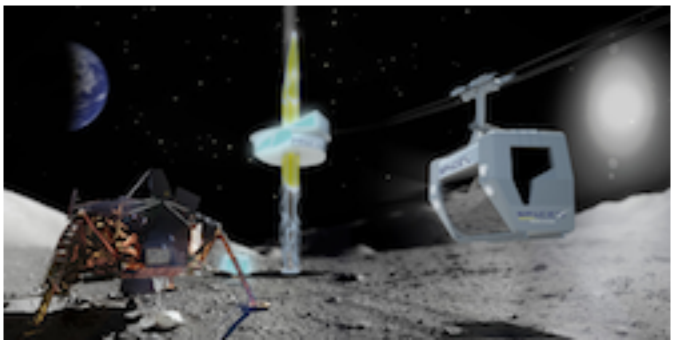
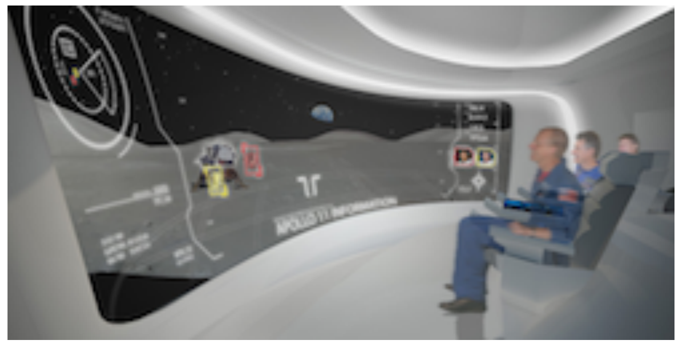
For those sites of historical significance such as the 6 Apollo landing sites, the restrictions will be severe: “**no new footprints** on the area traversed by the Apollo astronauts!” That means that ways to tour the site without disturbing it at all must be in place, and that requirement is sure to up the ticket price considerably.

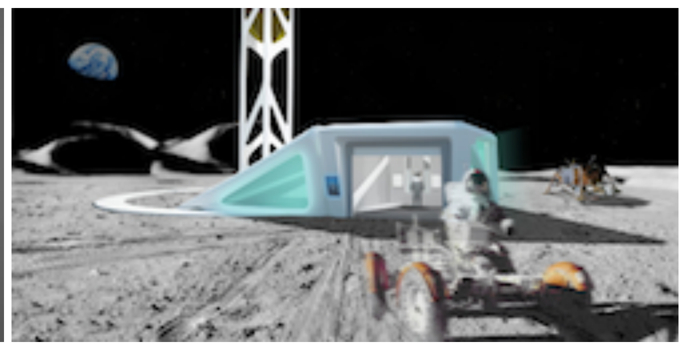
One possibility is a cable car, which would allow tourists to view the site from just above. That is one of the features of the “Tour the Moon” proposal by Frankie Sharpe, a student of M3IQ editor Madhu Thangavelu. We are happy to provide a preview of Sharpe’s proposal below.

Tour the Moon By Frankie Sharpe - http://www.frankiesharpe.com/

The Moon Studio was a USC (University of Southern California) design program based on current research involving the future of lunar explorations. Our studio project was to research the moon's hostile environment and develop a program that we thought could eventually become a viable proposal. Through my personal research and interest, I examined the possibilities of lunar tourism.

The basic concept of this proposal is to create a touring system that will allow visitors the opportunities to visit some of the most historic sites in our solar system. E.L.V.I.S. (Elevated Lunar Viewing and Information System) is a structure that covers an accommodations tunnel when not in use, but can elevate to help visitors get a better knowledge of the site they are about to explore. For sites that are too difficult to see on foot, or have restrictions placed on them like Apollo 11, a gondola could release from ELVIS to get a closer look. A maglev mass driver launching and landing systems helps reduce energy consumption in starting and stopping shuttles, while also providing a long enough underground runway so spacecrafts are safely out of the no-fly zones before powering on main propulsion.

