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

Moon Miners' Manifesto

India Quarterly Edition

www.moonsociety.org/india/mmm-india/

#7 SUMMER 2010

Students visit the Indian Deep Space Network in Byalalu, outside Bangalore – and a view inside the Control Room

Feature Articles This Issue

Welcome to Moon Miners' Manifesto India Quarterly Edition #7

Once again, we bring you a mix of space news, reports, speculation, and useful information. The pace of events on the space front continues at an exciting pace.

India's efforts, achievements, and contributions are noted worldwide. In this issue we report on Dr. Kalam's address to the International Space Development Conference in Chicago on the need for a worldwide effort to design and deploy Space-based Solar Power Systems to alleviate growing energy demand shortages and environmental effects of growing consumption of fossil fuels.

We also report on Indian student teams at that conference. Nothing is more important to us as editors, than to excite and motivate young people in India. They have a bright future ahead of them!

We would love to hear from our growing number of readers in India and elsewhere. So do feel free to write us at: ***mmm-india@moonsocietyorg*** *The Editors.*

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 everywhere, 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 young people and to people in general, contests & competitions, workshops, ground level research and technology experiments, private entrepreneurial ventures, moonbase simulation exercises, tourist centers, and other legitimate means.

About Moon Miners' Manifesto

http://www.MoonMinersManifesto.com

MMM is published 10 times a year (except January and July. The December 2009 issue began its 24th 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. 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
Madhu Thangavelu thangavelu-girardey@cox.net
David A. Dunlop dunlop712@yahoo.com
Pradeep Mohandas pradeep.mohandas@gmail.com
Srivinas Laxman moonshotindia@gmail.com

About MMM-India Quarterly

http://india.moonsociety.org/india/mmm-india/

This publication is being launched with this Fall 2008 issue. The Moon Society was founded as an International organization, but in fact has few members outside the United States, and these are for the most part 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 in India than in any other country.

And – *India has gone to the Moon, and is planning to go again!*

In short, we'd like 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 environmental 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 his assertions and want to share that bold vision with the forward-looking people of India.

Free Access:

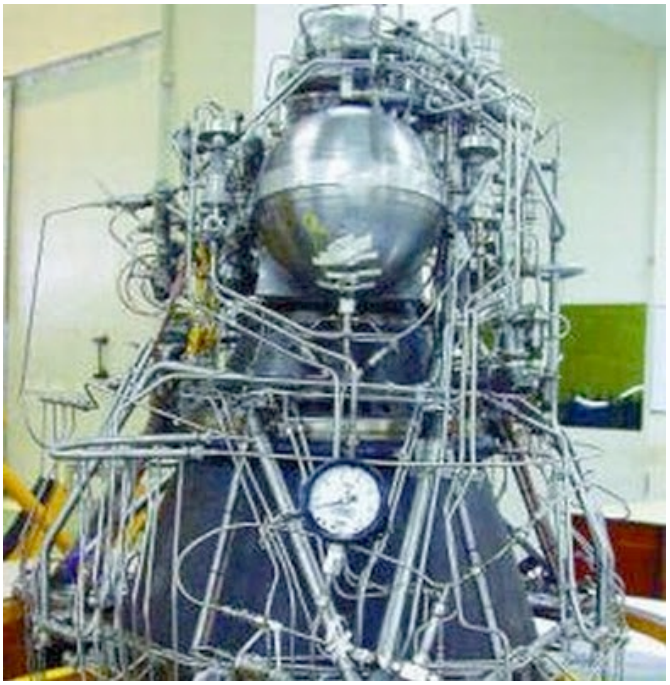
MMM-India Quarterly issues will be available as a free access pdf file, downloadable from the Internet. We encourage readers to share these files with others freely, and to use this publication to grow and cultivate wide-spread interest in the open-ended possibilities of space among the people of India,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

India
Space Front Updates

ISRO's 1st Cryogenic Engine Test Fails

By Srinivas Laxman

June 9, 2010 - After the successful launch of Chandrayaan-1 on October 22, 2008, the test of India's first cryogenic engine was to have been the most important space event of India, attracting not only considerable national interest, but internationally too. If successful, it would have once again rocketed India into the exclusive club of space-faring nations having access to critical space-related technology.



Considering the significance of this flight on the afternoon of April 15, 2010, the visitors' gallery adjoining the mission control room at Sriharikota was filled with several important people, including a few former ISRO chiefs. They were all eagerly awaiting the outcome of this mission, their eyes glued to the huge screens in front of them.

At sharp 4.27 p.m. as the red digital countdown clock in the mission control room hit the zero mark and the nearly 50-metre tall three-stage Geo Synchronous Satellite Launch Vehicle (GSLV) sprang into life and lifted off with an awesome roar carrying the 2200 kg G Sat-4 communication satellite, everyone in the visitors' gallery clapped, cheered and exchanged congratulatory handshakes. They kept staring at the screens as the mighty rocket flew higher and higher, traveling in a yellowish plume, trailed by a white and black smoke punctuating the clear sky over Sriharikota. After a while the rocket disappeared from everyone's view and its sound too slowly faded away.

Every few seconds one of the screens flashed the different stages of the flight and 304.9 seconds after take off it said that the cryogenic engine had ignited. This triggered another round of applause and there was a sense of achievement and relief among the scientists and engineers. The reason: this was the first flight of the GSLV with its third stage powered by an indigenous cryogenic engine. Everyone believed that the mission had succeeded catapulting this country into the exclusive club of space-faring nations.

But, the expression of joy soon gave away to one of concern and disappointment, because when the flight crossed the 454-second mark, the big screens showed that the rocket was deviating from its trajectory and finally it plunged into the Bay of Bengal. The first flight of the GSLV with an indigenous cryogenic engine was apparently not meant for the sky, but the ocean! This much-awaited and publicized mission had failed causing a tremendous amount of disappointment among the ISRO team who had slogged 24X7 during the last few months to ensure the success of this flight. A 18-year nearly Rs 230-crore programme which to have showcased India's space technology had come to naught. Scientists acknowledged that while the lift off was normal and there was no problem with the first two stages, the main purpose of the flight, which was to test the indigenous cryogenic engine was not successful.

At plant no 16 at the Godrej plant in Mumbai where the cryogenic engine was made, the workers became frustrated and disappointed when they heard about the failure. ``Many of them just left their work areas and went home that after-noon,'' remarked a senior official connected with the project at Godrej. Similar was the mood at Isro's Liquid Propulsion Systems Centre, Mahendra Giri in Tamilnadu where these engines are tested.

The failure set off speculation about the possible causes of the set back resulting in contradicting theories. A

technical inquiry is currently in progress to determine the cause of the failure and there is no indication as to when the findings would be publicised.

But a study of the flight showed that even though one of the big screens in the mission control room flashed that the cryogenic engine had ignited 304.9 seconds after lift off, many scientists kept saying that it had not started at all. The question then is who is correct—the screen or the scientists? It must be stated that information displayed on these screens is correct since it is hard data being transmitted directly from the rocket and the spacecraft.

Subsequently, ISRO chairman K.Radhakrishnan, announced that preliminary indications revealed that one of the possible causes for the rocket's deviation from its trajectory could be due to the failure of the two vernier thrusters which are a part of the cryogenic engine, to ignite. The main role of these thrusters is to provide attitude. Their failure to ignite led to a loss of controllability resulting in the rocket heading for the ocean instead of the sky!

What has surprised space scientists is the statement of Radhakrishnan expressing a degree of doubt whether the cryogenic engine itself had ignited despite the fact that the data on the screen indicated that it had started functioning 304.9 seconds after lift off.

On April 17 senior Isro scientists convened a meeting at the Vikram Sarabhai Space Centre in Thiruvanathanapuram to make a preliminary inquiry of the failure. Contrary to earlier reports they declared that the cryogenic engine did ignite in the vaccum of space. Their provisional conclusion was that the mission had failed after the turbo pump that supplied fuel to the cryogenic engine had stopped working, a second after ignition.

Radhakrishnan said that the next flight of the GSLV with an indigenous cryogenic engine will be in 2011. The failure has triggered a debate whether the GSLV which will carry, Chandrayaan-2---the second Indian moon mission, should be powered by a Russian cryogenic engine or an indigenous one. One school of thought says that since the mission was an important one, it would be advisable to rely on the proven Russian-made engine. Chandrayaan-2 is a joint Indo-Russian venture slated for lift off in 2013.

The next flight of the GSLV in a few months will use a Russian engine, since two more of these imported engines are still with ISRO.out of the six. Politically, the ill-fated GSLV with an indigenous cryogenic engine was an important mission, because in the 90s when India and Russia signed an agreement for the latter to supply six cryogenic engines to Isro for the GSLV programme, the US blocked the deal threatening Russia with economic sanctions. The US insisted that the deal flouted the Missile Technology Control Regime. At one point, Russia and the US reached an agreement and the former began supplying the engines to India, though after a considerable delay. This delay caused some amount of setback to the GSLV programme itself. Though Russia finally adhered to its commitment, India immediately set in motion an indigenous programme because it did not want to be once again become a victim of political feuds.

One of the points being raised by space experts is whether should ISRO have tested the indigenous cryogenic engine more thoroughly in vacuum conditions. ISRO says that the actual space environment cannot be simulated on the ground for such a test to be carried out. Facilities for such a test exist at the White Sands Test Facility in the US and in Russia too. But the chances of taking the engine to the US for such a test appeared to be slim because of political factors. But, then why not Russia? Isro needs to answer this question.

According to ISRO sources, scientists at the Ahmedabad-based Space Application Centre, which is a part of ISRO are upset that the G-Sat 4 ended up in the ocean. They say that since it was the very first flight of the GSLV with an indigenous cryogenic engine, ISRO should have flown a dummy payload first. G Sat-4 was experimenting some new technologies like electric propulsion system and a new bus management unit, which combines the functions of telemetry, tele-command, sensor electronics and control electronics. It had the Gagan navigation payload and the KA-band pipe regenerative transponder.

G-Sat 4 was the 19th geostationary satellite of India built by ISRO and fourth in the G-Sat series.

In addition to the technology experiments carried on board G Sat-4 there were:

- On board structural dynamics experiment to monitor on-orbit structural dynamic behaviour of the satellite during various phases of the mission.
- Velocity measurement package to measure the incremental velocity imparted to G Sat-4 during the liquid apogee motor firings and station keeping manoeuvres.
- Thermal control coating experiment to study the degradation characteristics of thermal control materials in space environment with time.

ISRO is now exploring the possibility of repeating some of these experiments on some of the future missions.

Immediately after the failure, chairman of the India chapter of the National Space Society, Suresh Naik, said that even in the US and Japan there was mission failures of rockets operated with cryogenic engines. Naik, a former ISRO official said that failures are pretty common in space flights.

The indigenous cryogenic engine was to operate in flight for 720 seconds. On the ground it was cumulatively evaluated for 7,767 seconds. It was tested for the first time on February 9, 2002. The advantage of cryogenic engines is that they are more efficient and provide more thrust for every kilogram of propellant it burns, compared to solid and liquid rocket engines. But, compared to the other two, cryogenic engines are very complex due to the use of propellants at extremely low temperatures. In December 2008, a major milestone was achieved with the flight acceptance test of the indigenous cryogenic engine.

But, two years later in April 2010, the real test failed.

End

India at Global Lunar Conference 2010 in China

From Pradeep Mohandas

Well, the Global Lunar Conference 2010 started on May 31. The programme listing is huge. The programme is co-organised by the Chinese Astronautical Society and the International Astronautical Federation. The Conference has papers from some interesting countries - Iran, Nigeria etc. Iran also talking about ways to explore the lunar water that Chandrayaan-I found in the permanently shadowed craters on the Moon.

I have listed below the **Indian contributions** which span mostly in technological and legal aspects of lunar exploration. The only University contributions come from SRM University and from across India.

- Terraforming the Moon with silicon utilizing organisms - Dr. Satadal Das, India.
- International Lunar Observatory update - Prof. U R Rao et. all
- L Band SAR Digital Receiver-Processor for ISRO's Chandrayaan-II mission, Nilesh Desai, Space Applications Centre, ISRO
- Testing of the first Indian Moon Mission - Challenges and Achievements - Vasantha Kumari et all, ISAC, ISRO
- Attitude Realisation with geometric constraints for Chandrayaan-I - Dr. Ramachandran Mankali et all, ISRO
- India's first lunar mission Chandrayaan-I Orbit Determination System, Dr. Narayanasetti Venkata Vignesham et. all ISRO
- Using Lunar Base for Electromagnetic Rail Guns in Planetary Defense, Archit Pandey, Lucknow
- Lunar Exploration by humankind, Perspectives on International Law, Global Science and International co-operation, Prof. S Bhatt, International Institute of Space Law, India.
- Property rights in Outer Space: Perspectives and Insights - Ketan Mukhejia, P&A Law Offices, India
- Property Rights on the Moon - Sourav Nath et all, National University of Juridicial Sciences, Kolkata, India
- Space Exploration and Utilisation: Moon - first milestone or roadblock - Mr. Mehmood Pracha, Organisation for Promotion of Legal Awareness
- Defining Boundaries of Space Law - Rohit Mukherji, Kolkata
- The Moon Treaty and its (in)effective role in better lunar governance - Ketan Mukhejia, P&A Law Offices, India
- Chandrayaan-I Lunar Laser Ranging Instrument Data Processing System - Deva Arul Daniel et all, ISAC, ISRO
- Selenary Civilisation - Abinash Kumar Swain et all,SRM University
- An Information System Suite for Chandrayaan-I by adapting space kernels - Mrs Umadevi Kannayan, ISAC, ISRO
- Attitude Determination System using signal observation from DGA and Sun Sensor for Chandrayaan-I - Ananth Krishna et. all, ISAC, ISRO
- The Shashi Settlement - Pallav Kumar Singh et all, SRM University
- Mounting of Star Sensors satisfying constraints of Chandrayaan-I lunar mission - Design and Realisation - Pandyan Ramalingam et all, ISAC, ISRO
- Compositional Variability of Basalts within Crater Le Monnier on the Eastern Edge of Mare Serentatis using Chandrayaan-I Hyper Spectral Imager (HySI) data - Dr. Prakash Chauhan, SAC, ISRO
- Khagol Shastra - Science of the Heavens - Amal Shaji Karapuzha et all, SRM University.

Most of the papers were really from China - almost as if they don't get to present anywhere else. There were also the presence of the Astrobiotics and Oddyssey Moon Teams who are competing for the Google Lunar X Prize,

There were reports from the ILEWG, and updates from the European Student Moon Orbiter. I do wish they had posted abstracts for each of the paper. **PM**

For more on this Conference, see pages x-x

China Accelerates Space Station Program

Source: http://www.space.com/news/china-prepares-for-space-station-100415.html

China is set on launching the first module of its space station next year, 2011.

Illustration of China's Tiangong 1 Space Station module

Over the next five years CNSA plans to complete the station as presently envisaged. It is likely that the third nation to launch humans into orbit will also be the third to deploy its own space station. In the meantime, Chinese astronaut Zhai Zhigang became his country's first space-walker as he hovered outside his Shenzhou 7 spacecraft September 27, 2008.

In addition to the Shenzhou manned capsules and to the Tiangong space station modules, China is working on a cargo carrier to serve the station. It will be comparable in size to Russia's Progress freighter, but smaller than Japan's H-II Transfer Vehicle (HTV) which also serves ISS.

Out of mutual technological respect, the US and China are discussing collaborations in space.

India, which is now building its own manned space capsule, has begun training its first class of astronauts, all with experience in the Indian Air Force. ISRO does not expect the first manned flight before 2016. But we would not be surprised if that milestone were advanced somewhat.

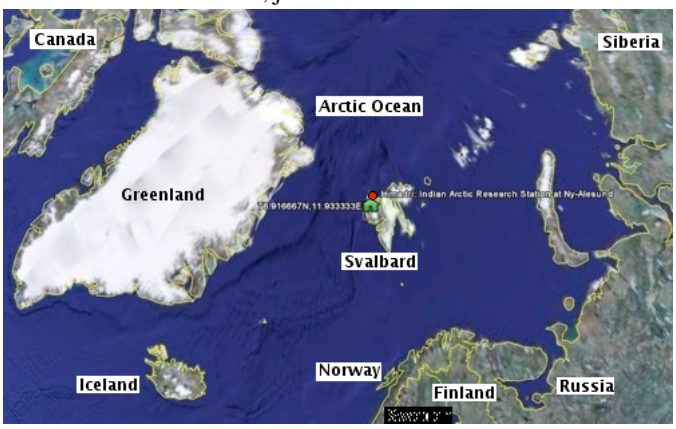
More and more, space is belonging to mankind as a whole! ***Editor***

India's Participation in the International Polar Science Effort Includes the Arctic

By Peter Kokh

On July 1, 2008, Union Science and Technology Minister Kapil Sibal inaugurated '**Himadri**' station in the international science outpost community of **Ny-Alesund**.

Wikipedia: - **Ny-Ålesund** ("New Ålesund") is one of the four permanent settlements on the island of Spitsbergen in the Svalbard archipelago. It is located on the Brøgger peninsula at Kongsfjorden. Like the rest of Svalbard, Ny-Ålesund is a full part of the Kingdom of Norway. At 78° 55' N 11° 55' E, Ny-Alesund is the northernmost permanent human settlement, just 1200 km from the North Pole.



http://www.thehindu.com/2008/07/02/stories/2008070253572000.htm

"With Himadri, India has become the 11th country to have established a full-fledged research station here. The others are Britain, Germany, France, Italy, China, Japan, South Korea, The Netherlands, Sweden and Norway.

"India began its Arctic research programme in August 2007 with five scientists. The National Centre for Antarctic and Ocean Research, an autonomous institution under the Ministry of Earth Sciences, will manage Himadri. Based in Goa, NCAOR has been coordinating India's polar research."

The Svalbard Global Seed Vault:

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

The international science effort here is largely focused on one critical project: The Svalbard Global Seed Vault; Nicknamed "the Doomsday Vault," the facility has been set up under a tripartite agreement between the Norwegian government, the Global Crop Diversity Trust and the Nordic Genetic Resource Centre. The primary funders of the trust are the Bill and Melinda Gates Foundation (Bill Gates is the founder of Microsoft), the United Kingdom, Norway, Australia, Switzerland and Sweden. India, Brazil, Ethiopia and Columbia have also contributed to the Trust.

