

“Towards an Earth-Moon Economy – Developing Off-Planet Resources”

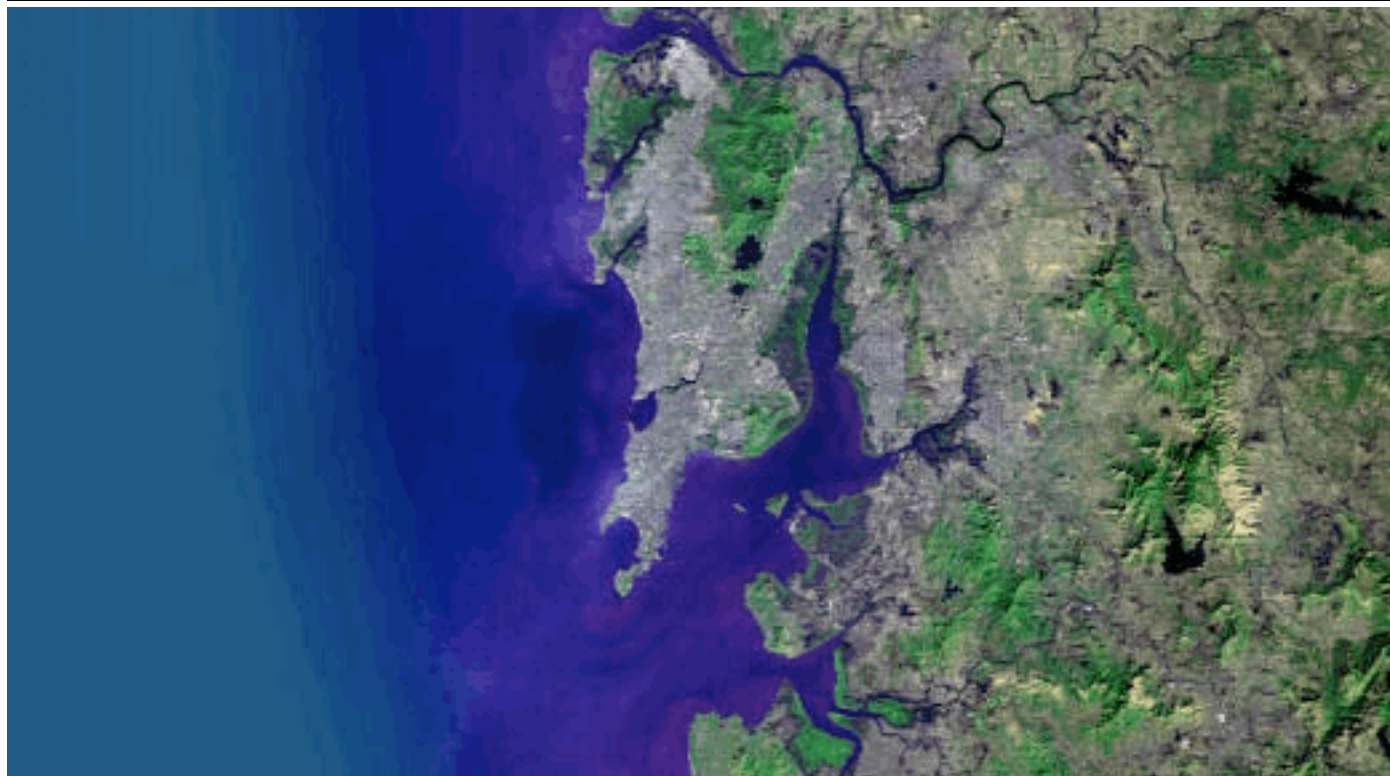
Moon Miners’ Manifesto

India Quarterly Edition

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

#6

SPRING 2010



Mumbai and Surroundings from Space – a beautiful sight

Feature Articles This Issue

Drama of The Moon Impact Probe <i>Srinivas Laxman</i>	p. 5
The Lunar Rock Pile: Hidden Assets <i>Peter Kokh</i>	p. 11
A Lunar Analog Research Station for India <i>Jayashree Sridhar</i>	p. 16
Salvaging Google Lunar X-Prize “also rans” <i>David Dunlop</i>	p. 26
Solving the Moon’s Water Puzzle <i>David Dunlop</i>	p. 29
A United Nations Humanity Centre & Retirement Complex <i>Madhu Thangavelu</i>	p. 32
Complete article & feature index on the last page	

Welcome to Moon Miners’ Manifesto India Quarterly Issue #6

This issue is the biggest so far. While the operational part of the Chandrayaan-1 mission is over, the analysis of the tremendous amount of data gathered by all her instruments is far from complete. New discoveries, some even more exciting, are continuing to come to surface.