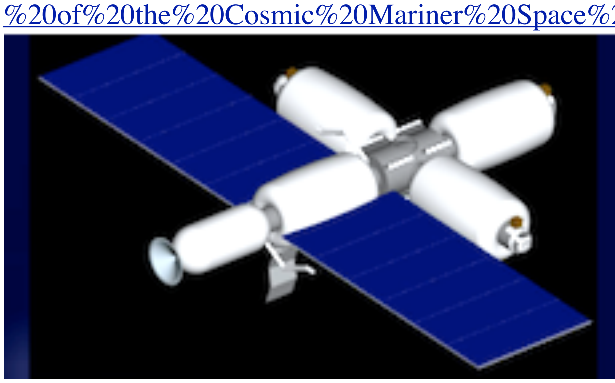
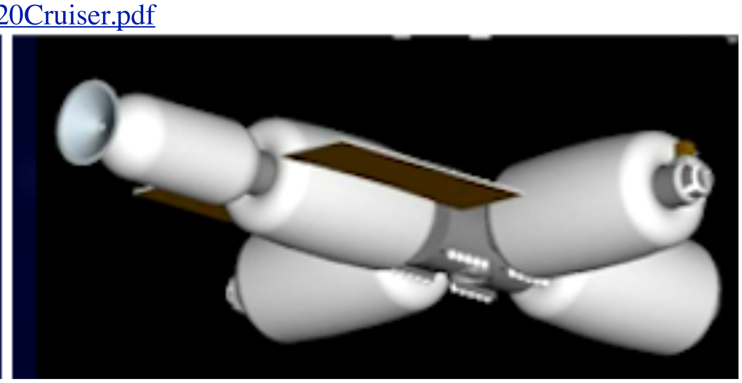
See the full proposal and the above and additional illustrations in original larger size at **www.frankiesharpe.com/**

Evolution of the "Cosmic Mariner" Space Cruiser

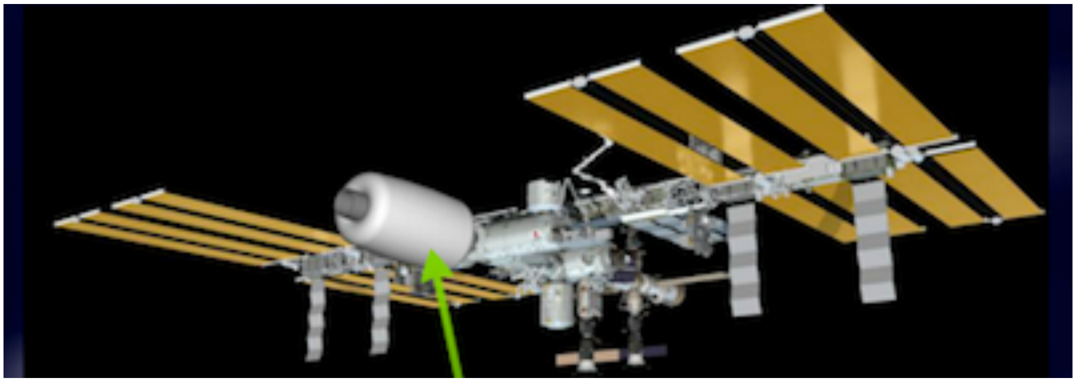
A student paper from ASTE 527 Space Exploration Architectures Concept Synthesis Studio, December 13, 2011 conducted by Madhu Thangaelu at the University of Southern California (USC) Los Angeles

By Perry Edmundson

http://denecs.usc.edu/hosted/ASTE/527_20111/The%20US%20Department%20of%20Space/J%20Evolution%20of%20the%20Cosmic%20Mariner%20Space%20Cruiser.pdf

Objective: Demonstrate a concept for a commercial space cruise ship that could be constructed at the International Space Station with both human and robotic methods, and sent to lunar polar orbit for tourist flights as well as to support lunar exploration. It would use new components, materials and technologies, customized for user needs.



Above: First inflatable module (system greenhouse) being outfitted at ISS Node 2

Construction Sequence: first inflatable module (bioregenerative life support system greenhouse) on axial port of Node 2. Install nofe (gray module). Assemble Power and Control Module, deploy solar arrays and radiator, install laboratory/medical and habitation modules, install Nuclear Propulsion Module (contains non-fissile nuclear material) onto Power a& Control Module. Stow deployables; depart from ISS. Rendezvous with nuclear fuel depot

EVAS required. ISS 1,015 hours robot assisted (Dextre, Robonaut 2 contribute 20%. Est EVA hours 200.