> "The facility preserves a wide variety of plant seeds in an underground cavern. The seeds are duplicate samples, or "spare" copies, of seeds held in genebanks worldwide. The seed vault will provide insurance against the loss of seeds in genebanks, as well as a refuge for seeds in the case of large scale regional or global crises.' (Wikipedia source noted above)

Full size image of Seed Bank Repository at:
http://en.wikipedia.org/wiki/File:Svalbard_Global_Seed_Vault_main_entrance_1.jpg

A view of Ny-Alesund - Himadri Station is one of the buildings left from early coal-mining settlement days, the reason for the town's establishment

Himadri Station

Site Management: Kings Bay AS

http://www.kingsbay.no/

"Since 1916 the Norwegian public corporation Kings Bay AS (Kings Bay) has owned and run the worlds northernmost settlement named Ny-Ålesund. During the mining period (formerly Kings Bay Kull Company - KBKC) the firm ran the company town with up to 400 inhabitants. Shortly after the coal mining activity had been stopped in 1963, the Arctic research station started developing, mainly due to the Norwegian Polar Institute starting permanent scientific work in Ny-Ålesund, and the Norwegian Research Council (NTNF) was commisoned to run the station." ###

India Signs on to Thirty Meter Telescope

World's Largest Telescope opens in Hawaii in 2018

http://www.tmt.org/news-center/india-joins-thirty-meter-telescope-project

http://www.tmt.org/news/cosmic-lens.html

http://www.efytimes.com/e1/fullnews.asp?edid=47691

For decades, the 200" 5m Hale Telescope on Mt. Palomar in Southern California was considered the limit of technological capability. We are now long past those limits and the assumptions on which they stood. There are now ten telescopes (11, considering that the Keck 10m is a twin) larger than the Hale. But the current "number one" 10.4 m telescope in the Canary Islands (Spain) will sink to a very distant 2nd place with the construction of the TMT, the Thirty Meter Telescope to be built on Mauna Kea (extinct volcano) on Hawaii Island. The TMT is expected to be open for business sometime in 2018.

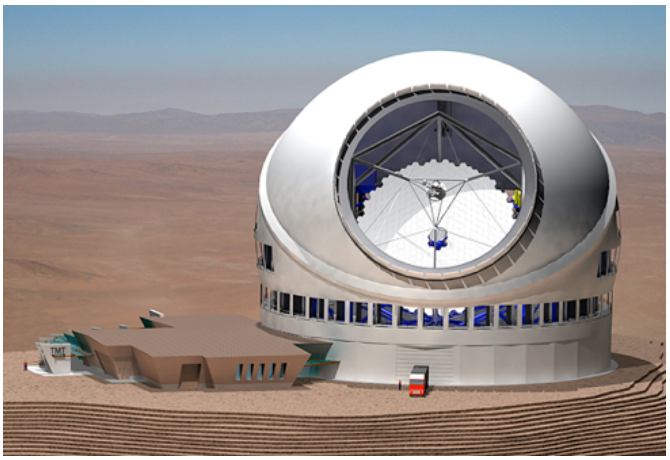
Many countries are signing up, and on June 24th, the Minister of Science and Technology of India, Mr. Prithviraj Chavan, announced the decision of India to join the Thirty Meter Telescope Project (TMT) as an Observer. During a ceremony in Washington, DC, Thirumalachari Ramasami, Secretary of India's Department of Science and Technology, said, "We believe the Thirty Meter Telescope will enable us to continue and expand our role as an international leader in technology development and fundamental research."

Work will begin on-site late next year on polishing the 30-meter primary mirror's 492 mirror segment blanks. Which will give TMT nine times the collecting area of today's largest optical telescopes and three times sharper images. This revolutionary telescope will integrate the latest innovations in precision control, segmented mirror design, and adaptive optics to correct for the blurring effect of Earth's atmosphere. For more details, see:

http://www.tmt.org/observatory

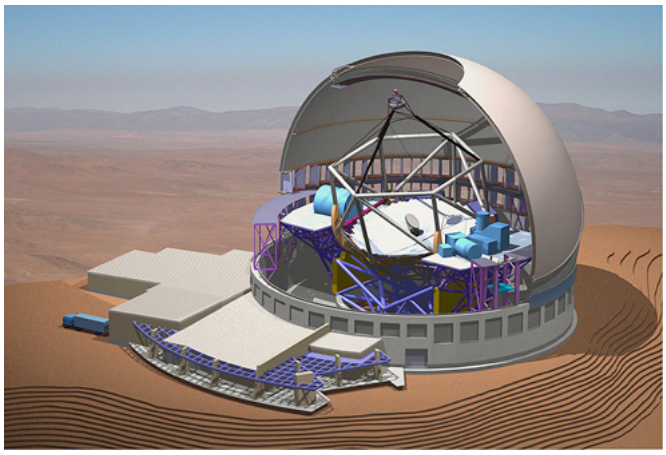
In addition to private foundations, Canada has been the principal national provider of funds to date and the Canadian partners propose to supply the enclosure, the telescope structure, and the first light adaptive optics. In proportion to the size of its population (34 million) is also the biggest contributor to the International Space Station.

The project has worldwide support from the Astronomical community as its "highest-priority large new project for ground-based astronomy."

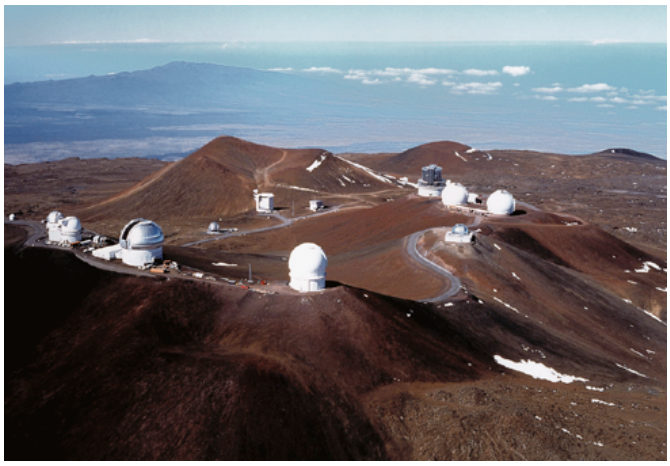


Previously, China and Japan had joined the growing list of international supporters. Funding has also been promised by Australia and South Korea.

TMT is a major research facility, and represents, along with the Atacama Large Millimeter Array (ALMA) in Chile, a level of financial investment in astronomical observatories on the ground well beyond anything done before. TMT will operate in the optical, near-infrared, and infrared wavelength ranges. Operation of the telescope will be through both the "classical" approach involving direct control by a PI and her or his team, and through a "service" mode, both utilizing an efficient queue-based observing approach for optimal efficiency.



This cutaway illustration reveals the basic structure of the TMT instrument itself.



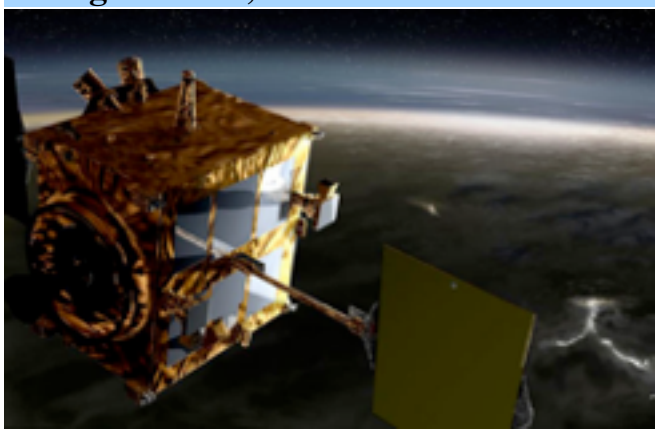
The current collection of telescopes on Mauna Kea

A rival 24 meter "Giant Magellan Telescope" is planned for Chile. Both TMT and GMT hope to produce images that far surpass those of the Hubble Space Telescope, but the James Webb Space Telescope may go even further. This is an exciting time for Astronomy, as one barrier after another, long thought to be invincible, is falling to new technological approaches.

Editor's Comment: There is a lesson here for rocket and space transportation technologies, where many feel that only minor improvements are possible. But just as the case with astronomy, when the best minds thought likewise, these "barriers" have proved to be **an artifact of unexamined assumptions.** We have moved beyond Astronomy 1.0 and it is time to move beyond Space Transportation 1.0 **PK**

Elsewhere in Asia

JAXA becomes 4th Space Agency to target Venus, 1st to launch Solar Sail



Akatsuki (Japanese: Dawn) formerly known as Venus Climate Orbiter and Planet-C

In Japan, it was early morning, Tuesday, May 18 (2144:14 GMT May 17th) when a JAXA H-2A rocket launched from the Tanegashima Space Center, carrying not only Japan's first mission to Venus, and its 3rd interplanetary mission.

Japan's Previous Interplanetary Missions
1985 ISAS: Sakigake/Suisei **Comet Halley** flyby
1998 ISAS: Nozomi (Planet-B) **Mars** Orbiter
2003 JAXA: **Asteroid Itokawa** sample return mission [capsule sample landed at Woomera, Australia, June 16th)

Akatsuki weighed 640 kilograms (1,400 lb) at launch, half that with fuel expended, and carries 34 kg (75 lb) of scientific instruments. Its solar panels provide 1200 w of power to its instruments. The probe is expected to enter an elliptical equatorial orbit around Venus this December. The period will be about 30 hours and it will range from 300 km above the planet to as far as 80,000 km.

Its mission is to study:

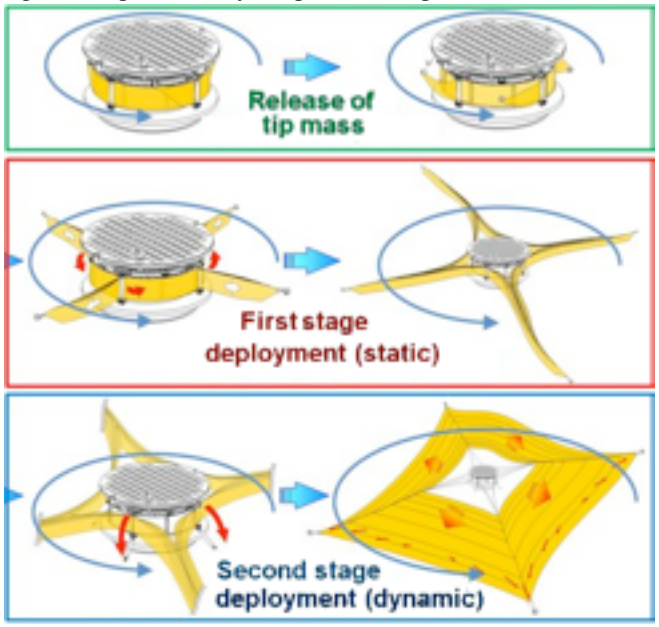
- lightning and airglow in visible wavelengths (552-777 nm)
- the structure of high-altitude clouds at a wavelength where they emit heat (10 μ)
- the distribution of specific atmospheric gases such as sulfur dioxide in ultraviolet wavelengths (293 to 365 nm)
- the heat radiation emitted from Venus' surface rocks (0.9 to 1.01 microns); could spot active volcanoes, if they exist
- the heat radiation emitted from the lower reaches of the atmosphere (1.65 to 2.32 μ)

Meanwhile, **Europe's Venus Express** entered orbit around Venus on April 11, 2006 and is still in orbit around the planet and functioning as expected.

IKAROS Solar Sail Hitchhikes a Ride towards the Sun

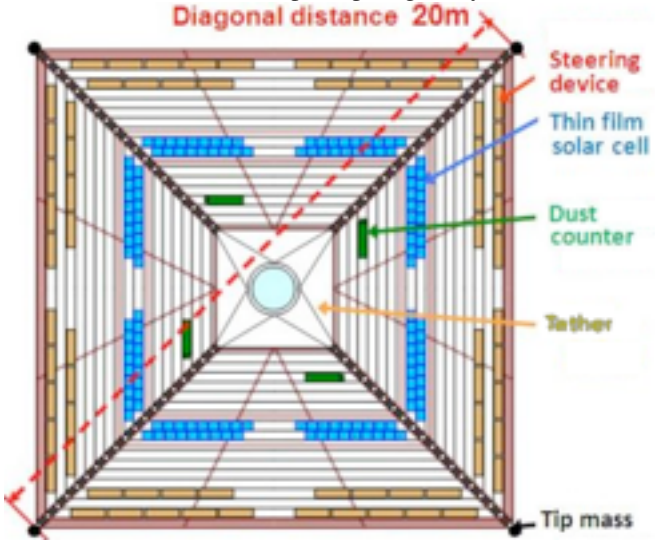
IKAROS (Interplanetary Kite-craft Accelerated by Radiation Of the Sun) is hardly the first solar sail project, but it is the first to launch to space successfully. The Planetary' Society's Cosmos 1 solar sail did indeed launch, but its Russian carrier rocket malfunctioned and the payload was lost. The Planetary Society is determined to try again, and has raised most of the money needed for its next attempt.

Ikaros is unique in that, in addition to the boost its large membrane gets from, it will also produce its own electricity from thin film solar cells on the: an elegant design choice! In another elegant design choice, unfurling of the sail membrane was accomplished June 11, 2010 by the centrifugal force produced by the probe's 20 rpm rotation.



Ikaros first mission is to prove its own ability to navigate and accelerate using sunlight, and by varying its orientation or posture relative to the sun. It is expected that solar sails can "tack" inward or outward much the same as terrestrial sailboats can by changing orientation to the wind.

The $1.3 M 186 m^2 sail, now fully unfurled, is large, some 20 meters measured tip to tip diagonally.



Ikaros' interplanetary itinerary is not known ##

South Korea's Space Ambitions Dealt a Setback as its Rocket Explodes in Space

June 10, 2010. After a 4th delay in a year the day before, the launch of South Korea's first rocket, designed and built with Russian help, ended in an explosive failure, 137 seconds after takeoff, at an altitude of 70 km. *South Korea has hoped to become only the 10th space-faring nation in the world.*

The Korea Space Launch Vehicle-1 (KSLV-1) had launched from the Naro Space Center on Oenarodo Island off the SW tip of the Korean Peninsula, some 485 miles S of Seoul. Naro-1, a previous rocket had successfully launched last August but failed to put its satellite into orbit.

South Korea is determined to join the ranks of nine other Space-faring nations. KARI engineers had made adjustments to the rocket's 2nd stage to reduce the likelihood of a flawed satellite release, which doomed the previous KSLV-1. At 33.5 m high, KSLV-1 should be able to launch a 100 k satellite into low orbit.

The payload was "Science and Technology Satellite No. 2 (STSAT-2)," designed by the Korea Advanced Institute of Science and Technology (KAIST) and the Gwangju Institute of Science and Technology (GIST). Their goal has been the development of advanced technology for small spacecraft, and the development and operation of "world-class space science payloads."

This satellite had two payloads: (main) DREAM (Dual-channel Radiometer for Earth and Atmosphere Monitoring) and (secondary) LRA (Laser Retroreflector Array). Their purpose was to study the effects of climate change ##

Malaysian Astronaut Datuk Dr Sheikh Muszaphar Shukor Stirs Nation's Youth

Shukor became the first Malaysian in space on October 10, 2007, hitching a ride to the International Space Station on board Soyuz TMA-11. Together with a second candidate, he had been trained for 18 months at Star City in Moskow. He is now planning to become a pilot as well.

Both Malaysian astronauts are heroes to the country's youth, inspiring them to take up careers in science and technology, as Malaysia continues its fast track development towards developed nation status. In turn, Shukor feels motivated by the young people he meets, to do his part in helping Malaysia succeed in its aspirations.

Shukor will be leading a hundred astronauts, from some 35 countries, on a tour across Malaysia during the week-long **23rd Planetary Congress of the Association of Space Explorers** to be held in Kuala Lumpur, during Space Week, October 4-10, later this year. During this tour, this very large and international group of astronauts will have a chance to meet and interact with more than 200,000 students. It almost makes one want to inquire about round-trip airfare to Kuala Lumpur! A hundred astronauts all at once! ##

Beijing Lunar Declaration 2010

International Assault on Moon's Secrets to Continue

From Bernard Foing, ILEWG Executive Director

467 International Lunar Explorers, registered delegates from 26 countries, assembled at **GLUC Global Lunar Conference** including the **11th ILEWG Conference on Exploration and Utilisation of the Moon (ICEUM11)** from 31 May to 3 June 2010, in Beijing. The GLUC-ICEUM11 was co-organised by the International Lunar Exploration Working Group (ILEWG), the International Astronautical Federation (IAF) and the Chinese Society of Astronautics (CSA), with the support of China Aerospace Science & Technology Corporation (CASC). More than 50 International and Chinese high-level officials attended the opening ceremony of the Global Lunar Conference and 400 students joined a Youth event at Beijing Institute of Technology.

The conference engaged scientists, engineers, enthusiast explorers, agencies and organisations in the discussion of recent results and activities and the review of plans for exploration. Space agency representatives gave the latest reports on their current lunar activities and programmes.

GLUC-ICEUM11 was a truly historical meeting that demonstrated the world-wide interest in lunar exploration, discovery, and science. More than 400 abstracts were accepted for oral and poster presentations in the technical sessions, organised in 32 sessions within 4 symposia: Science and Exploration; Technology and Resource Utilisation; Infrastructure and Human aspects; Moon, Space and Society.

The latest technical achievements and results of recent missions (SMART-1, Kaguya, Chandrayaan-1, Chang'E-1, LCROSS and LRO) were discussed at a plenary panel and technical sessions, with the Lunar Reconnaissance Orbiter (LRO) still in operation. Chang'E1 has generated many useful results for the community.

Four plenary panel sessions were conducted:

1. What are the plans?
2. New mission results;
3. From space stations & robotic precursors to lunar bases;
4. Moon, Space, Society

Participants summarised their findings and discussions and recommend:

To continue efforts by agencies and the community on previous ICEUM recommendations, and the continuation of the ILEWG forum, technical groups activities and pilot projects.