And neither have things slowed down worldwide. The heady pace of international efforts continues. There is a lot on which to report.

Plus our editors have many ideas to share. We live in exciting times. Even in the US, where the Obama Administration is trying to revolutionize NASA’s efforts and priorities, the outlook is for more activity, not less.

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@moonsociety.org

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.moonsociety.org/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

Srinivas 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 than in any other country.

And – India is going to the Moon, 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 organisations within the country.



India Space Front Updates

NASA, ESA Want To Be Part of the India-Russia Chandrayaan-II Mission

http://www.space-travel.com/reports/NASA_ESA_Want_To_Be_Part_Of_Chandrayaan_II_Mission_999.html/

Bangalore, Feb. 8, 2010 – ISRO Chairman K Radhakrishnan, responding to a question, acknowledged that both NASA and ESA are among "several candidates" who have sent proposals for instruments aboard Chandrayaan-2 and its two rovers.

An ISRO Scientific Board will "look at all the requirements, and what experiments we need to do, and what mass is available, and what each proposed instrument would require. And looking at the Chandrayaan-I accomplishments, what are all the things that you have to follow up?" ##

India, Russia working on Legal Framework for Space Programme

<http://www.deccanherald.com/content/51889/india-russia-working-legal-framework.html>

A legal framework will be needed for Russia's cooperation in ISRO's manned space programme, which will involve use of Russian Soyuz spaceship

Moscow, February 8, 2010: Head of the Federal Space Agency Roskosmos Anatoly Perminov told a radio audience that this cooperation will also involve development of India's manned space ship and its launch vehicles. "Some of the issues require clearance from Russia's government."

"During Russian President Dmitry Medvedev's New Delhi visit in December 2008, ISRO and Roskosmos had signed a MoU for cooperation in the Indian manned space programme and the talks are underway for **acquiring a Soyuz spaceship, which would take two Indian astronauts on an orbital mission under the command of a Russian cosmonaut.**"

ISRO has sought Russia's help in developing a **spaceship lighter than the "Soyuz", which could be adopted for launch aboard lighter Indian space launch vehicles.** Any Russian involvement in helping India in developing heavier space launch vehicles would be seen as violation of Missile Technology Control Regime (MTCR) by Moscow. Development of a lighter spacecraft for launch on ISRO vehicles already under development.

M3IQ Comment: Heavier is not always better. The Soyuz is a decades old vehicle dating back to the mid-1960s. Engineering a lighter weight, but equally functional vehicle, with today's manufacturing processes should not be a problem. Plus, a lighter weight craft on a lighter rocket will pile up the savings for India over the long run. ##

India Looks To Global Effort For Manned Mars Mission

http://www.space-travel.com/reports/Human_Flight_To_Mars_Will_Be_A_Global_Mission_999.html

"As a leading spacefaring nation, India with its low-cost but high-end launch vehicle technology will be a part of the international consortium for the manned mission to Mars."

Bangalore – 01.29.2010: ISRO Chairman K. Radhakrishnan believes that by 2030, a first manned flight to Mars could be undertaken by a consortium of spacefaring nations, by combining their resources and technological contributions. Such an "ambitious mission will pose scientific and technological challenges to all space agencies." A start in this direction has already been made. In October 2009, NASA and ESA signed an agreement to expand collective capabilities, resources and expertise for exploration of Mars.

To this collaboration, India would bring its low-cost but high-end launch vehicle technology. India is already planning an unmanned mission to Mars' surface, and in the process of defining the instruments that will make the trip.

M3IQ Comment: The hurdles that must be overcome for a manned Mars mission are formidable. Trip times of 6-9 months may expose astronauts to excessive cosmic radiation. Development of faster rockets such as VASIMIR and/or nuclear thermal rockets that could make the trip in 6 weeks instead of 6 months would be a considerable help.

Currently, no space-faring nation has the biological life-support systems that will be needed both for the long journeys and for the long stay time on the Martian surface. Currently, fresh oxygen and water must be brought to the International Space Station every two weeks or so. We could not support a trip to Mars, much less a long stay on the surface with that kind of technology.

Robert Zubrin of the Mars Society demonstrated that we could produce the fuel for the return trip out of the elements in the atmosphere, combining carbon and hydrogen to make methane. That feat would mean ships could be much lighter as they would not have to carry to Mars all the fuel needed for a return trip. Equipment landed on Mars in a prior unmanned mission would have the fuel ready before the astronauts ever left Earth, thus establishing a considerable measure of security and assured return.