Follow-on Missions: Solar Power Satellite / other Satellite Construction, Near-Earth Asteroid missions, Mars etc.

Merits: √ Uses as starting point, √ Reasonable level of human activity to support assembly, √ Possible use of existing launch vehicles, √ Main technologies already in deployment, √ Realizable within 10 years, √ Multiple simultaneous uses presnt attractive commercial business case

Limitations: √ Large investment, √ Dependent on interfovernmental agreement for use of ISS (as construction yard), √ Requires nuclear fuel depot in LEO, √ Dependence on sufficient lunar users

Areas for Future Study: √ In-depth analysis of business case, √ Launch manifest, √ Thermal management of nuclear reactor, √ Thrust loads on structure, √ Impact on ISS,
√ Detailed assembly work plan

GREAT SPACE VIDEOS

http://spaceports.blogspot.com/2012/05/**europeans-will-look-for-life-on-jovian.html**

http://www.space.com/15687-**saturn-oddball-moon-phoebe-planet-video**.html

http://www.space.com/15878-**spacex-dragon-iss-share-berth-time**-video.html

http://www.space.com/15875-**spacex-dragon-grappled-iss-problem-video**.html

http://www.space.com/15949-**milkyway-galaxy-crash-andromeda-hubble**.html

http://**mars-one**.com/en/

http://www.space.com/16113-**red-dwarf-stars-sun-video**.html - less nearby Brown Dwarfs than expected

http://www.space.com/16405-**private-foundation-seeks-to-save-aquarius-underwater-lab**-video.html

http://www.oneworldoneocean.org/ (scroll down to "a mission to inner space"

https://ieeetv.ieee.org/player/html/viewer?gclid=CMXphq3eq7ACFSMDQAoddRxLWQ#**inbrooklyn-warehouse-honeybee-robotics-is-developinglunar-excavator-that-may-help-us-colonizemoon-**

Sunita Williams, of Indian extraction (Gujarat), to command International Space Station
http://www.space.com/16376-**preparing-to-command-the-iss-sunita-williams**-video.html

http://www.space.com/14864-**manned-asteroid-explorer-prototype-training-wheels-video**.html

Multi-probe Venus mission with drone airplane and rover/sampler by Geoffrey Landis / NASA RASC team
https://rt.grc.nasa.gov/files/venus_mission.mp4

VIDEOS ONB THE SQUARE KILOMETER ARRAY (Some Australian, some South African)

http://www.smh.com.au/technology/sci-tech/its-a-telescope--but-not-as-we-know-it-20110601-1fgwb.html

http://www.youtube.com/watch?v=GiMiTKB4M2A

http://www.youtube.com/watch?v=TyRqcebnFTo&feature=related

GREAT BROWSING LINKS

SPACE STATIONS / COMMERCIAL SPACE

http://www.space.com/15681-**satellite-repair-robot-spacecraft-technology**.html
http://www.space.com/15874-**private-dragon-capsule-space-station-arrival**.html
http://www.space.com/15832**-spacex-dragon-1st-station-flight-pictures**.html
http://www.space.com/15885-**spacex-dragon-capsule-station-astronauts**.html
http://www.space.com/15951-**spacex-praise-dragon-spacecraft-success**.html
http://www.space.com/15930-**spacex-dragon-capsule-future-spaceflights**.html
http://www.space.com/16056-**dream-chaser-space-plane-review**.html
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http://www.space.com/16340-**china-shenzhou-9-spacecraft-undocking**.html
http://www.space.com/16367-**private-moon-missions-excalibur-almaz**.html
The space industry grapples with satellite servicing http://www.thespacereview.com/article/2108/1

MOON

http://www.space.com/14955-**cosmic-rays-moon-space-radiation**.html
Cislunar Space and the Cislunar Econosphere (by Ken Murphy, TMS president)
http://www.thespacereview.com/article/2027/1 & http://www.thespacereview.com/article/2033/1
Titanium paternity test fingers Earth as moon's sole parent (ruling out "Mars-sized impactor"
http://www.spaceref.com/news/viewpr.html?pid=36571
GRAIL lunar gravity mapping Mission to be extended, orbiting lower for higher resolution
http://www.nasa.gov/home/hqnews/2012/may/HQ_12-175_GRAIL.html
International Partners prefer the Moon as next goal - http://www.thespacereview.com/article/2094/1