1. Science and exploration

- World-wide access to raw and derived (geophysical units) data products using consistent formats and coordinate systems will maximize return on investment. We call to develop and implement plans for generation, validation, and release of these data products. Data should be made available for scientific analysis and supporting the development and planning of future missions
- Outstanding Questions: Structure and composition of crust, mantle, and core and implications for the origin and evolution of the Earth-Moon system; Timing, origin, and consequences of late heavy bombardment; Impact processes and regolith evolution; Nature and origin of volatile emplacement; Implications for resource utilization. These questions require international cooperation and sharing of results in order to be answered in a cost-effective manner
- Ground truth information on the lunar far side is missing and needed to address many important scientific questions, e.g. with a sample return from South Pole-Aitken Basin
- Knowledge of the interior is poor relative to the surface, and is needed to address a number of key questions, e.g. with International Lunar Network for seismometry and other geophysical measurements
- Lunar missions will be driven by exploration, resource utilization, and science; we should consider minimum science payload for every mission, e.g., landers and rovers should carry instruments to determine surface composition and mineralogy
- It is felt important to have a shared database about previous missions available for free, so as to provide inputs to future missions, including a gap analysis of needed measurements. Highly resolved global data sets are required. Autonomous landing and hazard avoidance will depend on the best topographic map of the Moon, achievable by combining shared data.
- New topics such as life sciences, partial gravity processes on the Moon should be followed in relation to future exploration needs.

2. Technologies and resources

- A number of robotic missions to the Moon are now undertaken independently by various nations, with a degree of exchange of information and coordination. That should increase towards real cooperation, still allowing areas of competition for keeping the process active, cost-effective and faster.
- Lunar landers, pressurized lunar rover projects as presented from Europe, Asia and America are important steps that can create opportunities for international collaboration, within a coordinated village of robotic precursors and assistants to crew missions.
- Development, modernization of existing navigation capabilities, and provision of lunar positioning, navigation and data relay assets to support future robotic and human exploration. New concepts and new methods for transportation have attracted much attention and are of great potential.

3. Infrastructures and human aspects: From space stations & robotic precursors to lunar bases

- It is recommended to have technical sessions and activities dealing with different aspects of human adaptation to space environments, the modeling of subsystems, microbial protection and use of inflatable technologies

- While the Moon is the best and next logical step in human exploration, we should make best use of the space stations as stepping stones for exploration and human spaceflight beyond Low Earth Orbit.
- Further research is needed on lunar dust aspects in regard to humans and interaction with habitats. We note high interest in CELSS for Moon and Mars bases, and recommend further research and development.
- We recommend the development and use of terrestrial analogues research sites and facilities, for technology demonstrations, comparative geology and human performance research, and public engagement. We endorse the proposal of development of a site at La Reunion for international Moon-Mars analogue research.

4. Moon, Space, Society and Young Explorers

- We consider that the current legal regime as set out in the Outer Space Treaty and the Moon agreement are satisfactory for current and future missions, but may require further clarification for future exploration. Issues of transparency and security will need to be addressed.
- Great things are happening for Young Lunar Explorers, with inspiring missions and hands-on activities as coordinated by ILEWG. Lunar exploration is encouraging students of all ages to pursue higher education.
- More possibilities for participatory engagement should be offered to the society for example via interdisciplinary activities with the humanities.
- We appreciate the work from COSPAR panel on Exploration PEX that should be shared further.
- Continued cooperation should be enforced at all levels. The space community feels strongly that joining the forces of space faring nations to explore the Moon should be seriously implemented, with the views of expanding a Global Robotic Village and building in the long run a Manned International Lunar Base.
- We propose that a panel be formed through ILEWG with the help of IAF and Chinese Society of Astronautics in cooperation with space agencies, COSPAR and other stakeholders in order to initiate a permanent Inter-national Space Exploration Governance Forum.

We, the participants of the GLUC-ICEUM11 conference, commit to an enhanced global cooperation towards international lunar exploration for the benefit of humankind.

Endorsed by the delegates of GLUC-ICEUM11
Beijing, 2 June 2010

Hall in which the Technical Sessions were held

THE book WORM

Higher Hill Publishing Inc. (December 21, 2009) English
ISBN-10: 0984405801 **ISBN-13:** 978-0984405800
Paperback: 312 pages Review by Peter Kokh

http://www.Platinum-Moon.com/

Platinum Moon is **a science-fiction novel**, and the reason we are noting it, is that it is the first novel about opening the Lunar Frontier written after the recent "sea change" imposed by US President Barach Obama on NASA's future direction, with the cancellation of the Constellation Moon Program and strong emphasis on new technologies and commercial providers of launch services.

The novel is listed by Amazon.com (which has printed my personal review) but also has its own website, above. In the novel, the rush is on for lunar resources, in particular Platinum, a metal that is involved in a quarter of today's industrial and manufacturing operations, and would be crucial to the creation of a "hydrogen economy."

It is not NASA that opens the Moon, but a corporation whose ship is manned by an international crew from the US, France, and India. Just published, it is perhaps the most realistic novel yet written about the Moon.

A surprise to us, the author is a new member of the Moon Society. For more information, go to Amazon.com and search for "Platinum Moon." You will find Amazon.com's own synopsis, plus our review.

Science Fiction should not be dismissed. However "unrealistic", science fiction novels and stories have inspired many space enthusiasts, and even rocket scientists. **PK**

MMM-India Quarterly Editors:

Peter Kokh
kokhmmm@aol.com

www.lunarpedia.org/index.php?title=Peter_Kokh

Moon Society President
Editor:
Moon Miners' Manifesto

Madhu Thangavelu
thangavelu-girardey@cox.net
Mother from Kerala, father from Tamil Nadu, grew up in New Delhi. Now teaching at U. Southern California. Conductor, Graduate Space Exploration Concept Synthesis Studio USC Schools of Engineering & Architecture

David A. Dunlop
dunlop712@yahoo.com

Moon Society Director of Project Development

Exec. Director of LUNAX (LUnar National Agricultural eXperiment)

University of Luna Project

We are proud to introduce our newest co-editors

Srinivas Laxman
moonshotindia@gmail.com

Mumbai

Well-known space writer

Pradeep Mohandas
pradeep.mohandas@gmail.com
http://parallelspirals.blogspot.com/ - blog
moving to Coimbatore
Formerly President of SEDS India

Spotlight on our Editors: Madhu Thangavelu

Madhu Thangavelu conducts the ASTE 527 graduate Space Exploration Architectures Concept Synthesis Studio in the Astronautical Engineering Department within the Viterbi School of Engineering at the University of Southern California. [See p. 24] He also teaches the Arch599 Extreme Environment Habitation Design Seminar in the School of Architecture where he is a graduate thesis adviser.

Mr. Thangavelu's educational background is in Architecture (Masters in Building Science, USC School of Architecture) and in Engineering (Bachelors in Science and Engineering, NIT, India). Versions of Madhu's Masters thesis (conceived during ISU '88 at MIT) entitled "**MALEO: Modular Assembly in Low Earth Orbit. An Alternate Strategy for Lunar Base Establishment**" were published in several journals worldwide.

At USC, he was mentored by, and worked as a research assistant under the late Professor Eberhardt Rechtin, who established the System Architecting Engineering Program at USC. Professor Rechtin, together with the Deans of Engineering and Architecture Schools, was also instrumental in guiding the Space Exploration Architectures Concept Synthesis Studio curriculum through USC Graduate School. The studio was established in 1994.

Since 1992, he is a creative consultant to the aerospace and entertainment industry in this newly evolving field of space architectures complex concept synthesis. Mr. Thangavelu's concepts have been reviewed and appreciated by NASA, the National Research Council, the National Space Council (Bush Sr. Administration), and his work has been presented before the National Academy of Sciences.

He is an alumnus (1988 MIT), visiting lecturer at the International Space University (ISU) and co-chaired the Space Systems Analysis and Design Department at their 2002 summer session in California. He continues to present and publish original concepts in Space System Architectures and chairs related sessions at conferences.

He is also a co-author of the book "**The Moon: Resources, Future Development and Colonization**", John Wiley &Sons 1999, and second edition was published by Springer/Praxis in 2007. He is a former Vice Chairman for Education, Los Angeles Section of the American Institute Of Aeronautics and Astronautics (AIAA). He is director of Space Exploration Projects at the California Institute of Earth Art and Architecture. Most recently, his concept creation work was greatly appreciated for proposing ideas that pointed to the "leading-edge sensor concept" for return to flight of the space shuttle fleet.

Above: O'Paul Roy and Madhu

Mr. Thangavelu, his spouse, space system architect Catherine Girardey are both naturalized citizens and live with their children Chloe Saras (16), Chelsea-Manon (13) and O'Paul Roy (7) in Palos Verdes Estates, California

7 WONDERS of the Moon

"7 Wonders" of the Moon

An *"Armchair Pick"* by Peter Kokh

From orbit, as through any modest telescope, it will be quickly apparent that the Moon offers an unexpectedly diverse landscape. Eye-catching paintings of over-imaginative artists aside, (there are no craggy peaks untouched by erosion and few if any rough edges — all terrain features having been inexorably softened by the eons-long rain of micro-meteorites) this world does have some striking features all the same.

On Earth the rugged awesomeness of crustal rock outcrops and other features forged by a contest between brute geological forces and the relentless onslaughts of an ever active weather system are set in contrast to the beauty of vegetation in wild strobe-like stasis of species competing for niche space. On the sterile and barren Moon there is no such counterplay between geological awe and botanical beauty. Moonscapes, however otherwise dramatic or boring in feature, are all of one canvas in being displays of "magnificent desolation" (Buzz Aldrin, Apollo 11 landing crew, 7/20/'69).

Many humans are quite insensitive to natural beauty (e.g. "when you've seen one waterfall, mountain etc., you've seen them all.") and will react to the Moon in character: "when you've seen one crater, you've seen them all". To those of us with an eye for differences and especially to those of us with an appreciation of untamed geological drama, the Moon, *boring only to the boring,* boasts a wealth of spectacular vistas.

As on Earth, the most spectacular views of the terrain itself will be had from the unobstructed vantage points of high ground — from crater and ridge tops, mountain peaks, rille edges, and promontory points. These overlook craters and walled plains, the frozen lava seas of the maria, straight and sinuous valleys, rolling, cratered, and chaotic terrain etc. As on Earth, there will be sights that merit only local or regional fame, and those that deserve a place on the global honors list.

Here is an armchair selection of nominees for a place on the "Seven Wonders of the Moon" list, the pick of one Earth-bound, telescope-, moonglobe-, and lunar photographic atlas-equipped student of the surface of "Earth's significant other". Five of the Wonders on the list are surface features. Two spots are extra special treats in the lunar heavens.

Five Nearside Wonders of the Moon

1. Earth itself, an apparition in lunar nearside heavens with 3 1/2 times the breadth, blocking out 13 times as much of the starry skies, and shining with 60 times as much glaring brilliance as does the Moon as seen from Earth — all in a spinning ever changing marbleized riot of blues, greens, browns, and whites. It goes through the same series of sunlit, night-darkened phases, as does the Moon in our skies — with spectacular differences. "New Earth" when eclipsing the Sun during what we interpret as a Lunar Eclipse is a dark circle in the heavens crowned with the fiery ring of the sunset-sunrise line as sunlight scatters in the dust of the atmosphere. The night-darkened portion of the globe is in the last century increasingly "star-studded" with the city lights of burgeoning urban areas and oil and gas field burnoffs of "waste" natural gas and hydrogen. Meanwhile the frequent reflection of the Sun off ocean and ice accentuates the sunlit portions.

Full Earth illuminates moonscapes with sixty-some times as much brilliance as Full Moon brightens Earthscapes. This will be handy for getting about during the long lunar nights. But without a dust and water vapor laden atmosphere on the Moon, Earthshine shadows are inky black and impenetrable, and starlight is not drowned out. However, for the eye's pupils to open enough to appreciate the starry vistas, the brilliance of Earth must be baffled out of one's field of vision.

While Earthbound students can patiently study a seemingly eternally changeless Moon, lunar settlers and visitors who turn their gaze upon the Earth will have an unending drama of spectacular kaleidoscopic change to admire and study. It will be a treat without the distraction of flora and fauna and weather in the foreground, a Van Goghish canvas of color understatingly matted by black sky and gray regolith.

Astronomical painters such as Bonestell have tried to help us envision what it will be like to look upon Mars and the various other planets from the surfaces of their natural satel-lites. But the view from the Moon need take second place to none. Yet not all lunar settlers and visitors will be able to appreciate it with equal ease.

To paraphrase the opening sentence in Caesar's report on the Gallic Wars, "Omnis Luna in quattuor partibus divisa est": "All the Moon can be divided into four parts".

In the central part of the Nearside hemisphere, Earth is either directly overhead or at a very uncomfortably high angle above the horizon. Settlers might aptly nickname these central regions **"the Crooknecks"**. Included is most of Mare Imbrium, Mare Tranquilitatis, Mare Nectaris, Mare Serenitatis, Mare Vaporum, etc.

"The Postcardlands" are the peripheral portions of nearside, regions in which the Earth hovers perpetually a comfortable 5-40° above the horizon. Adjacent to these, straddling the "limb" of the lunar globe that forever keeps the same side turned towards Earth are **"the Peek-a-boos"**. Because the Moon's axis is not perpendicular to its orbit around the Earth and because that orbit is somewhat eccentric and the Moon travels faster when nearer Earth and slower when further away, all the while rotating at a fixed rate, about

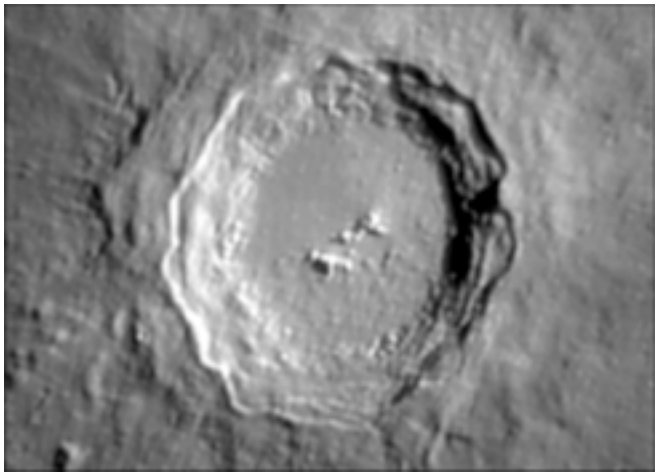
7° to either side of the 90° East and 90° West lines are alternately turned towards Earth and away from Earth. Taken together, the above three regions cover nearly 60% of the lunar surface.

The remaining 40+% is in **"the Obliviside"**, the Farside heartland from which Earth is never visible. This fact sets the scene for the last two Wonders on our list.

2. Copernicus. Nearside has many striking large craters. Any amateur astronomer who studies the Moon through a backyard telescope will recognize a couple dozen by location, appearance, and name. And each will have his/her favorites.

Even to the naked eye a few craters stand out a quarter million miles away. During Full Moon, **Tycho** in the mid-south is the radiant point of bright streaks of lighter regolith splash-out that stretch for thousands of miles. Smaller **Aristarchus** catches one's attention with the super-imposed brilliance of Venus. **Plato's** dark floor ("Academy Campus"?) can be picked out just north of Mare Imbrium, the Sea of Rains.

Through the binoculars even more can be easily recognized. But even though there are sixty-some other nearside craters as large or larger, easily the most striking of all, from Earth, is **Copernicus**. With its extensive debris slopes, it sits alone in southern Oceanus Procellarum, the Ocean of Storms, without neighboring rivals. **Mount Nicolaus*** at its center reveals a glory of detail. [* The author has published his suggestion that crater central peaks be known by the first name of the famous person after whom the host crater is named. They are otherwise known only as "central peak of ..."] A stunning low angle photo-mosaic of Copernicus taken by Lunar Orbiter 2 in late '66 was billed by the media as the "Photo of the Century". Indeed its psychological impact was without precedent.

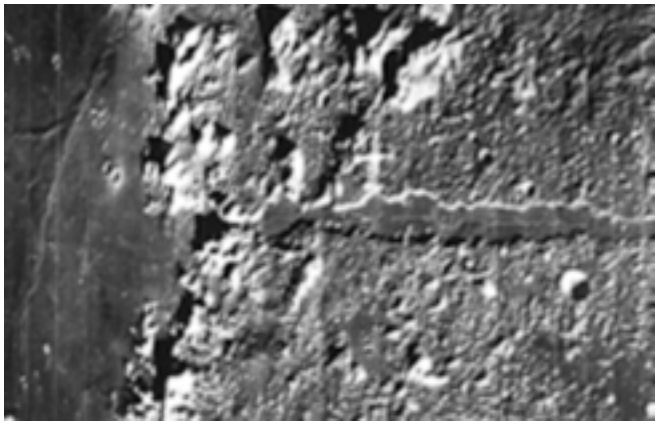


Early settlers will have as favorites prominent craters that lie in easy excursion reach of their settlement site. And it will be these that are first offered on itineraries of tourists from Earth. As tourist support infrastructure grows, however, those sights with world-class splendor will be offered. If Copernicus is not handy to the initial settlement site(s), it will soon be reached "by beaten path" nonetheless. In low gravity "sixth-weight" it should be easy enough to build an elevator-equipped observation room-capped tourist tower 2 miles (10,000 ft., 3 km) high atop Copernicus north rim to showcase the scene.

3. The Straight Wall. In southern Mare Nubium, the Sea of Clouds, lies a 90 mile long escarpment or cliff known as "The Straight Wall". Because it runs north and south, it is cast into high relief by the rising Sun and is very prominent in even a low-power scope a day after first quarter (first Half Moon).

While the "wall" is not really that high, this sunrise shadow play can be appreciated from surface viewpoints as well, especially those above the average elevation of the plain to the east [a mischievous use canonized by astronomers. The thought never crossed their ivory tower minds that the orientation of people on the surface might someday matter. What is the "eastern" hemisphere of the Moon *as seen from Earth* is really the "western" hemisphere from a lunar point of view as determined by the progress of sunrise and sunset.]. This feature probably does not deserve a thousand mile detour, but it is unique and special enough to be on the itinerary if established trade and travel routes pass nearby.

4. The Alpine Valley. Running like a *canal* through the mountainous terrain between Mare Imbrium and Mare Frigoris a couple of hundred miles east of Plato is an arrow-straight cut or trench, probably made by a massive piece of ejecta from the impact explosion that carved out the Imbrium basin. About a hundred miles long, it is sure to be a mainline route for traffic and utility lines between these two mare areas. All along the route there are high points to either side which must offer quite a vista. Some of these may one day host tourist lookouts, rest stops, and hotels.