MARS

http://www.space.com/15869**-nasa-mars-strategy-mission-ideas**.html
http://www.marsdaily.com/reports/**Mars_Astronauts_Could_Risk_DNA_Damage**_999.html
http://www.abc.net.au/news/2012-04-03/**canberra-lab-to-broadcast-mars-landing**/3930118
Mars Express Gravity results plot Mars' volcanic history -www.esa.int/esaSC/SEM6HJNW91H_index_0.html
DragonLab-g: an early step to Mars and beyond http://www.thespacereview.com/article/2089/1
Green Mars? Mars soil as a Growing Medium - www.lpi.usra.edu/publications/reports/CB-1063/RedMars2.pdf
Humans to Mars can be relevant to Terrestrial Problems http://www.thespacereview.com/article/2106/1
Mars Science Lab (Curiosity) Landing Zone - www.nasa.gov/mission_pages/msl/multimedia/pia15685.html

ASTEROIDS

http://www.space.com/15416-**asteroid-mining-planetary-resources-hiring**.html
http://www.space.com/15419-**asteroid-mining-billionaires-private-spaceflight**.html
http://www.space.com/15405-**asteroid-mining-feasibility-study**.html
http://www.space.com/15401-**asteroid-mining-huge-dollars-sense**.html
Don't send astronauts to the asteroids, bring asteroids to the astronauts
http://space.alglobus.net/presentations/DraftAsteroidMiningTalk2012.pdf

ANALOG STATIONS AND RESEARCH

Antarctic Research Stations: Parallels for space - http://www.spacearchitect.org/pubs/AIAA-2010-6106.pdf

ROBOTICS

http://www.space.com/16146-**nasa-contest-unleashes-robots**.html

ASTRONOMY / ASTROBIOTICS SPACE TOURISM

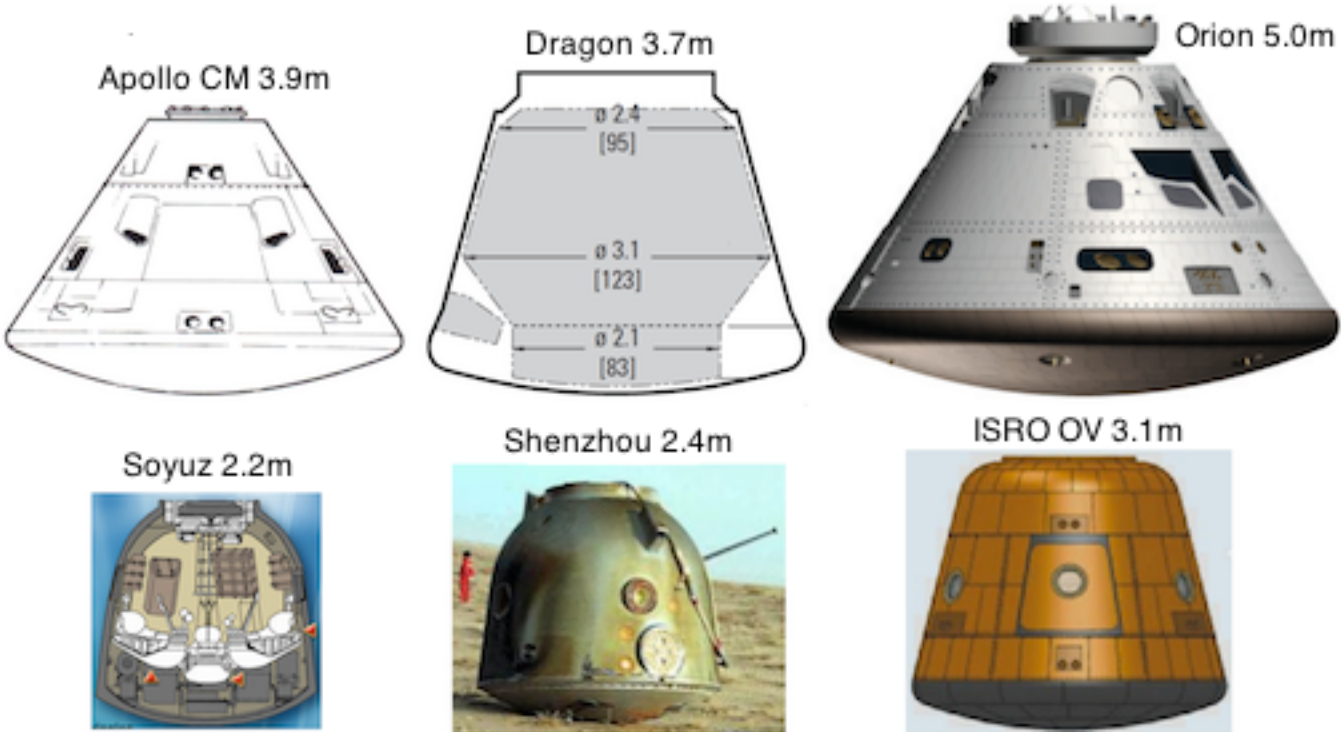
http://www.space.com/15883**-worlds-largest-radio-telescope-ska-array.html**
http://www.space.com/15949**-milkyway-galaxy-crash-andromeda-hubble.html**