5. The lavatubes. While we have strong evidence such features exist and in what kind of lunar terrain we are likely

to find them, we have yet to actually map, much less explore, even one. These cavernous wormholes made by subterranean rivers in the still cooling lava floods that, layer upon layer filled most of the Moon's larger impact basins over three and a half billion years ago. Some near surface tubes have partially or wholly collapsed to form broken or continuous sinuous rille valleys. But many others must lie intact, invaluable geological preserves as well as handy shelter for the more volume-hungry needs of lunar settlement and industry. Lavatube exploration is sure to be an honored lunar "outlocks" activity.

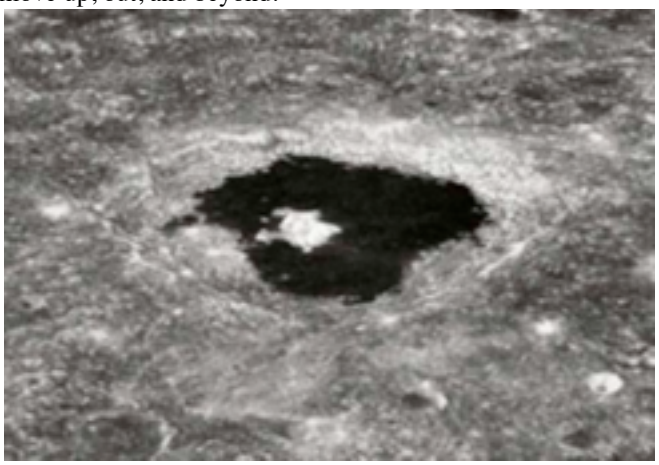
Two Farside Wonders of the Moon

6. The Milky Way. One of the lesser-recognized ways in which we are allowing our terrestrial environment to continue to degrade is urban nocturnal light pollution. Today there are millions of youth who have never seen the Milky Way. For those of us fortunate to live in or visit at least occasionally, countryside areas well outside built-up populated areas, the sight of the Milky Way in dark star-bedazzled skies is unforgettable. But we glimpse it at the bottom of an wet and dusty atmospheric ocean. Even in mid-desert where on cold crisp nights the seeing is best, we are somewhat handicapped.

On the lunar surface, atmosphere is absent. But anywhere in the Nearside Crooknecks or Postcardlands, and part of the time in the Peekaboos, there is the distracting brilliance of Earthlight that must be baffled not only from view, but from reflection on one's helmet visor.

It is in Farside during nightspan, with both Earth and Sun below the horizon, that the Milky Way shines in full undampened, unchallenged glory. To look up from such a vantage point and scan this river of star clouds as it arches across the heavens from horizon to horizon is a treat no human has yet experienced. For those with soul enough to appreciate it, this awesome sight will be *a*, for some *the*, reason to visit, or settle in, Farside. Many will choose the peripheral Peekaboos along the limb, for in these areas one can enjoy both the Milky Way, and Earthrise/Earthset, alternately.

7. Tsiolkovsky. The standard approach and landing trajectory that ships bearing settlers, tourists, and visitors will take to surface settlements will bring them in on a descent swing around Farside. Mare Orientalis, the dramatic bullseye-shaped Eastern Sea (misnamed because it is in the *western* Peekaboos) will be the feature most watched for, if, of course, it be sunlit at the moment. But deep in Farside, again depending on the time of sunth, another spectacle awaits them, to this writer's eye the most dramatic crater on the Moon — Tsiolkovsky, aptly named after he who taught us that Earth is but our cradle, and that it was our destiny to move up, out, and beyond.



Like Plato and Grimaldi on Nearside, Tsiolkovsky's basin is flooded with mare-like deposits — in its case some of the darkest mare regolith to be found anywhere on the Moon. This only serves to set off even more strikingly the **Mount Konstantin** massif that dominates Tsiolkovsky's interior. What a perch for a monastery or Shangrila!

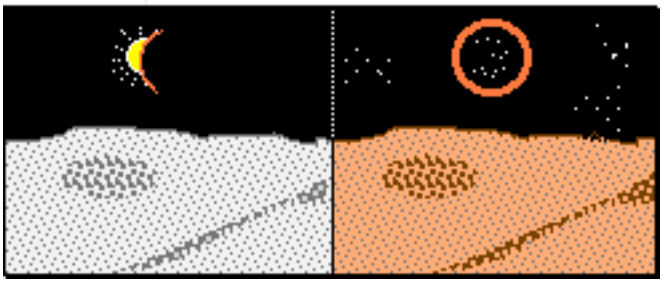
If the day comes when human settlements in the solar system organize in some politically cooperative way, what better site for a capital or headquarters than on Tsiolkovsky's dark flat floor south of the Konstantin massif. It is handy enough to Earth on which most of humanity will continue to live for a long time to come. Yet its horizons face away from the hidden cradle world out upon a Milky Way-crowned universe of unlimited opportunity. And who could pick a better name? It's frosting on the cake that those approaching from space could pick it out instantly by naked eye a half million miles out

National Parks and other Preserves

Any discussion of great natural wonders would be incomplete without considering what we might to do preserve such heritage. **Scenic Preserves** would establish regulations restricting buildings, road placement, and other developments in the foreground or background visible from scenic overlook sites. **Geological Preserves** would go further, protecting not only specific viewpoints but the physical feature itself from development, some types of mining, etc. Designation as a **National Park** would signify the intention to develop tourist and other recreational use facilities nearby so that the feature could be popularly enjoyed in a controlled fashion, as well as preserved from other types of development.

There is the added question of preservation of scenic orbital perspectives, i.e. of preventing developments that might be defacing on a large scale. Given the impotency of efforts to control forest clear-cutting in the Pacific Northwest where ugly scars that seem to grow cancerously insult anyone peering out an airplane window, lunar authorities will have to insulate themselves from the palm-grease of developers if they are to have any luck. But solving the future's problems is the chore of those alive at the time. We can but warn. ##

Postscript: I first wrote this essay in the Fall of 1993. I was looking at the Moon as it "always was." Not quite ten years later, in the Spring of 2003, it occurred to me that there was another "wonder" – one that was temporary and passing, but repetitive – **being anywhere outside** (or "out-vac" as I call it) **on the Moon's nearside, *during a total lunar eclipse* (as seen from Earth.**

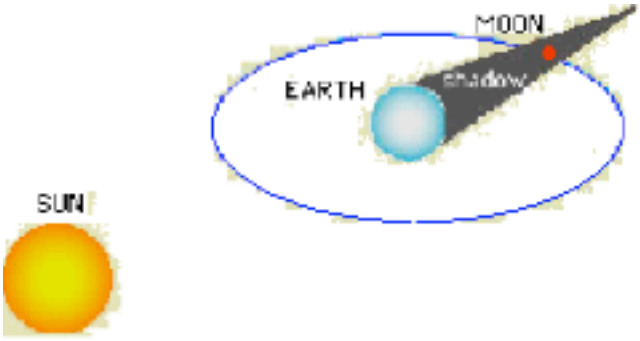


Experiencing Eclipses on the Moon

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

Most everyone has seen a total lunar eclipse at one time or another. They aren't all that rare. But no one has ever experienced such an event from the Moon's surface. What would the experience be like? What would we see in the lunar heavens? How would it transform the appearance of the surrounding moonscape?

For observers on the Moon, what we Earth-dwellers experience as an eclipse of the Moon, will for them, be an eclipse of the Sun, our home star disappearing behind the Earth. So the phenomenon that they would/will experience will bear closer comparison to the one that those fortunate enough to have seen a total solar eclipse on Earth have felt.



Shown: Moon passing thru Shadow Cone (Umbra)

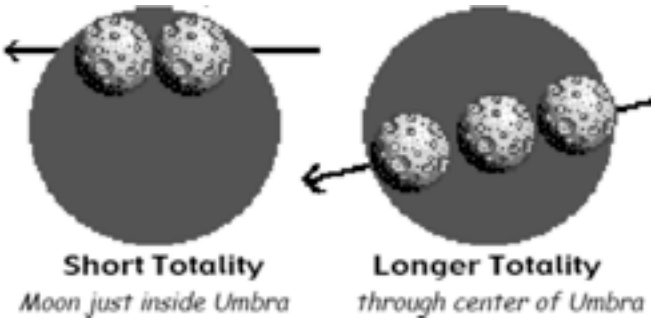
Let's try to visualize and feel the sight and impressions that would-be future Lunan pioneers can anticipate.

Comparisons

Those of you fortunate enough to have witnessed totality in a total solar eclipse (anything even a tad short of totality counts as zilch - yes, there is that much difference) were probably as little prepared for the overwhelming effect of the experience on oneself as I was, when I saw my first from Minot, North Dakota in February 1978. The sky darkens gradually, suddenly going black, as the Sun disappears and the stars come out, in what should be bright daylight. Where the Sun had been there appears in its place a very black hole in the sky surrounded by a ring of flames, the corona. Meanwhile the air temperature drops some tens of degrees, and an eerie silence falls. For many first time witnesses, the experience is so unexpectedly transfixing that the goal of seeing yet another total eclipse suddenly soars out of nowhere to somewhere near the top of one's personal life agenda. For me, that quest next led to Bratsk, Siberia in August, 1981.

Much of the magic of this experience arises out of an unlikely coincidence. The size and distance of the Moon makes its apparent size vary from just smaller to just a bit larger than the apparent size of the Sun. Total solar eclipses occur in the latter case. Because of the close approximation in apparent size, totality is brief, commonly two minutes give or take, with a maximum of seven.

But from the Moon, Earth's apparent diameter is some three and a half times as great as that of the Sun. When the Sun disappears behind the edge of the Earth, it will take quite a bit longer before it peeks out from the other side. Totality on the Moon can last some three hours.



Moon just inside Umbra through center of Umbra

For us on Earth, during totality, the Sun's flaming corona can be seen surrounding the black hole in the sky that is the Earth. From the Moon, the Sun's corona will also be eclipsed for most of totality. However, the black Earth will sprout its own "coronalet" as sunlight beaming down upon the hemisphere of Earth turned away from the Moon, lights up the dust in the atmosphere. This light is refracted into the shadow cone. Portions of the Moon passing closer to the edge of the Umbra will be brighter, those closest to the mid-umbra darker. Clouds and volcanic dust in Earth's atmosphere will also have an effect so the actual appearance, brightness, colors and color variation will change throughout the event and differ from eclipse to eclipse.

Watchers on the Moon will see an unbroken ring of sunsets and sunrises, much less brilliant than the Sun's corona, but also much larger in diameter, and an awesome sight. Stars hidden by the Sun's glare will reappear in the sky. The glow from this 'coronalet' will repaint the Moon's surface in very unmoonlike hues. For the pioneers, it will be a magical time in which they might imagine themselves transported to deep twilight on Mars! The direction and length of shadows will not change from what they would be if the Earth were not blocking the Sun. But the edges of shadows will be much fuzzier, contrasts less sharp. Familiar moonscapes will reveal themselves in this whole new light.

For crews, tourists, and settlers on the Moon's nearside, it will be an unforgettable experience. While for them, this will be a "solar" eclipse, the real show will be on

the Moon's surface, with the show in the sky just completing the "Landscape." That's in contrast to the experience of solar eclipses on Earth where the main event is in the sky. For a treatment of the coloration and brightness-darkness of the Moon during Umbra, see "Danjon Scale:"

http://sunearth.gsfc.nasa.gov/eclipse/OH/Danjon.html

Timing and Frequency

How often do these events occur? The Moon's orbit around Earth is tipped some 5 ° to Earth's orbit around the Sun, so the Moon spends most of the time either above or below the plane of Earth's orbit and does not pass through Earth's shadow every orbit. There can be as many as three eclipses a year, as few as zero. Only a third are total. While one seldom sees either lunar or solar eclipses noted on calendars - (just the phases of the Moon) "umbra" dates are likely to be noted on Lunan calendars. Where on the Moon Eclipses will be visible

The Umbra Experience is only visible on the Earthfacing side of the Moon. That means that the Sky Show of black Earth outlined by the ruddy sunrise-sunset ring of dust-refracted sunlight will be high overhead in the central areas of nearside (the "crooknecks") and at more comfortable elevations above the horizon nearer the limbs (in the "post-ardlands"). Some events may be visible in the limb regions, others not, depending on the angle of libration (variance from facing Earth dead-on) at the time.

Both the proposed Angus Bay and North Junction sites will offer comfortable viewing, with Earth some 20- 30° above the horizons, with shadows of mid-range length. In contrast, at a site near the center of nearside, not only would the sky show be directly overhead (zenith), but there would be no shadows, it being a high "un-noon" situation. Tourists coming from Earth to experience the umbra will head to areas closer to, or in the limb region. Umbra will occur early in dayspan for areas east of the Earth-facing meridian, at mid-dayspan along that meridian, and later in dayspan for areas to the west. Impact on frontier culture

The Moon is a world of gray shades, overwhelmingly so. Indeed, Lunans will be challenged to infuse their homes and settlement areas with color to make up for the sensory deprivation that greets them out on the surface. To be able to view familiar out-vac surroundings through the filter of sunlight refracted through Earth's dusty sunrises and sunsets will bring periodic relief and delight. Umbra will also provide the best viewing of the many clusters of city lights on Earth's nightside, framed in the sunrise-sunset ring.

The hours-long event will be occasion enough to let kids out of school, even workers. Umbra could even become a holiday of sorts. For these pioneers, who will have given up much that we take for granted, who can begrudge them this periodic pleasure. Add to that, that each Umbra will be different, and the same event will be experienced differently in various places on the Moon. **M3IQ**

Postscript: Umbra-clad moonscapes

Where one is on the Moon will make quite a difference. The relative brightness of the brighter highlands and darker maria (lava plains or "seas") will be much the same. The reddish umbra light may make some areas stand out. Shadows will be in reduced contrast with the umbra-lit areas and have softened edges (owing to the greater diameter of Earth's sunrise-sunset ring than the angular size of the sun's disk), but in the same direction.

During a short totality, portions of the Moon nearest the edge of the umbra shadow remain relatively bright, where as portions deeper within the umbra are considerably darker. For pioneers, the brightness or darkness of the eclipse "twilight" and of surrounding moonscapes will depend on one's position on nearside relative to the umbra center.

Popular vantage points - The spectacle will be more comfortably viewed *the further one is from the center of nearside (the closer to the horizon Earth sits in the lunar "sky.")* Vantage points that include both mare and highland terrain in the foreground will be more interesting. "Experts" and Umbra devotees may seek out special vantage points. Visiting Tourists - *People will come to the Moon from Earth, even from Mars, to experience the brief spectacle.*

Because of demand, prices for Lunar Eclipse Excursions flights to the Moon, or even just to loop around during the event, may be higher than other flights. An eclipse experience would highlight a visit The Spectacle of Earth's city lights. I think that the Nearside Umbra experience (by far the best to view Earth's city lights) should be added to the list oif "7" Wonders of the Moon, expanding the list to eight, or demoting the Straight Wall, but why do that? The others: (Nearside) Copernicus (or other major crater), Alpine Valley, Lavatubes; (Farside) Tsiolkovsky, and the heavenly splendor of the Milky Way. **M3IQ**

Color the Moon

"anything but gray?"

By Peter Kokh

Moonscapes are studies in graytones from near black to near white. Exceptions are rare. When Apollo astronauts stumbled on a small patch of regolith with a faint orange tint to it, there was a great deal of excitement on two worlds.

Living in such an environment while maintaining morale will require doing something about this situation of sensory deprivation. We have the capacity to see colors, and as in other matters, appetite follows capacity. Colorizing the lunar environment, both in indoor and out-vac settings, will take some careful forethought and prior experimentation. There follows a short quote from the previous article cited.

> The principal avenues for introducing color on the Moon as in Space Settlements built mostly of lunar materials are these: **1)** luxuriant **green vegetation** and colored foliage and flowers; **2)** naturally **colored cotton** and natural **organic fabric dyes** that do not stress water recycling systems; **3) vitreous stains** for coloring glass and glazing ceramics; **4) inorganic "paints"** that do not tie up precious carbon or nitrogen; finally **5)** colored **"neon" lighting** using noble gases scavenged from regolith-moving activities.

In this article, we'd like to talk about bringing color to the Lunar outdoors. Now that may sound a bit ambitious! We do not mean to colorize whole moonscapes, only the external faces of settlement structures: the shielding mounds, the airlock "porches," etc. things that personalize one family's homestead from another's when viewed from out-vac, from out on the surface.

• See MMM #55 May 1992, p 7. MOON ROOFS.
This article has been republished in MMM Classics #6, available as a free download pdf file from
http://www.moonsociety.org/publications/mmm_classics/

Early Colorizing Agents

Perhaps the first colorizing agent to appear will be rust-ochre from harvested pure iron fines that are allowed to oxidize in a humid environment. This will happen quite naturally inside lunar homesteads if regolith is brought inside along with large rocks to create a Japanese style sand garden. The regolith will have to be sifted to remove the troublesome fine powder portion, but any of the iron fines remaining, or any large particles to which iron fines adhere. will inevitably rust. This will be a welcome "splash" of color.

Regolith shielding mounds could be lightly "dusted" with rusted iron fines to customize it. As this would be but a thin coating, in a windless environment, a little will do.

Probably next will be white. Lime, calcium oxide, can be produced from highland regolith which is very rich in calcium. But perhaps the first source of white dust available to those who want to put their digs in the "limelight" will be titanium dioxide, a byproduct of producing iron and oxygen from ilmenite, FeTiO3, Iron Titanium Oxide.

Ilmentie is not found everywhere. Regolith rich in this ore is very dark, the Taurus-Littrow valley Apollo 17 site being an example. But it offers one of the easiest routes for both oxygen and iron extraction, with titanium dioxide as a byproduct. Oddly, the very same people who propose beginning lunar industry with ilmenite want us to go to the polar "eternal light" sites, and the two are nowhere collocated. But assuming NASA and the planetary scientist bandwagon comes to its senses and does not choose a polar dead end site, ilmenite-derived white TiO2 may be available early on.

Now many of the virtually unlimited colors we are used to enjoying will not be sourceabe on the Moon because they incorporate one or more elements found on the Moon only in trace proportions: copper, lead, cadmium, etc. – or they organic compounds, many of them derived from petroleum and other fossil-derived deposits.