SPACE TOURISM

http://www.space.com/16057-**virgin-galactic-spaceshiptwo-launches-2013**.html
http://www.space.com/16082-**intergalactic-travel-bureau-nyc-arts-festival**.html
www.flightglobal.com/news/articles/**excalibur-almaz-details-plans-for-capsule-and-space-station**-372347/
http://www.space.com/16071-**xcor-lynx-spacecraft-space-tourism**.html

M3IQ PHOTO GALLERY

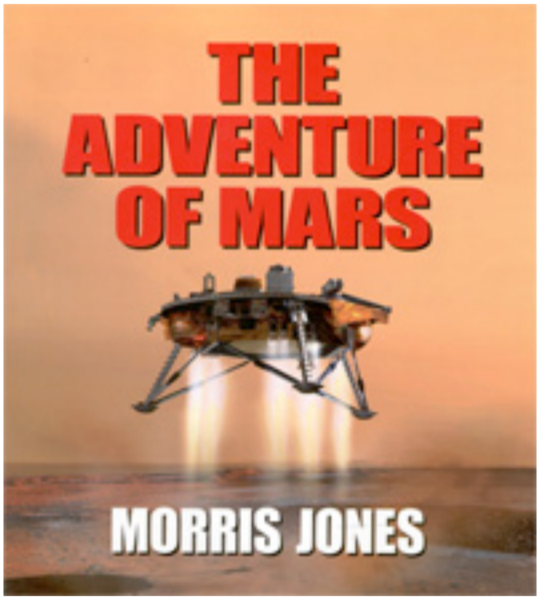
International Space Station and docked (upside-down) space shuttle Endeavor, at an altitude c 350 km, was taken by Expedition 27 crew member Paolo Nespoli from Soyuz TMA-20 following its undocking on May 24, 2011



The various manned capsules in use or under development

DragonLab-g: an early step to Mars and beyond http://www.thespacereview.com/article/2089/1

Some Books on Mars



Dr. Morris Jones B. Sci,. M.A., PhD. For more than a decade, Dr. Morris Jones has been an internationally known and respected authority on space exploration. He has written more than 100 articles, appeared on global television, and written high-level academic reports.

The Adventure of Mars: Mars remains one of the most exciting destinations in the solar system. Mars has always been the enigma. The object of mystery. Canals on Mars? Are there really Martians? The book details the amazing story of the machines that have visited this planet, and prepared us for the day when humans will go there.

Meet the Viking landers and Mars Exploration Rovers:

- What did they really find?
- Could Mars once have supported life?
- How has Mars changed? and Why?
- How do you drive a rover by remote control from Earth?

Explore the planet with stunning photographs from high-resolution cameras

US purchase site: http://www.spacefrontier.com.au/shopping/shopdisplayproducts.asp?id=1&cat=Books

(M3IQ does not know if this book is available from booksellers in India)

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Paperbacks from Apogee Books

http://www.apogeebooks.com/Books/**OntoMars.html**

http://www.apogeebooks.com/Books/**OntoMars2.html**

http://www.apogeebooks.com/Books/Mars1.html

http://www.apogeebooks.com/Books/**Mars2.html**

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Available on Amazon.com

Destination Mars: New Explorations of the Red Planet by Rod Pyle (Apr 24, 2012)

The Case for Mars: The Plan to Settle the Red Planet and Why We Must by Robert Zubrin, R. Wagner 2011

Postcards from Mars: The First Photographer on the Red Planet by Jim Bell 2010

The Scientific Exploration of Mars [Hardcover] Fredric W. Taylor 2010

Destination Mars by Seymour Simon 2010

Planet Mars: Story of Another World by François Forget, François Costard and Philippe Lognonné 2010

Trailblazing Mars: NASA's Next Giant Leap by Pat Duggins (Sep 19, 2010)

Discovering Mars: The Amazing Story of the Red Planet by Melvin Berger (Dec 1992)

Moon Miners' Manifesto - Resources

http://www.moonsociety.org/chapters/milwaukee/mmm/

MMM is published 10 times a year (exc. January and July. The Dec 2011 issue began its 26th year of continuous publication.

Most issues deal with the **opening of the Lunar frontier**, suggesting how pioneers can make best use of **local resources** and learn to **make themselves at home.** This will involve psychological, social, and physiological adjustment**.**

Some of the points made will relate specifically to **pioneer life** in the lunar environment. But much of what will hold for the Moon, will also hold true for **Mars and for space in general.** We have one Mars theme issue each year, and occasionally **other space destinations** are discussed: the asteroids, Europa (Jupiter), Titan (Saturn), even the cloud tops of Venus.

Issues #145 (May 2001) forward through current are as pdf file downloads with a Moon Society username and password. Moon Society International memberships are $35 US; $20 students, seniors – join online at:

http://www.moonsociety.org/register/

MMM Classics: All the "non-time-sensitive editorials and articles from past issues of MMM have been re-edited and republished in pdf files, one per publication year. A 3-year plus lag is kept between the MMM Classic volumes and the current issue. **As of December 2011, the first twenty-two years of MMM, 200 issues, will be preserved in this directory,** These issues are freely accessible to all, no username or password needed, at:

www.moonsocietyorg/publications/mmm_classics/

MMM Classic Theme Issues: introduced a new series to collect the same material as in the Classics, but this time organized by theme. The first MMM Classic Theme issue gathers all the **Mars** theme articles from years 1-10 in one pdf file. A second pdf file collects all the Mars Theme issues from year 11-20. The 2nd Classic Theme is "**Eden on Luna**," addressing environmental issues underlying lunar settlement. **Asteroids**, **Tourism, Research**, **Select Editorials, and Analog Programs** have been added. New Theme Issues will be coming: Lunar Building Materials, The Lunar Economy, The Lunar Homestead, Modular Architecture, Modular Biospherics, Frontier Arts & Crafts, Frontier Sports, Other Solar System Destinations, and so on.

www.moonsociety.org/publications/mmm_themes/

MMM Glossary: The publishers of MMM, the Lunar Reclamation Society, has published a new Glossary of "MMM-Speak: new words and old words with new meaning" as used in Moon Miners' Manifesto.

www.moonsociety.org/publications/m3glossary.html

The initial edition 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 MMM, but to our vision and goals.

All of these resources are available online or as free access downloads to readers.
But M3IQ does need your help!

MMM-India Quarterly Advisors, Liaisons, Contributors, Correspondents, Illustrators

If M3IQ is to help spread the word about Space in India, among the public at large, especially among the students and younger people, it must become a truly Indian publication. We need people from many fields in India 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: mmm-india@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 serve the education of the public in India, and in the education of young people on whom the future of India and the world will rest.

Guidelines for Submissions: M3IQ is intended for wide public distribution to encourage support for space research and exploration and development. M3IQ 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 *MMM-India 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.moonsociety.org/india/mmm-india/

MMM-India Quarterly will remain a free publication.

Upcoming Conferences & Events - http://www.spacecalendar.com/downrange/

INDIA **------2012 -----**

July14-22 — Committee on Space Research, ISRO, Mysore, ***India:*** 39th Scientific Assembly of Committee on Space Research (COSPAR).