But some feasible alternative options include:

- **Pale Yellow:** Sulfur, as a pale yellow powder, alone, or mixed with titanium dioxide, it could give a faintly creamy look to surfaces dusted with it.
- **Red:** aluminum oxide mixed 4:1 with ferric oxide Fe2O3. A spinel, FeO.Fe2O3, produces a darker red. A tomato red can be prepared from Uranium oxide, which likely can be found with known Thorium deposits
- **Red-brown:** (in addition to rusted iron) might include the reddish brown of iron chromate FeO.Cr2O3, the Indian red-brown of magnesium-iron oxide MgO.Fe2O3, and the red-brown manganese titanate MnTiO4
- **Pink:** the least expensive approximation of pink will be a mixture of iron oxide rust with white lime or titanium dioxide. Feasible alternatives are a manganese-alumina pink and a chromium-alumina pinkish red. Cobalt-magnesium combinations might produce a pink to lilac range .
- **Yellow:** in addition to the pale yellow of sulfur, the only feasible options would seem to be vanadium-zirconium and titanium-iron oxide preparation
- **Orange:** the cheapest route is adding iron rust to sulfur powder, *slowly*.
- **Green:** The deep emerald green of chromium oxide may be the standby. This could be blended with available yellows and blues to produce neighboring tints. Chromium oxide can also be pasteled by adding titanium dioxide. Later on, and more expensive to prepare, a blend of yellowing vanadium and bluing zircon in the presence of sodium fluoride (if fluorine can be produced, a difficult but high industrial priority) is an option. Praseodymium (from KREEP deposits) phosphate with a calcium fluoride additive is another.
- **Blues:** Cobalt aluminate yields the most beautiful matte blue*, and cobalt silicates and oxides produce mazarine blue, royal blue, flow blue, and willow blue. A titania-alumina blue, TiO2.Al2O3, with a corundum structure is a possibility but hard to prepare by synthesis as opposed to starting with Ti-rich bauxite. Alternatives include a vanadium-zirconia blue and a silica-zirconia-vanadia-sodium fluoride system of blues, turquoises and greens.

* *at a local chemical supply house, I paid $128 for a few ounces of cobaltous aluminate in 1995. So blue will not be cheap. However it can be mixed with lime or titanium dioxide to produce lighter pastel tints , or with manganese dioxide or ferrous oxide black to produce grayed blues for a proportionately diluted bottom line.*

Back to our Out-vac Applications

To colorize anything out-vac, (out on the vacuum washed surface) by dusting stabilized surfaces with colored powder will not be cheap both because of the expense of preparing some of these powders, and because of the amount needed to make an effect on large surfaces. We can predict that except for iron oxide rust, titanium dioxide white, calcium oxide white, and sulfur yellow, all of the above mentioned compounds would be too expensive to apply liberally. In that case, except for those to whom money is no object, *we are talking about subtle colorations, tinted grays, not expanses of pure colors*. The less you can afford to shell out, the more subtle the color shading of the basic regolith. That said, one could fairly cheaply specify lighter highland regolith, and against that background, less colorizing powder will go further.

Grayed Colors as particularly appropriate

For the visitor or traveler, to come upon a patch of surface that was colored in some pure, ungrayed fashion, would probably be offensive and grotesque. Gray regolith tinted with colorants, however, would seem to pay due homage and respect to the host terrain. Regolith mounds so shaded would stand out, but not garishly. They would set the tone of synthesizing human tastes with the host palette.

Lime white, and iron rust will be the two options inexpensive enough to be used liberally so as to minimize graying by the regolith on which they are dusted.

Now there will be gaudier displays of color out-vac, but in the form of road-signs etc. where there is a need to have the item in question stand proud from the surface so as to be recognized and understood. But our point is that we can subtly colorize the external manifests of human occupation on the Moon while still paying all due respect and blending in. We wonted be substituting pure colors for gray. We will be subtly colorizing the grays. This economics-reinforced practice will serve to wave our basic human pride, and at the same time proclaim to all that we are proud to be Lunans. Grayed colors will be part of Lunan culture. **M3IQ**

Colorizing Lunar Frontier Interiors

By Peter Kokh

In the previous article, we mentioned that moon dust, exposed to humidity, will take on a rusty hue. What could be easier than that to break the stranglehold of a monotonously black-gray world! Of course, green vegetation and flowers will be most welcome as well, but those are imports, but very complementary ones.

Rusting Regolith - Lightly steaming moondust in a tumbler drum will rust the iron fines that pervade the sample. Putting the dried rust in molds, and then sintering it, could create "***Luna Cotta***" flowerpots, bowls for a fountain, sculptures, and other desired decorative and/or functional objects. *Terra Cotta* has always provided a good color contrast for the greens of vegetation, and may be the easiest way (other than plants and flowers) to bring refreshing dabs of color into early pioneer living spaces.

Early relief from black-gray-white monotones

Here we want to talk about how we can escape from black-gray monotony using the Moon's own mineral resources to produce an "indigenously-derived" color wheel.

The first "Period" of lunar décor will be dominated by the simple palette of a range of near-black to near-white moon dust tones, ***with welcome relief by rust hues and shades.***

In the early days of photography, we had something similar, thanks to the availability of a natural ink excuded by cuttlefish: "sepia" (from the Greek word for cuttlefish, which belong to the cephalopods, which include the octopus and the squid.) Below are two forms of a photograph, one in black and white tones, the second in sepia tones. If we could add rust tones and hues to the moontones palette, that woud be most welcome!

Given that common early frontier building materials such as steel, aluminum, concrete, and basalt will tend to be in the white-gray-black palette, the addition of terra cotta like pottery and sepia-like paintings will be welcome visual relief, complemented, of course, with abundant indoor vegetation for a wealth of greens, and some floral colors.

Lighting can help

In time, as neon and other noble gasses are retrieved from the upper moondust layer, colored "neon lighting" may be an option. These elements are brought tot he Moon by the solar wind and become affixed to the fine surface particles. Another option is stained glass lampshades and lamp bulbs themselves. These options will allow bathing otherwise white or whitish walls with color.

Fabric wall hangings?

While used fabrics are something we will want to biodegrade and feed back into the biosphere, perhaps some worn apparel can be woven or otherwise transformed into wall hanging rugs, macramé and other items to give homestead interiors a welcome splash of colors other than gray tones. We now have naturally colored cotton strains. Organic dyes can also help. If there is one thing universal about pioneers throughout history and worldwide, it is their resourcefulness and ingenuity. "Necessity is the Mother of Invention!" We will see that proverb verified many times over on the early human lunar frontier! **M3IQ**

Moon Society, India *update*

By Pradeep Mohandas, Secretary

First up, let me introduce you to the newest addition to our Executive Committee, **Mamta Bharati**. She is from the Netaji Subhas Institute of Technology (NSIT), New Delhi. She is currently doing her instrumentation engineering and has participated in projects related to Formula SAE (Society of Automotive Engineers) etc.

Second, we'd like to thank **Avinash Siravuru** for being a great liaison between SEDS and the Moon Society. He also showed interest and is part of our new Executive Committee. Replacing him as the SEDS-Moon Society liaison will be **Komal Agrawal**.

The Moon Society, India opened provisional membership to members interested in joining Moon Society, India. We started getting enquiries for membership and we thought we should not let these people go and at least should keep them in the loop. To do this, we devised something called provisional membership. This is temporary in nature, does not carry any fee and only gives us access to people who are interested in the idea of Moon Society, India as a way of keeping in touch. The provisional list is now at 25 members including members of the Executive Committee. The membership is being given only to people residing in the Union of India.

Jayashree is working on recruiting 3 other Executive Committee members.

The bye-laws must be read by all members of the Executive Committee. I am waiting for the 3 Executive Committee members to be recruited and for them to go through and acknowledge that they have read the draft and suggest changes, comments etc. All these will be incorporated into the Draft 1 document. Draft 2 will be created separately. This enables a transparent process, enables future members to see what we had in mind in drafting the bye-laws and above all ensures that I don't end up drafting a bye-law which will help no one but me. I also have an interest since this distributed ownership means that I cannot be blamed alone. :)

May and June being exam months in India have seen reduced activity but I hope this will pick up once this phase is gone through.

Warm regards,
Pradeep Mohandas.
moonsocietyindia@gmail.com

SEDS India National Conference 2010

LUNAR TREK

An event co-sponsored by:

THE MOON SOCIETY, India

INTRODUCTION:

SEDS India National Conference is a conference organised for and by the technical science students, providing an opportunity for the young space enthusiasts for those who are looking for a career in space science as it brings them into direct contact with the leaders of Indian Space Research. Not only does it aim to bring space science and technology to the forefront, but it also gives a platform to the young minds to present their innovative ideas towards the development of the same.

This year it was enriched with interactive guest lectures by the likes of Mr. Srinivas Laxman, along with workshops and a plethora of events. It was indeed a "Progeny of Astral Thoughts"!

It was successfully conducted this year on 10th and 11th April and over 135 participants from all over the country participated in it.

Contributing to the vision of Mr. Madhavan Nair which is to launch a rover to the moon in the form of Chandrayaan-II (based on a Russian design), we had **Lunar Trek 2.0** – the second annual national level moon rover design competition. This event required the budding engineers, whose mind's eye flutters past the starry firmament, to demonstrate their aptitude in fabricating a rover which zooms on the rugged Lunar Terrain.

EVENT DETAILS

The Problem Statement was to steer a rover through the uneven terrain and to place a rock sample (5 cm x 5cm x 5 cm) that it is carrying in the predefined test facilities where it shall be analyzed and at the starting point the robot dimensions were not to exceed 20cm x 20cm x 15cm, however it may expand once it starts moving.

The course consisted of loose sand, clay, course aggregate and cement, pit falls and boulders.(2.4 m x 2.1 m). The track was prepared by the student organisers of the event. They spent Rs. 4000 in procuring the raw materials needed.

JUDGEMENT CRITERIA:

The organisers came up with a formula to fairly choose the winner. The participant with maximum number of points based on the following calculations was to be the winner.

Formula Used - [d/(t+w)]+p+e

Where,
D - distance
T - time
W - weight of the rover
P - no. of pits crossed
E - no. of hills crossed

The event was sponsored by **MOON SOCIETY OF INDIA**, a non-profit educational and scientific foundation formed to further scientific study and development of the moon.

A FEW SNAPSHOTS

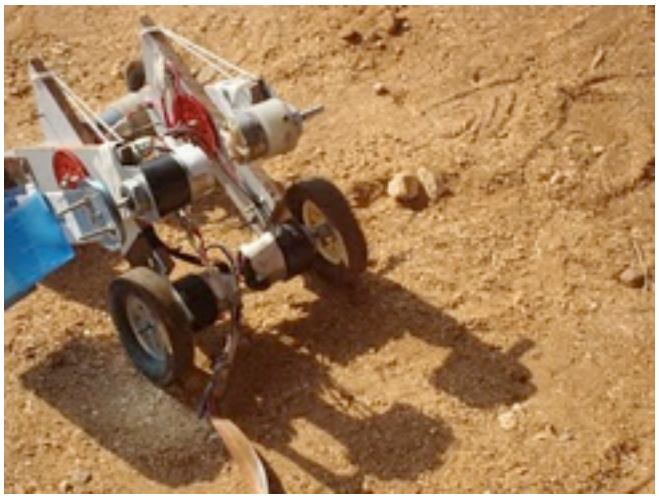
Checking the Rover Specifications

The Terrain – The Flags mark the course

Space Journalist Mr. Srinivas Laxman observing the rover.

PARTICIPANTS AND WINNERS:

The event witnessed 10 participants who came up with different mechanisms for lifting the payload, the best one was made by Mr. Abir, whose rover cleared in 2:16 minutes. The second best time was in 4 minutes made by Ankur. Both are from Vellore Institute of Technology.



LUNAR TREK FINANCIAL REPORT:

Income

Rs. 9000 = Money received from Moon Society

Expenditures

Rs. 4000 – For the Track

Rs. 5000 – Prizes (certificates of participation given to all, and mementos given to the winners)

THE PAYOFF FOR MOON SOCIETY, INDIA

The response to the event was rewarding. As a result of our sponsorship of this event, 12 members have signed up for membership in the Moon Society at SINC 2010.

Two Moon Society India Executive Committee members each gave a talk while at the Conference: **Jayashree Shridhar**, President, Moon Society, and **Srinivas Laxman,** Member, Executive Committee of the Moon Society.

Aerial View of the VIT Vellore Campus

Another Strong Showing at ISDC 2010 in Chicago for Student Teams from India

June 29, 2010, Dave Dunlop

The International Space Development Conference hosted annually by The National Space Society was held the last weekend in May in Chicago, Illinois.

One of the exciting aspects of this context is the presence of international teams competing in NASA's International Space Settlement Design Contest. This year a number of teams from India competed. There were some very impressive presentation and poster on display, which showed both the hard work and creative efforts put forward.

We have included pictures of these teams but have not been able to identify all the participating schools and team members. Students proudly displayed their work in the Exhibit Room, and also had the chance to explain their designs to interested conference-goers.

NSS Director Lynn Zielinski with one Indian student team

Discovering a Lavatube Skylight on Mars: An Example of What Students Can Do

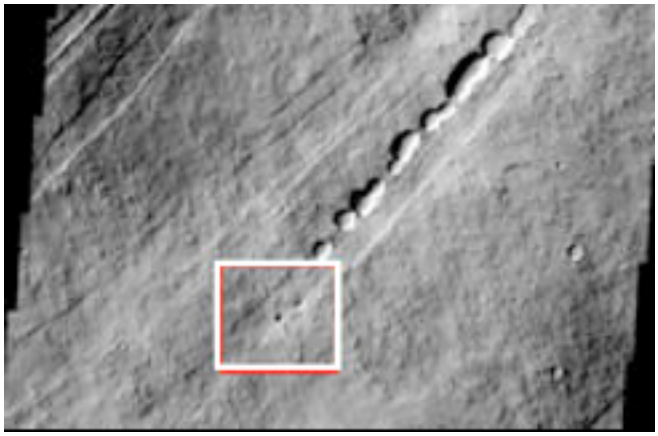
http://asunews.asu.edu/20100617_skylight

Seventh Grade Students (ages 11-12!) in a California (US) Middle School, undertook a project to look for lavatubes in the data flow from the THEMIS instrument on NASA's Mars Odyssey Orbiter which has been studying the red planet since 2001. This effort was a class project for the Mars Student Imaging Program (MSIP), a component of Arizona State University's Mars Education Program.

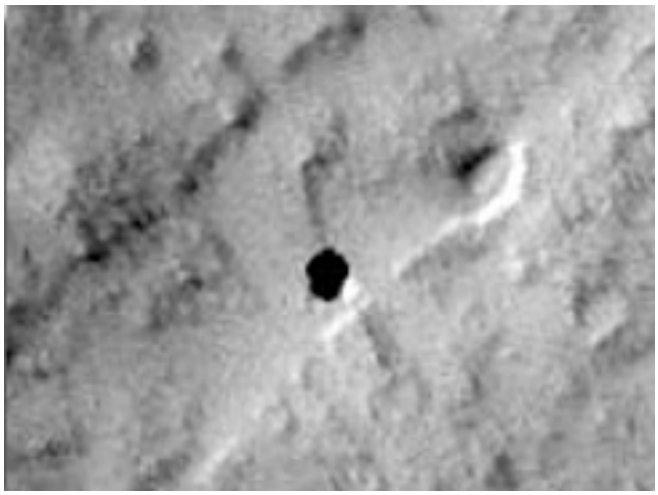
http://msip.asu.edu/ - http://marsed.asu.edu/

They found clear evidence of a "skylight" – a deep black pit on Mars surface, which is clearly the result of the collapse of part of the surface above an underground lava tube. Several such skylights have previously been found on the flanks of Mars great shield volcanoes, just the kind of terrain we'd expect to house lavatubes, as do shield volcanoes on Earth.

As these subsurface voids of great size and volume offer ready-made shielding from the cosmic elements and stable temperatures, this bodes well for the prospects of establishment of human communities on Mars someday. To date, one such skylight has been identified on the Moon by Japan's Kaguya probe.



the original frame that caught student attention



In the top frame, the small black dot is visible but had not previously caught anyone's attention until this study.

"Too much data" for the professionals to look at

There is such an enormous volume of data coming in from the various probes about the Moon, Mars, and Venus, that the "principle investigators" and their teams can only scratch the surface. This leaves an enormous fertile source for "data mining" by students and others.

Students do not have to wait until they graduate from university to begin to make significant contributions. This kind of project needs little in the way of expensive equipment, just patience and time.

We recommend that students in India consider doing similar projects collaborating with ISRO, and even with NASA. These students will be proud of their achievements for the rest of their lives!

Data Mining as a wide-open career

Many a probe has produced far more data than there is money to analyze. Many probes and orbiters have had their data analysis shut down prematurely after the first easy conclusions were drawn simply because money was needed elsewhere. Data mining by students, whether as part of a group project, as in this case, or by an individual in support of a thesis, is a promising way to get more research done.

Agency-paid analysts have looked for the obvious, searching in promising directions. But there may be many discoveries just waiting to be made, including unsuspected paradigm-busters that end up defeating previously wide held beliefs and assumptions are the reward for tireless hours spent looking for more.

At ISDC 1998 in Milwaukee, there was a presentation on just this need, to throw the seemingly thankless task at unpaid students, whose reward may be just the thrill of a new discovery, but could be the stuff of a doctorate-winning thesis

Perhaps the most novel means of analyzing "too much data" was the SETI@home project, enlisting owners of hundreds of thousands of computers to import a data stream from JPL that could be analyzed by a program running in the background, without disturbing whatever else the computer was doing.

The point is, one does not have to go looking for new data, when there is so much in our possession that has never been looked at. At the end of the *Magellan* mission that crated the first radar map of Venus, it was thought that the total data mass from this mission was greater than all the knowledge in all the books of mankind. To this day, only a small fraction of the data was analyzed, As soon as the easy finds have been made, and new finds become few and far between, there is strong motivation to not spend any more money pumping what may be a dry well. Its not that we think that there is nothing new to find, but that the law of diminishing returns demands spending time and money elsewhere.

But for unpaid students, hobbyists also, its not about money, but the chance to make a name, for oneself and/or to successfully defend a thesis. Meanwhile, another lavatube "skylight" has been discovered on the Moon's farside. With student help we could find many more on both worlds!

http://lroc.sese.asu.edu/news/index.php?/archives/246-Depths-of-Mare-Ingenii.html

[An Exciting, Productive Student Project in California]

The International Space Station: Investing In Humanity's Future: 2010-Utilization 2015-Evolution 2020-Life Extension

Foreward:

Madhu Thangavelu, one of our M3IQ Co-editors, conducts the **Space Exploration Architectures Concept Synthesis Studio**, Department of Astronautical Engineering, Viterbi School of Engineering & the School of Architecture, at the University of Southern California (USC)

For the Synthesis Studio's Fall 2009 Team Project, his students undertook an ambitious look at ISS

Course Description:

This interdisciplinary course is all about the formulation and articulation of creative ideas. It is also about speculation; visualizing future applications for space technology. The aim of this synthesis-oriented program is to encourage and refine programmatic and conceptual design synthesis skills for the creation of complex high technology projects. Space exploration and space applications are the areas of focus. Inductive and analogous processes, associative logic, metaphorical models and other system architecting tools are employed to quickly create alternative "concept architectures", which in essence, are rudimentary but global ideas or visions of a project.

These alternative concept architectures even precede engineering requirement documents and, in fact, they help in critically examining the need for a project and then assist in creating solid requirements through the crucial iterative processes involving inductive reasoning, debate and discussion. This exercise directly contributes to the speedy evolution of resilient "strong boned" complex architectures. Besides presenting poignant, project specific, interdisciplinary scientific concepts and engineering theory behind space system architectures, participants will be introduced to architectural concept generation theory, methods, form finding processes, visualization and presentation techniques followed by a unique, hands-on studio approach that allows the participants to realize their own concept architecture project in a rapid manner.

Participants will work on both a small individual mini project and a larger team project. These concept architectures are then presented to an expert panel of faculty, agency and industry professionals for feedback and discussion. The class will also feature lectures on relevant topics by visiting professionals who are experts in the field.

For the Fall semester of 2009, the group term project was to design for the utilization, evolution and life extension of the International Space Station. With the international community and political implications in mind, the students set out to define the needs, benefits and possibilities of the international space station into the next decade and beyond.

Project Sections: each with a PowerPoint Presentation

01 Synergy Through Policy: Giving Freedom to ISS

02 ISS for Earth Observation: Seeking Out New International Partnerships

03 International Space Station: Earth Preservation and Space Exploration

04 Ballute Cargo Recovery System (BCRS) for ISS Experiments

05 Improving Consumption Regimen for the ISS

06 The "Farm:" An Inflatable Centrifuge Biology Research Module on the International Space Station

07 Non-Destructive Testing and Evaluation

08 Debris Mitigation System and New Service Module

09 International Commercial Model

10 Space Station v1.5: Using the ISS to Develop Technologies and Practices to Improve Utilization

11 ISS Nuclear Systems Testbed

12 Construction of an International Space Vehicle Using the Space Station

To download any or all of these presentations, go to:

http://denecs.usc.edu/hosted/ASTE/TeamProject20093/

For a look at a previous class project in 2008, go to:

http://astronautics.usc.edu/concepts-studio/lookingglass.htm

Editor's Comment: I have looked at each of these presentations, and they each offer original, sometimes brilliant suggestions of how we can further develop this great international resource. I urge students and other readers to look at each of them. You will never think of ISS in the same way again. The potential for further development and for even more extensive international partnership as well as for greater corporate and commercial involvement is enormous.

Rather than deorbiting this first international laboratory in space, there are ways to both expand ISS and to keep it technologically and operationally "young." Indeed, ISS has the potential to take on a life of its own, both in service of continued and expanded study of our home planet and of the environmental and technological changes it is undergoing, but also in service of further space exploration of our solar system.

It is clear that what is now a NASA hegemony must be transformed into a truly international management and ownership. How this will happen is not clear, but these students have some suggestions worth pondering and pursuing.

We have included this article in this issue, not just to showcase the work of one of our co-editors, but to showcase the ability of students everywhere to leapfrog the often stodgy thinking and assumptions behind the status quo and find pathways to a brighter future. We hope that many students, and their teachers, in India will be inspired by this organizing brainstorming effort and try similar projects.

About the project director:

Madhu Thangavelu was born in India. His Mother came from Kerala, father from Tamil Nadu. He grew up in New Delhi, met his wife in Strasbourg, France, and is now teaching at U. of Southern California [USC], in Los Angeles. *See page 12*

GREAT BROWSING

NASA, DARPA hold conference on Space Debris
http://www.space.com/news/091208-space-junk-cleanup-meeting.html

Space Station to get chance to realize its full potential
http://www.thespacereview.com/article/1620/1

How big is the International Space Station?
http://www.lifeslittlemysteries.com/images/stories/iss-how-big-100511-02.jpg

Obama budget includes ISS Artificial Gravity tests
http://www.space.com/businesstechnology/artificial-gravity-tests-astronaut-health-100512.html

Moon's polar craters may be electrically charged
http://www.nasa.gov/multimedia/videogallery/index.html?media_id=14044418

Model helps search for lunar dust fountains
http://www.physorg.com/news195408608.html

Citizen science: Lunar Reconnaissance Orbiter images
http://www.moonzoo.org

A post-American Moon
http://www.thespacereview.com/article/1618/1

Japan Could Put a Human(oid) on the Moon by 2015
http://www.space.com/businesstechnology/japanese-humanoid-moon-robot-100504.html

"Mission pull" and "technology push"
http://www.thespacereview.com/article/1627/1

Private Launch Industry ready for "Lift-off"
http://www.space.com/missionlaunches/space-access-society-meeting-100417.html

The Privatization of US Space Exploration
http://www.thespacereview.com/article/1617/1

6 private companies could launch humans into space
http://news.yahoo.com/s/space/20100604/sc_space/6privatecompaniesthatcouldlaunchhumansintospace

Space Tourism: Suborbital Joy Rides at Lower Costs
http://www.space.com/news/space-tourism-new-deal-100430.html

Need to understand how humans can live in space
http://www.thespacereview.com/article/1613/1

Mars once had an ocean 2/3rds the size of the Atlantic
http://www.space.com/scienceastronomy/ancient-mars-vast-oceans-100613.html

Wet Era On Early Mars May have been Global
http://www.marsdaily.com/reports/New_Clues_Suggest_Wet_Era_On_Early_Mars_Was_Global_999.html

Widespread Glacial Meltwater Valleys On Mars
http://www.marsdaily.com/reports/Brown_Team_Finds_Widespread_Glacial_Meltwater_Valleys_On_Mars_999.html

Mapping Project sees Huge Historic Seas On Mars
http://www.marsdaily.com/reports/Mapping_Project_Consistent_With_Huge_Historic_Seas_On_Mars_999.html

Mars Rover Curiosity to carry 3d Camera
http://www.space.com/news/james-cameron-3d-camera-curiosity-100430.html

Designing Rolling Rovers for Mars
http://www.physorg.com/news194695118.html

How human exploration of Mars can help on Earth
http://www.thespacereview.com/article/1644/1

Mole-Like Heat Drill Envisioned to Explore Europa
http://www.space.com/businesstechnology/europe-mole-like-drill-design-100430.html

Asteroid #24 Themis found to have surface water-ice
www.nasa.gov/topics/earth/features/water_ice_asteroid.html

Akatsuki - Japan's Venus Climate Orbiter
www.jaxa.jp/countdown/f17/pdf/presskit_akatsuki_e.pdf

Prospects for Britains role in Space
http://www.thespacereview.com/article/1640/1

Jupiter suddenly loses one of its stripe
http://www.space.com/scienceastronomy/missing-jupiter-cloud-belt-mystifies-scientists-100521.html

Hints of Life found on Saturn's moon Titan
http://www.newscientist.com/article/dn19005-hints-of-life-found-on-saturn-moon

Kepler Space Telescope finds 306 new exo-planets
http://arxiv.org/abs/1006.2799

Color-Changing Planets: Clues to Alien Life?
http://www.space.com/scienceastronomy/color-changing-planets-alien-life-100513.html

Being able to actual spot aliens may take centuries
http://www.space.com/scienceastronomy/alien-contact-will-take-centuries-100429.html

GREAT SPACE VIDEOS

MOON COLONY VIDEOS - The Moon Society

30 plus thought-provoking videos, produced for the Moon Society by Chip Proser (Celestial Mechanics)

Saving the Earth by Colonizing the Moon
http://gaiaselene.com/Saving%20Earth/SavingEarth.html

The Moon Society
- **The Moon Society**
- **Moon Rush – Dennis Wingo 5 parts**
- **NASA – Pete Worden 3 parts**
- **Paul Spudis – 2 parts**
- **Rick Tumlinson – 6 parts**

http://gaiaselene.com/Moon%20Society/MoonSociety.html

The Lunar Greenhouse
http://gaiaselene.com/Moon%20Society/MoonSociety.html

Refueling Depot in Orbit
http://gaiaselene.com/GASteroid/GASteroid.html

Space Solar Power
http://gaiaselene.com/Solar/Solar.html

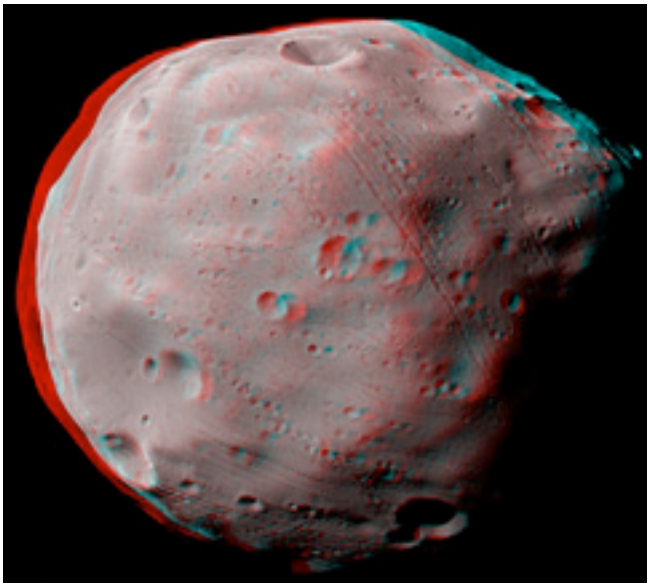
ASSORTED SPACE VIDEOS

Why we need human explorers
http://www.ted.com/talks/brian_cox_why_we_need_the_explorers.html

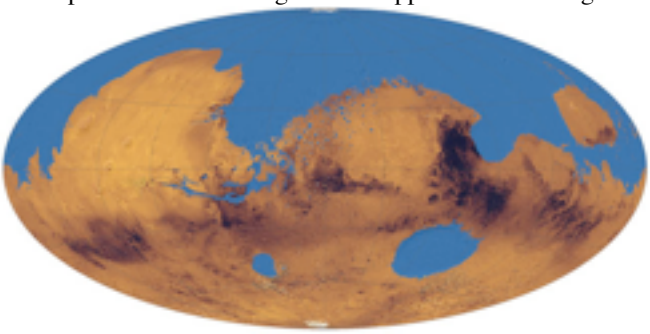
The "Case for Mars" set to Music (Zubrin, Sagan, etc.)
http://www.youtube.com/watch?v=2kKCtDcrrHo

Moonbase Alpha Game Trailer ***
http://www.nasa.gov/offices/education/programs/national/ltp/games/moonbasealpha/index.html

M3IQ PHOTO GALLERY



A stunning 3D anaglyposh of Phobos. You can really see the depth of the craters and grooves on the surface.– You will need a pair of 3D blue/red glasses to appreciate this image.

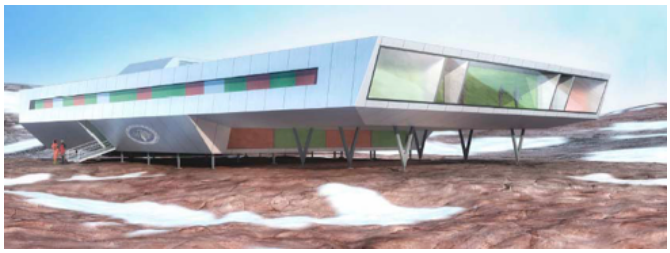


Area of Mars covered by water about 3 billion years ago: Somewhat larger than the Indian Ocean (below)
http://www.space.com/scienceastronomy/ancient-mars-vast-oceans-100613.html

Indian Ocean for comparison

After nearly 5 years of suspense, Haybusa Asteroid Sample Capsule lands intact in Austrailian desert near Woomera

It may take months to analyze anything captured within. The source, asteroid **Itokawa**, is shown in the background.



Artist's illustration of India's new **Bharati Station** at Larseman Hill, Antarctica, 3,000 km east of Maitri Station

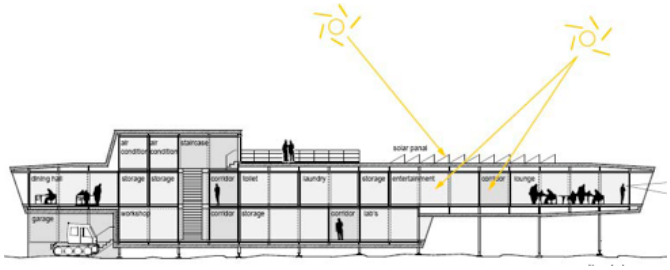


Illustration of cross section on **Bharati Station**

[from] Draft Comprehensive Environmental Evaluation of New Indian Research Base at Larsemann Hills, Antarctica
http://www.ncaor.nic.in/Draftcee/file6of14_chapter3.pdf

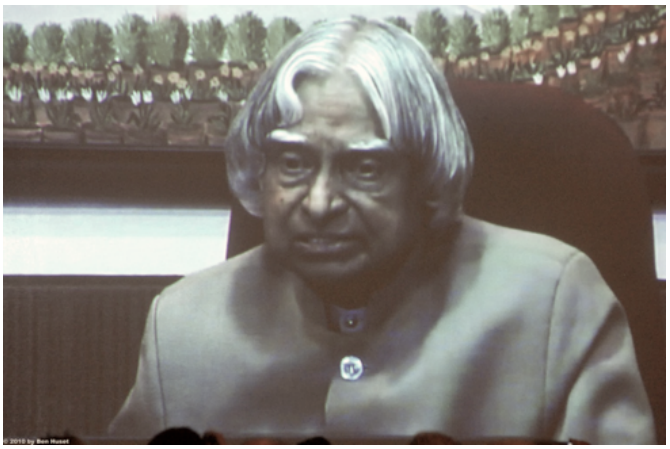
India's (1) polar ● and (2) Antarctic stations ● ●

While the lunar environment will be quite different, much of the polar research experience may be applicable for any future India or international outpost on the Moon.

The Challenges of Dr. Abdul Kalam to the National Space Society & to the World

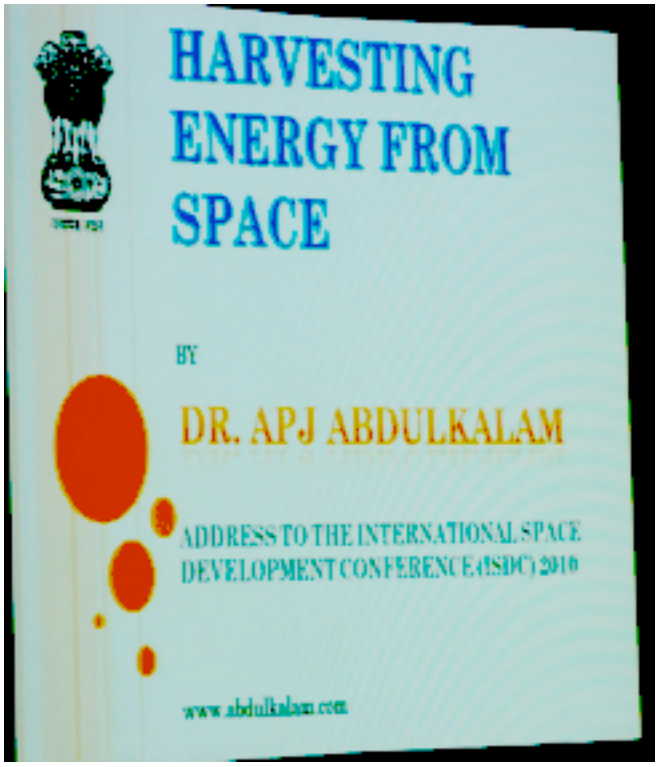
By David Dunlop

On May 30th, Dr. Abdul Kalam addressed attendees at the 2010 International Space Development Conference in Chicago via a teleconfrerence hookup from India.



An Honor for NSS

Space Based Solar Power has been proposed for a long time, since the first advocacy of Solar Power Satellites by Dr. Peter Glaser in the late 1960s. It has undergone several significant technical and economic appraisals during this period.(1) But a new threshold for the National Space Society and SBSP was crossed in May 2010 at the International Space Development Conference in Chicago when the ISDC audience was addressed by Dr. APJ Kalam, former President of India on the topic "Harvesting Energy From Space". (2)



This to my knowledge was the first time a former head of state of a major country had addressed the ISDC. Dr. Kalam discussed space solar power in the context of India's energy needs through the year 2052, not only as the former head of state in India but also as one of India's foremost rocket scientists. He called NSS "an enlightened audience for this address."

A Global Space Vision

Dr. Kalam did not stop with India's needs. In his ISDC address, He called for a World Space Vision and for action by Integrated Global Leadership through a Global Energy Technology Initiative for Harvesting Energy from Space. The Global Space Vision includes:

1. Large Scale Societal missions (including Space Solar Power Mission) required for and enabled by low cost access to space.
2. Evolution of a Comprehensive space security doctrine, policy, and program.
3. Expansion of Space exploration and current application missions.

The World Space Vision 2050 would enhance the quality of human life, inspire the spirit of space exploration, expand the horizons of knowledge, and ensure space security for all nations of the world."

A Challenge to NSS: Kalam stated,

1. "The organizers of the ISDC may address to the leaders of the G-20 a comprehensive paper on all aspects of space solar power and to request the participation of experts for a cooperative International Preliminary Feasibility Study project that would benefit all nations. "
2. "Meanwhile, an Interim Working Group could be set up to suggest the structure and content of the Preliminary Feasibility Study, and that should lead on seamlessly to the creation of an international steering committee. and two or three International Study Teams of world experts."
3. "These Study Teams may cover among other aspects of space transportation and cost of access to space, efficiency of energy conversion, power transmission from space, possible collaborative mechanisms, experiments from nations and possible organizational mechanisms with potential sources of funding."

He made the observation that, "the present capabilities of **major space faring nations*****(my emphasis) are not optimally utilized and called for a 'certain paradigm shift' in international collaboration to bring the benefits of space to humanity as a whole." The launch vehicles, spacecraft, potential applications, space scientific research potential, and huge financial challenges call for a coordinated international approach. Dr. Kalam said his experience suggested this could be successful if each nation made substantial contributions in technology and resources.