ELSEWHERE – a selection by the editor **--- 2012 ----**

Aug 3-5 — The Mars Society, *Pasadena CA:* '15th Annual International Mars Society Convention.'

Oct 25-27 — ESA, International Association of Sedimentologists, et al, *Marrakech, Morocco:* 3rd Conference on Terrestrial Mars Analogues.

Nov 8-11 — Students for the Exploration & Development of Space (SEDS), *Buffalo NY:* 'SEDS SpaceVision 2012 Conference: Crossroads – How Our Generation Will Take Us To The Space Frontier.'

Note: ***If you know of a scheduled space event in India that is not listed at the address above, please inform us of this in advance –*** email mmm-india@moonsociety.org

Student Space Organizations in India

SEDS India
Students for Exploration and Development of Space - India

http://india.seds.org/ -

http://en.wikipedia.org/wiki/Students_for_the_Exploration_and_Development_of_Space#SEDS-India

NATIONAL HEADQUARTERS- SEDS VIT - C/O ,
Dr. Geetha Manivasagam, - Room No. 401 , CDMM Building , VIT Univ.,
VELLORE-632014, Tamil Nadu - Phone No. +919952749426 -Anmol Sharma (Director, Chapter Affairs)

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Deepak Namdev, Joint Secretary (Events and Projects - tia747@gmail.com

SEDS-India Chapters (currently 6):
http://india.seds.org/CHAPTERS.HTML

SEDS VIT (Vellore) (756 members)
SEDS GGITM (Bhopal) (136 members)
SEDS KCT (Coimbatore) (100 members)
SEDS VEL TECH (Chennai) (419 members)
SEDS NITW (Warangal) (100 members)
SEDS NITT (Thiruchirapalli.) (17 members)

SEDS-India Projects - http://india.seds.org/projects.html

VITSAT - 1 - small satellites to demonsrate miniaturization of technology and implementation of a variety of payloads
SEDS VIT UAV - automatically controlled aircraft, withsensors, servos, communication equipment, GPS, Microcontroler
CanSat - a satellite in a Tin Can - to conduct basic atmospheric studies at cloud base, provide a test for amateur communication protocols, provide basic knowledge of a Satellite to the students

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And you wish to add your email address o our new-issue-ready announcement list,
Write **mmm-india@moonsociety.org** Put "Subscribe" in the subject line of your email.
Include any comments you would like to make!

Feel free to send us email addresses of others - Individuals and/or organizations and/or lists.
We have been trying, without success, to find email addresses for any of the numerous Indian professional organizations in many major cities outside India (in the United States there are at least half a dozen)

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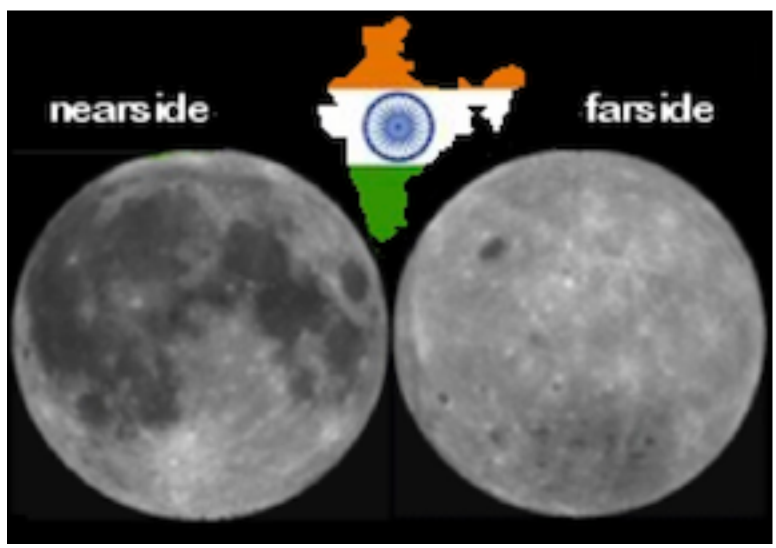

Moon Miners’ Manifesto - India Quarterly #15

Engage! And Enjoy!