"We are witnessing such phenomenon in other areas also. The countries of the world had come together to find solutions for the global economic turbulence. Issues like energy and water are in the realm of international community. *Then is it not an opportunity for the space community of the world, which has played a key role to bring the world together, to think ahead and create a 'World Space Vision' and work out 'mechanisms' for taking up missions?"(Italics mine)*

"Hence, it is a great challenge and opportunity for the world of nations, **particularly space faring nations** (my emphasis) to create imaginative mission mechanism(s) to take up global R&D program(s) and implementation so that the twenty first century can blossom to create SSP and its enabling technologies. I wish the Special Symposium a very special success."

A Potential Nationl Space Society Response

I am proud as an NSS member, to belong to an organization not only recognized for its enlightenment by someone of the stature of Dr. Kalam but an organization also given a special charge to address a comprehensive paper to bring Dr. Kalams World Space Vision Challenge to the forum of the G-20 nations. Our advocacy of Space Solar Power has been noticed by President Kalam who also specifically complimented our NSS Space Solar Power library on our web-site. The NSS collaboration with other organizational advocates of Space Solar Power has clearly paid off and been effective as an open advocacy effort.

The NSS has therefore received an historic charge and responsibility unique in our experience. NSS has experience in the US with annual advocacy efforts with the US Congress, but we have never before approached the forum of the G-20 nations or even the more narrow group of all the space faring nations.

NSS membership however, is diverse as well as international. The President and Chairman of the NSS Board, of Directors is Mr. Kirby Ikin from Australia where there are several NSS chapters. The 1994 ISDC was hosted in Toronto by Paul Swift of our affiliate organization, the Canadian Space Society. And one of the highlights of ISDC 2010 in Chicago was the Space Canada sponsorship of the dinner hosted by renowned Canadian broadcaster Bob McDonald with Space Canada's new film on Space Solar Power.

NSS chapters are found in seven other G-20 member nations such as Brazil, France, Germany, India, Mexico, and the Netherlands as well the US. We can therefore claim an international advocacy within our own membership, chapters, and affiliates. The NSS vision of space development is one inclusive of the interests of the whole world and our advocacy is consistent with the embrace of a World Space Vision and Global Energy & Space Solar Power Technology Initiative suggested.

Perhaps what I like best about Dr. Kalam's proposal is that while it is couched in terms of space technology, lowering the cost of space access, space energy supply, and yes, space exploration, its focus and strength of impact is clearly centered on our most important planet, the Earth. How could NSS advocacy be any more mainstream?

Geopolitical and Geocommercial Aspects

I find it interesting that Dr. Kalam focuses on two international groupings: First he discusses the opportunity for a paradigm shift and collaborative improvement of the major space faring powers, those nations with the national technology means. Then he proposes a Global Vision brought to the G-20, the most important economic members of the global economy, which also collectively represent 90% of the global economy, 80% of the global trade, and 66% of the global population. To this larger economic forum he would assign the development of 'mechanisms' for implementation that speak to both the economic and political process. The close ties of NSS to the Space Solar Power research community and to the Space Investment Summit are potential assets in the development of a comprehensive paper for the G-20.

Space Security

Dr, Kalam called for the evolution of a comprehensive space security doctrine, policy and program. This is very important arena, which implies a more active stance with regard to the topics of space security doctrine. Space security is a term which covers the national activities involving the national defense capabilities of every country as well as the safety and reliability of space assets and capabilities.

I think in the first instance space security involves principles comparable to the "freedom of the seas doctrine" in which all nations pledge to support the right of free access to space for all of the international community. This would also imply that international assets would be used in support of such right of access as well as assistance for assets in distress. It would also be important to constrain the waste of resources that could result from a militarization of space.

It must also address the poor international record with regard to the generation of space debris and the need to remediate both the threats posed by this growing problem and to develop proactive practices to prevent the growth of space debris. The "pollution of the commons" is what is at stake and the risks must be balanced and monetized in terms of insurance and remediation costs that are reflected in the price of market driven services. Space security is necessary for increased geocommercial space investments.

New Space Mission Applications & Global Growth

Space communications resources are part of vital infrastructure affecting the economies of every nation. Therefore the expansion of the growth of the space economy is threatened by the failure to come to grips with space debris. Proposals for increased development of space stations and human presence in LEO and cis-lunar space, for larger more capable GEO platforms, and for solar power satellites must address both investment requirements, risk management, and the development of active measures to mitigate the risks of space debris.

The current $150 Billion annual global space economy is only a slight fraction of what could be orders of magnitude greater space-based economic activity in the next four decades. These additional space mission applications are the third element of his challenge and the call for study panels on: communications growth, Earth observation activities, space tourism, space manufacturing, and space solar power, and expanded space exploration. These study panels will underscore the economic and growth potential to create a truly Earth-Moon econosphere in cislunar space which will expand activities in LEO, GEO, Earth-Moon Lagrange Point 1, and on the lunar surface. Lunar in situ resources can be brought to bear on production of space solar power facilities and even space computation facilities.

Creating Mechanisms for Action

Dr. Kalam further calls for the appointment of an Interim Working Group and study panels. *International*

*coordination could be facilitated by the formation of a **Space Solar Power Working Group** on the order of those such as ILEWG (International Lunar Exploration Working Group) and MEPWG Mars Exploration Group working programs.*

Members of such an Interim Working group might include some of the many international contributors to the Space Solar Power symposia and the International Academy of Astronautic study on space solar power represented from Canada, Europe, India, Japan, and the US and broadened to include both Russian and Chinese participation. The International Academy of Astronautics study group on space solar power, with the leadership of Drs. John Mankins and Nobuyuki Kaya of Kobe University has been working the past two and a half years to complete the first international study of space solar power. The first preliminary report should be completed by the end of this year with full publication expected in the Spring of 2011. This study should provide a timely foundation for expanded collaborative international research and additional recommendations originating from an Interim Working Group.

NSS, consistent with its free market values, would expect an Interim Working Group to develop into a more well-resourced Space Solar Power Working Group with formal participation and support from:

- COSPAR: Committee On SPace Research
- CCSDS: Consultative Committee for Space Data Systems
- National Space Agencies of major space faring countries
- The Commercial Aerospace sector
- The Commercial Power Industry
  (Electric Power /Research Institute would be a logical participant in the US)
- Representation of the Global Investment Sectors
  The World Bank.
  The Space Investment Summit group
  Regional Development Banks
- NSS: The National Space Society
- TMS: The Moon Society
- Other Space Solar Power Advocacy organizations

[www.moonsociety.org/reports/space_solar_alliance.html]

Summary

It is a honor that NSS has been requested by Dr. Kalam to advocate the cause of space solar power to the most important technological and economically powerful nations of the world. As a long term member of NSS I feel that we must step up to the bar in accepting his challenge and lend our voice to The Global Case for Space Solar Power. It is a compelling case for the world. **DD**

Author's Footnotes:

(1) See NSS Space Solar Power Library
http://www.nss.org/settlement/ssp/

(2) Interested readers can find the entire text of Dr. Kalams's May 30 speech to the ISDC 2010 at
www.abdulkalam.com - *click on **speeches***

(3) Chart of Space Faring Nations capabilities
[Next Column]

(4) ISS partners:
http://www.nasa.gov/mission_pages/station/structure/elements/partners.html

Group of 20 Nations and Space Faring Capabilities

1 Argentina		CONAE		T, S
2 Australia		CSIRO	(1926)	T, S, @,
3 Brazil		AEB	(1994)	T, S, @,
4 Canada	ISS	CSA*	(1989)	T, S, -, @, A,
5 China,		CNSA	(1993)	T, S, -,@, #,* A
6 France	ISS	CNES*	(1961)	T, S, -,@, +,* A
7 Germany	ISS	DRL*	(1969)	T, S, A
8 India		ISRO	(1969)	T, S, - , @,* A
9 Indonesia		LAPAN	(1964)	T, S,
10 Italy	ISS	ASI*	(1988)	T, S, -, @, A
11 Japan	ISS	JAXA	(2003)	T, S, -, @, +,*A
12 Mexico		AEXA	(2010)	T, S, A
13 Russia	ISS	ROSCOSMOS	(1992)	T, S, -,@,+,#,*A
14 Saudi Arabia		KACST-SRI		T, S, A
15 South Africa		SANSA	(2011)	T, S, A
16 Republic of Korea		KARI	(1989)	T, S, A
17 Turkey		TUBITAK	(1991)	T, S
18 United Kingdom	ISS	UKSA*	(2010)	T, S, -, A
19 United States	ISS	NASA	(1958)	T,S,-,@,+, #,*A
20 European Union	ISS	ESA	(1975)	T, S, -,@,+,* A

KEY: ISS International Space Station Partner
T Technology Base
S Own Satellites
- Own Launchers
@ Launch site(s)
+ ISS access
# Manned Space Program
* Manned program in development
A Astronaut(s)

Author Bio

Dave Dunlop s a long time NSS member has been active in ISDC programming, particularly in the "Lunar Track," and as part of the NSS affiliate, The Moon Society, promoting Space Solar Power using lunar resources.

[**Editor's Note:** Both the author and the editor retain dual memberships in The Moon Society and The National Space Society, which organizations signed an affiliation agreement at ISDC 2005 in Washington, DC. David Dunlop is Moon Society Director of Project Development and a Director of the Moon Society as well as incoming Regional Director of the National Space Society representing the states of Illinois, Wisconsin, Michigan, Indiana, and Ohio. Peter Kokh, who held that regional director position in the early 1990s and chaired ISDC 1998, is a current member of the NSS Board of Advisors, as well as President of The Moon Society.

The Moon Society, as an affiliate of the National Space Society, has worked collaboratively to develop programming for the International Space Development Conference. We welcome the efforts and support of other advocacy organizations in responding to the challenges presented by Dr. Kalam.

MS and NSS members may wish to make the national leaders of the countries in which they reside and have citizenship aware of Dr. Kalam's challenge with regard to space based solar power and the need for international collaborative efforts.]

A New Economic Geography of the Moon

By David A. Dunlop

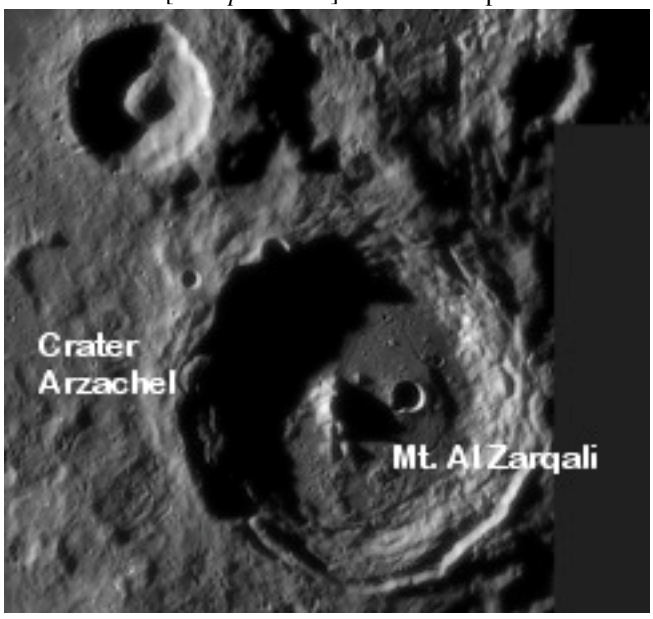
An "Economic" Geography of the Moon? Really?

Some have the opinion that it may be premature to discuss an economic geography of the Moon. For decades the Moon was abandoned as a location of human enterprise either by robot proxy or for direct human presence. Human presence on the Moon may still be 15 years away, not withstanding talk about the Chinese lunar program and space development. The recent water discoveries change the picture of the future that NASA was planning for the now defunct Constellation program.

In that scenario NASA was aiming to develop a small 4-person "man tended" lunar outpost on the rim of Shackleton Crater a few kilometers from the illuminated "Peaks of Eternal Light", where presumably a more extensive source of solar power could be had for surface operations and base support. From this vantage point, lunar surveys including sortie missions would be launched to provide a more regional scientific investigation.

The economic geography of this lunar base location was selected in consideration of the many targets of interest in the vast and deep South Pole Aitken basin on the basis for lunar geology of this previously unsampled terrain and for other science objectives. The SBA Basis is the deepest basin on the Moon and one place where samples of the lunar mantle might be had.[1] SBA bay be somewhat different from the mare and highland terrain that was explored in the six Apollo landings. It is recognized that although the local terrain may be rough, an exploration sortie strategy hopping from that base to other areas of interest was also part of the overall exploration strategy. It also exploited the fact that tall nearby peaks would receive sunlight some 70% or more of the time and that line of sight communications with Earth would still be possible.

1 Editor's comment: There is some expectation that the central peaks of some larger craters on both nearside and farside, may include mantle upthrust materials. None of these features [*example below*] has been sampled to date.



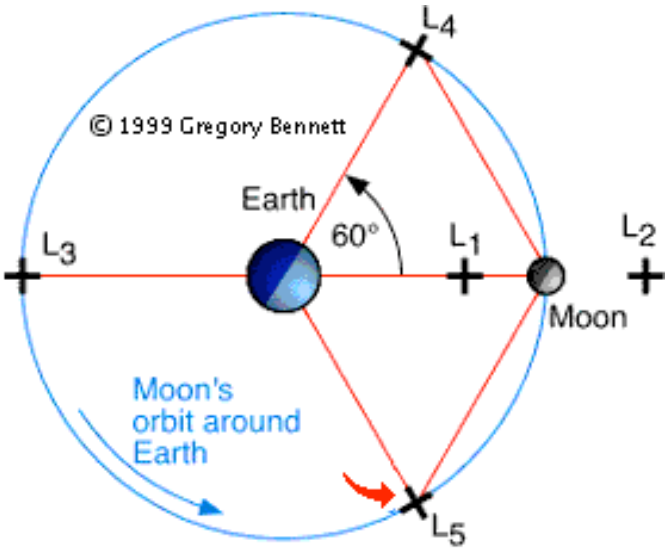
Both Peter Kokh and I have been critical of this SP/SPA rational as being too parochial and putting all our lunar base /human presence eggs in one local basket. This rationale is one primarily driven by geological exploration priorities. Yet this strategy eliminates most of the lunar surface by concentrating the limited resources deliverable in one regional location with a reliance on occasional sortie missions to fill in the blanks, *while totally ignoring commercial possibilities and development*.

Priority One: A Supply Chain

In another article, I point out the preliminary priority of creating a supply chain, which would enable a range of space development efforts.

> *The Moon requires a robust and flexible supply chain, and its establishment and growth as traffic warrants that priority should be "job one" not only for NASA but for other space faring nations.*

A Second priority and precursor investment should be comprehensive communication from the entire lunar globe. An early objective might be the establishment of long duration communication satellites at L4 and L5 so that signals could be directly relayed to Earth from 5/6^{ths} of the lunar surface. This direct communication relay system would serve precursor lander missions and would enable telerobotic operations the Moon's nearside and on 2/3^{rds} of the Moon's farside as well.



Third, the discovery of substantial water-ice in both polar areas, and lesser amounts of moisture elsewhere has broadened the exploration objectives. Few lunar geologists would argue against the importance of the South Pole Aitken basin for understanding the Moon's ancient history and stratigraphyaz. But in addition to the unexplored highland terrain of the SBA basin, there is also the unexplored KREEP terrain of the Mare Imbrium rim area and areas of Oceanus Procellarum with volcanic features, such lava domes, lava tubes and skylights, extensive rilles, and vast pyroclastic deposits. Volcanic vents might also provide additional clues to sampling the lunar interior. On the far side, a new type of spinel rock has been found in the Mare Moscoviense Basin, which may also be a place where the crust is thinnest.

Fourth, investments in a lunar exploration effort should aim to open the global lunar frontier and to support a range of options and activities. The objectives of lunar exploration as a strictly scientific enterprise is a different lunar undertaking than one aimed at scientific, commercial and political objectives. The Moon was there, from the beginning of the space age, for more than just science. Its geopolitical significance was more of a driver of exploration efforts than science. Today the drive to explore the Moon is again a matter of geopolitical competition, protestations to the contrary notwithstanding. National flags on the Moon are again important as a statement of national economic and technological power. Commercial power is not yet a significant driver, but that too will become a measure of national ambitions and vision.

Lunar Exploration Models:

The collaboration of former enemies and rivals?
Or the creation of a Collective Partnership?

I would hope that a judicious and rational international Moon program would be mounted rather than one of competing parallel efforts. Nevertheless historical competition and parallel efforts were the model used by European exploration and in the establishment of beachhead colonies for their respective empires during the colonial era. I suspect that what occurs will be a blend of the two models.

For the moment, the American attempt to create a unilateral lunar program model with the Constellation program has collapsed and lost internal US political sponsorship. Truth be told I believe that the US and its ISS partners in ESA and Japan believed that an international program would have emerged from the US Constellation because discussions of that nature were occurring during the height of that effort, at least with the European Space Agency. I suspect that similar discussions have occurred with the Japanese space agency as well and perhaps others as well.

Russia's Space Administrator Permakov announced that the Russian Space Agency looked to its own human presence on the Moon after 2025. The redevelopment of the Russian economy and its progress will, in my opinion, result an attempt to regain a position of national autonomy in space operations. Permakov did announce that the Russian space program budget would be increased some 300% by 2015.

China's Space Agency has announced a lunar program that includes a lunar sample return in 2017 but few doubt that its manned program, which includes development of an orbital laboratory, will also have a lunar objective. It also indicates it is not in a space race to the Moon. It seems clear that China's geopolitical objective is also to achieve an autonomous space operations capacity.

Supply Chain Architecture

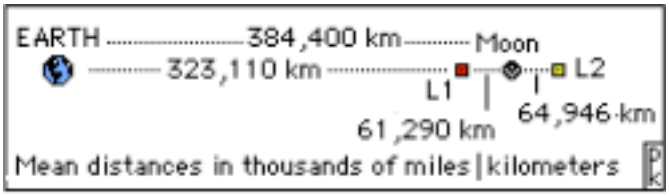
With the limited launch resources existing today, a supply chain based on the entire repertoire of launch vehicles would be needed to create a *robust, permanently occupied and sustainable* lunar base, on the international collaboration foundation of the ISS model.

A European lunar program architecture would include a supply chain that includes a low lunar orbit (LLO^2) space station that would offer refueling, an emergency way station for astronauts on the way to the Moon, and an abort to orbit mission option for astronauts on the lunar surface. This particular supply chain architecture seems far wiser if not "smarter" than the Constellation direct-to-surface architecture. For one, it creates a surface rescue option from the lunar orbit station. The political ill will caused by a lunar program neglecting astronaut crew safety for dollar savings would surely outweigh the financial costs of using a minimalist system in the first place. Accidents and misfortune in exploration are an inevitable part of human society. The effort to support and minimize the loss of life in collaboration is of overwhelming political and economic importance, especially early in the endeavor. In a business model these consideration would be addressed under the heading of risk reduction where cost of insurance and investments in training and safety protocols are standard expectations.

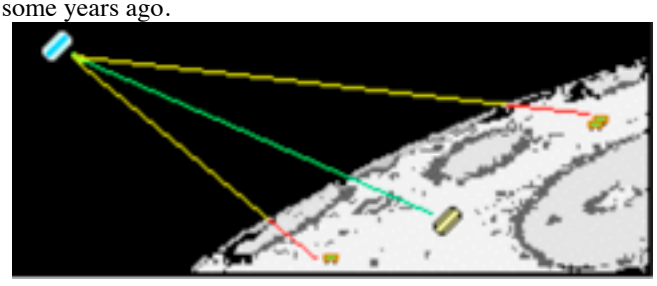
This architecture also builds into the infrastructure the refueling depots and fueling supply system extending from LEO to L1 and down to the lunar surface. It necessitates the creation of a refueling industry infrastructure.

Fortunately a focus in the 2011 Obama NASA budget directs serious towards **an orbital fueling resupply and cryogenic storage technology development.** Harrison Schmidt had been an outspoken critic of Constellation plans to utilize hypergolic fueled engines for lunar surface operations rather than an evolution into ISRU oxygen production for refueling operations on the lunar surface. It seems his counsel has had some impact in the new administration and on the development of an economic model for lunar operations not looking narrowly at "least cost' science objectives.

A station at the Earth-Moon Lagrange Point 1



A station at L1 could start as a refueling depot and evolve into a permanent crew facility like ISS with adequate supplies for emergency use. It could have several docking ports that insure that there is always (a) back-up(s) rescue lander(s). There would always be a fueled lander ready to go down to the Moon for rescue of astronauts in trouble on the surface, even allowing a surface mission to abort to the LI station as a last resort. This L1 facility might also serve as a potential point of medical treatment more immediate than the Earth in the early phases. Sortie missions could be launched from L1 to anywhere on the lunar surface rather than hopping from one surface location to another one. An L1 facility might also serve as a way station for missions out to Mars, the asteroids, or further. NASA had looked at this option some years ago.



Such a station, built by commercial rockets and out of inflatable modules, would cost a tiny fraction of the amount spent to date building up the International Space Station, in a period when such new technologies have not yet been available. We will already have had experience putting together such stations in low Earth orbit.

An L1 station could also serve as a transfer point for lunar tourism to the Moon. This facility might also serve as a point where sample curation facilities for Mars samples, or other incoming samples could be located especially if there is any concern about importing alien organisms into the Earth's biosphere.

There are many reasons why an L1 node could be an international precursor node to support construction and expansion of international lunar research complexes. This L1 scenario provides a flexibility and robustness that a single surface base does not and possibly build upto a lunar industrialization and settlement capacity.

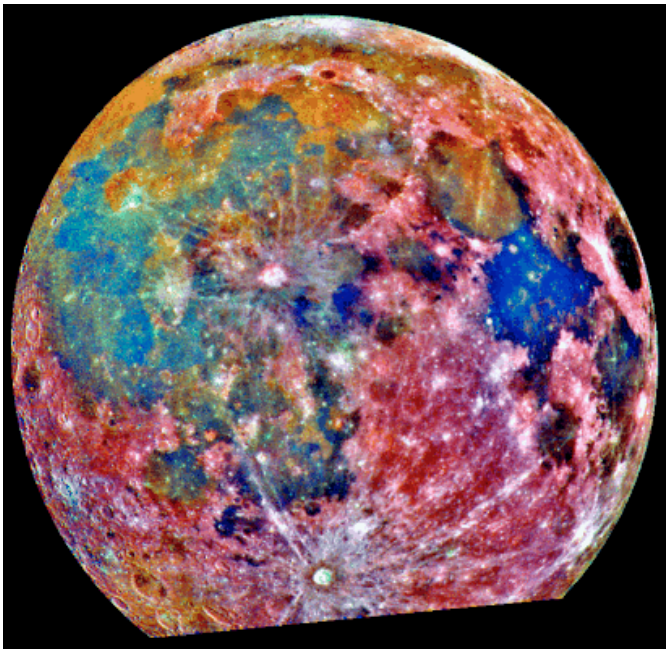
For presentation by Peter Kokh on
"**Building an L1 Gateway in Phases**", go to:
www.moonsociety.org/spreadtheword/pdf_slideshows.html

ISRU Economics - Commercial On Ramps

√ Oxygen

Commercial use of indigenous lunar resources is the foundation and early key to a future global lunar economy. Oxygen production as a means of reducing the imported fuel mass is generally accepted as the first practical objective. There is little argument that O2 production technology would seem high on the lunar surface program development list. Wherever a recurrent point of human operations is planned, an O2 production system and local tank farm will be essential infrastructure. Ilmenite as a favorable source mineral for O2 production would favor mare areas with high titanium basalts but this also constrains the locations to those mare areas where feedstock is available.

[The bluer mare areas on this Galileo false color image]



www2.jpl.nasa.gov/galileo/sepo/cruise/moon/false2.html

I suspect that another unexplored alternative may be the use of biogenic production technologies using microbiological techniques to liberate oxygen from a range of lunar minerals, and this may find global application and thus support multiple production sites.

√ Water

I do not think that a focus on just one lunar region is now likely as a program objective. It seems likely exploration priorities will include both the North and South polar regions as well the Oceanus Procellarum where lava tubes, and pyroclastic sourced water supplies are located without the penalty of water recovery from intensely cold terrain. Water concentrated in the polar cold traps at 106 Kelvin or lower may prove very expensive indeed to extract. However, confirmation of areas of water concentration in the "desert" of the lunar globe will spur either competition or collaboration for access and development of these resources.

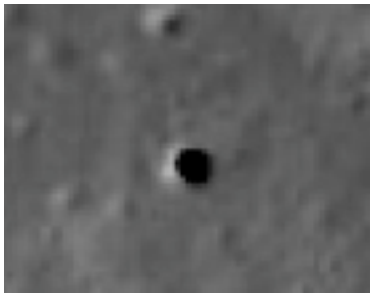
Unless some form of lunar monopoly operation is established by international partnership, shared access to scarce and limited resources will be an immediate issue for international collaboration. Capitalistic doctrines and attempts to establish control of "water rights" for one nation or even a limited group of nations would directly conflict with Moon Treaty views which stress equal access to resources as a common human heritage. In practical terms, however, those who are positioned on the lunar surface with production investments will have practical control of limited and scarce water resources and will be in a position to set the price for lunar-sourced water as they would for Earth imported water.

√ Lava tubes

These relics from a multi-billion year volcanic lunar past will be early and interesting targets for scientific exploration and characterization as they are potential sources of information about the lunar interior. It is even conceivable that they may form another sort of lunar cold trap where ancient volcanic volatiles and some surface generated water and OH hydroxyl radicals may have frozen out in the cold dark interior.

While development advocates perceive these subsurface voids to be ready made shelters from cosmic and solar radiation and micrometeorites, the difficulties of access from the surface opening to a lava tube floor at significant depth may require a sizeable imported infrastructure before these "pre -made shelters" are truly an accessible and usable resource for habitation, scientific, and commercial use.

An invaluable precursor mission might be a special rover that could investigate the 65 m wide lavatube skylight discovered by Japan's Kaguya orbiter.



An AXEL-type rover could anchor itself on the skylight rim and winch itself down the opening, taking radar mapping scans at intervals until it reached the bottom. The

data would travel up the "nanocable" to an antenna on the surface anchor just in case the rover failed to winch itself back up successfully. The AXEL concept would require significant development and elaboration for this application.

For the Kaguya skylight, see M3IQ issue #4 pp. 8-9 and
http://www.planetary.org/blog/article/00002173/
For an article on the original AXEL probe, see
www-robotics.jpl.nasa.gov/systems/system.cfm?System=16
http://www.jpl.nasa.gov/video/index.cfm?id=806

√ Peaks of Eternal Light

The polar areas where high elevations increase the available solar power are another limited resource. Collaborative investments and development of these advantageous sources of solar electric power is also sensible with prices based on utilization and ROI [return on investment] requirements.[1]

The further development of small nuclear fission reactors[2] as a continuous power system would pretty much take away this issue as well as open the entire surface for human and large robotic operations. It could provide an essential baseline power capacity supplemented by dayspan solar power. There are, however, a number of practical ways extra solar power production capacity could be turned into stored energy for use during the nightspan. These include fuel cells and flywheels, to name just two. Some sort of surplus or stored power system will still be needed at either pole to cover gaps in the sunlit period.

√ Mass production and transportation

The mass production of O^2, the creation of tank farms to store this production, and the propulsion capacity to launch it off the lunar surface will become the first integrated, industrial lunar complex. A tankage industry will be required not only for O^2 needed for rocket fuel and life support, but for imported ammonia and or methane which can provide both the Hydrogen for water formation and a nitrogen atmosphere as well as additional carbon.[3] Solar wind gases captured through mining surface regolith will also require gas tanks and separators.

Other industrial commodities such as silicon solar panel arrays for solar power satellites are industrial products that will require both large capital investments and permanent human presence. Industrial products may also require launch systems such as mass drivers to bring the price point for lunar resource production and use in cislunar space to a point competitive with "upport" through Earth's gravity well.[4]

Iron fragments in the lunar soil may be efficiently separated by magnetic means, and iron may therefore be the first and lowest cost metal resource to be produced on the lunar surface. Even so producing steel would require at least a 1 or 2% carbon component. More research on possible lunar alloys of iron with other lunar metallic resources such as aluminum, titanium, or magnesium is needed.[5]

Space Tourism on the Moon will of necessity ride the same infrastructure that enables scientific and other commercial operations. It may offer income streams[6], which provide not only justification for safety redundancy in LEO and LLO and the lunar surface as far as a human habitation, but also an income stream, which accelerates whatever might otherwise develop. **DD**

Editor's Footnote Comments

1 The Moon's axis is inclined by 1.5° to the Earth-Moon system's orbit around the Sun. If the Moon were a perfect sphere, you would need to erect a solar power tower some hundreds of meters high to catch sunlight when that pole was inclined away from the Sun. This means that near polar peaks that are sufficiently elevated above that point, could enjoy sunlight on some portion of their highest points through much of the lunar period. It would seem, however that 100% illumination is not available at either pole. Better estimates range 76-86%. That means that some sort of power storage system will still be needed.

2 There are a number of small (c. 100 kw) nuclear reactors already in use that could serve as prototypes.

3 Of all the volatile elements, it is N, not H or C that is least abundant on the Moon in proportion to the need to support biospheres and agriculture, and thus "the pinch point." There is the outside possibility, should Phobos and/or Demios be found to have a carbonaceous chondrite composition, that these mini-moons could be a source.

4 It is generally understood that the major market for lunar products will be Geosynchronous Orbit (Solar Power Satellites, power relay satellites, giant platforms collocating hundreds of communications, GPS, and other satellites. It takes just 1/23rd of the energy (fuel) to ship a given mass from the Moon's surface into GEO as it takes to boost the same mass up to GEO from Earth's surface.

5 This may require research on "paths not [previously] taken" in the past because they had then seemed less promising. *On the Moon, second best may be good enough.* As a community of persons interested in development of lunar resources to help solve problems here on Earth, we need to encourage young people to get into the field of chemical engineering and metallurgy, that is, young people with a "Young Turk" mentality, ready to take a second look at options already dismissed by their mentors as "unprofitable" (because there were other options, options which may not be practical on the Moon.)

6 It is not inconceivable that the demand for lunar tourism, even for "working tours" may be sufficient to be a driver in both the development of needed technologies and of various ways to bring down prices for both transportation and operations. In recent years, many interested people have signed up for archaeological or paleontological "digs" and pay for the experience and for the opportunity to be involved in possible discoveries. The willingness of *paying* private individuals from outside the privileged "astronaut" ranks to make a contribution should not be so quickly dismissed. If such opportunities were open to anyone participating in a "lottery," this experience would be open to healthy and trainable individuals from many walks of life and from all nations. **PK**

"The Bigelow Inflatable system should permit the creation of another equatorial space station for an order of magnitude less cost but with twice the usable volume, as early as 2014-2015."

Upcoming Conferences & Events

http://www.spacecalendar.com/downrange/

INDIA

July 27 — Indian Space Research Organization, Launch PSLV / Cartosat 2B, **Sriharikota**, India: ISRO Polar satellite launch vehicle set to launch Cartosat 2B remote sensing satellite and secondary payloads.

Aug 25-28 — Indian Space Research Organization, Confederation of Indian Industry, **Bengaluru**, India: 'Bengaluru Space Expo 2010'

ELSEWHERE – a selection by the editor

Jul 5-7 — ASDC.National Space Society Australia, **Adelaide** Australia: '11th Australian Space Development Conf.' '16th National Space Engineering Symposium (NSES).'

Jul 18-25 — Committee on Space Research (COSPAR), **Bremen**, Germany: '38th COSPAR Scientific Assembly.'

Jul 20 — International Space University, **Strasbourg**, France: 'Gerald Soffen Memorial Panel: The Future of Space Science and Space Exploration'

Aug — SpaceX, Launch Falcon 9 / Dragon C1, **Cape Canaveral** FL: 1st active Dragon C1 spacecraft

Aug 1-21 — International Astronomical Youth Camps (IAYC), **Klingenthal**, Germany: 'IAYC 2010.'

Aug 2 — JAXA, Launch H-2A / Michibiki, Tanegashima Space Center, Japan

Sep 1, 3 — SHIFTboston, **Boston** MA / Online: Sep 1 Application deadline for Moon Capital Competition to design a 2nd generation living and working Moon habitat;

Sep 2 — Venus Exploration Analysis Group (VEXAG) , **Madison** WI: '8th Meeting of the VEXAG.'

Sep 23-25 — Space Generation Advisory Council, **Prague**, Czech Republic: 'Space Generation Congress 2010,' the Global Space Congress for university students and young professionals interested in today's key space issues.

Sep 27 -Oct 1 — International Astronautical Federation, Czech Space Office, **Prague**, Czech Republic: '61st International Astronautical Congress & International Institute of Space Law

Oct — People's Republic of China, Launch Long March 3A / Chang'e 2, **Xichang**, China: A Chinese Long March 3A rocket will launch **Chang'e 2**, China's second lunar orbiter.

Oct 7-9 — COMEXCEBA, **Toluca**, Mexico: '2010 1st International Aerospace Congress of Mexico

Oct 11-15 — International Astronomical Union, **Torino**, IT: IAU Symposium 276: The Astrophysics of Planetary Systems: Formation, Structure, and Dynamical Evolution.'

Oct 11-15 — Space Research Institute of Russian Academy of Science, **Moscow**, Russia: Solar System Symposium.'

Oct 18-21 — International Academy of Astronautics, **Damascus**, Syria: '1st IAA Regional Conf. in Middle East.'

Oct 22 — Spaceport America, Virgin Galactic, Las Cruces NM: WhiteKnightTwo / SpaceShipTwo to make flyover of Spaceport America for inauguration of runway.

Oct 23-27 — NSS Puerto Rico, Leeward Space Foundation, **San Juan** PR: 'Puerto Rico Space Congress

Oct 28-30 — SpaceLand, **Sardinia**, Italy: '2nd SpaceLand Expo-Congress' / Summit on SMES and Space Tourism.'

Moon Miners' Manifesto Resources

http://www.MoonMinersManifesto.com

MMM is published 10 times a year (except January and July. The December 2010 issue will begin its 25th 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:

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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 November 2009, the 1st twenty years of MMM, 200 issues, are 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 Clasics, 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** and **Tourism** have been added and **Research** and **Select Editorials** are underway. New Theme Issues will be coming): Lunar Analog Projects, Lunar Building Materials, The Lunar Economy, The Lunar Homestead, Modular Architecture, Modular Biospherics, Frontier Arts & Crafts, Frontier Sports, Other Solar System Destinations, and so on.

www.moonsociety.org/publications/mmm_themes/

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

www.moonsociety.org/publications/m3glossary.html

The initial addition includes over 300 entries, many with illustra-tions. Additional entries are under construction. It is hoped that new members will consider this to be a "Read Me First" guide, not just to Moon Miners' Manifesto, but to our vision and goals.

All of these resources are available online or as free access downloads to readers of MMM-India Quarterly

Student Space Organizations in India

The Planetary Society of Youth (TPSY)

http://www.youthplanetary.org/

Shri: R.V.Burli, President
The Planetary Society of Youth
Opp. VRL Office - Bagalkot - 587101
Karnataka - India
Tele: (R) +91-8354-222725
(M) +91-9343110567
E-mail: president@youthplanetary.org

Mr. Amrut Yalagi, Secretary
The Planetary Society of Youth
21st, Main Road, VIjay Nagar, Near Engg.College
Bagalkot - 587 102, Karnataka - India
Tele: (R) +91-8354-233911
(M) +91- 9880071339
E-mail: amrut@youthplanetary.org
amrut1243@gmail.com

Astronautical Soc. of India Student Chapter (ASISC) http://www.indianspace.in/

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SEDS NITW (Warangal) (100 members)
SEDS GGITM (Bhopal) (89 members)
SEDS KCT (Coimbatore) (27 members)
SEDS ISM (Dhanbad)
SEDS NIT Trichy (Trichy) (17 members)
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See map on last page of this issue

SEDS-India Projects
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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.

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Printing this publication in the US would not be costly, but mailing it overseas to addresses in India would be.

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"Only those who risk going too far can possibly find out how far one can go."

T. S. Eliot

For once you have tasted flight you will walk the earth with your eyes turned skywards, for there you have been and there you will long to return.

Leonardo da Vinci

"No grimmer fate can be imagined than that of humans, possessed of god like powers, confined to one single fragile world."

Kraft Ehricke

Key: ISRO Centres; Moon Society; SEDS; NSS

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