We would have to shield our lander-habitat on Mars, and it is possible we could do that with polyethylene beads manufactured in advance by a similar chemical process, again from the elements in Mars' atmosphere, which is 97% carbon dioxide and 3% nitrogen, plus some water vapor.

Recent findings have disclosed sizable glacier fields in some parts of the red planet, that have been preserved from sublimation and loss to space by a covering of wind-blown Mars dust. This is encouraging, as we may be able to tap such sources for drinking water and for agriculture to produce most of the food the visitors from Earth would need.

As for the Moon, the benefits of a Mars effort would include development of biological life support systems, and other self-reliance systems that can only help advance any permanent occupation of the Moon. **M3IQ**

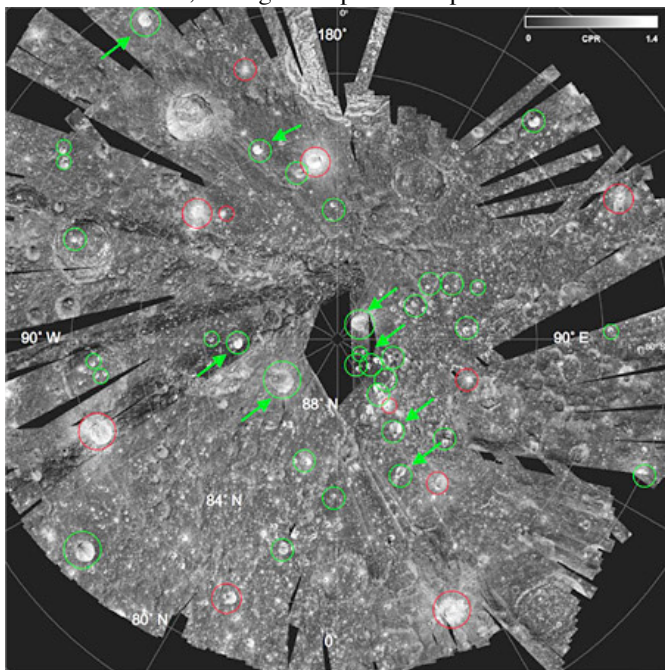
“At least 600 Million Tonnes” of Water-Ice Found at Moon’s North Pole

http://www.nasa.gov/mission_pages/Mini-RF/multimedia/feature_ice_like_deposits.html

M3IQ Special Report and Commentary – Peter Kokh

Mini-SAR on Chandrayaan-1 makes find

Even more exciting than the mixture of dust and ice found by NASA’s LCROSS probe at the south pole, is the finding of virtually pure ice “all over the place” around the Moon’s North Pole by a NASA instrument aboard India’s Chandrayaan-1 orbiter. The Miniature Synthetic Aperture Radar or Mini-SAR for short, data yielded a map of the Circular Polarization Ratio (CPR) of the north pole of the Moon. The map highlights (green circles) more than 40 small craters with water ice. The craters range in size from 2 to 15 km in diameter and are found throughout an area within 10° of the North Pole, having some portion in permanent shadow.



For a larger, higher-resolution version of the above, go to: http://www.nasa.gov/images/content/431341main_CPR%20map%20North%20pole.jpg

Mini-SAR used the polarization properties of reflected radio waves to characterize surface properties. It sends pulses of radar that are left-circular polarized. Typical planetary surfaces reverse the polarization during the reflection of radio waves, so that normal echoes from Mini-SAR are right circular polarized. The comparison is revealing.

“High CPR in this case is being caused by water ice, which is only stable in the polar dark cold traps.” “The estimated amount of water ice potentially present is comparable to the quantity estimated solely from the previous mission of **Lunar Prospector**’s neutron data (“several hundred million metric tons.”) This is very gratifying for all those who worked hard to make Lunar Prospector real. LP started as a “grass roots” space-enthusiast project in the late 1980’s, then finally flew as a NASA Discovery Mission in 1998-99. Some have dismissed the value and interpretation of Lunar Prospector’s positive findings.

“The ice must be relatively pure and at least a couple of meters thick to give this signature.”

There is no mention in the cited NASA announcement about Mini-SAR data being used to create a similar CPR map of the region surrounding the South Pole, where LCROSS found not layers of water-ice but of a layer of ice-particles mixed with moon-dust. This may come later, as the instrument did fly over both polar areas.

It would be hard to explain how the ice presence would be substantially different either in concentration or amounts between the two poles. On the other hand, Lunar Prospector did show twice the concentration of “hydrogen” surrounding the North Pole as around the Moon’s South Pole. One suggested difference, however, is source. At one pole, the water ice particles could have accumulated slowly over the eons; at the other by one big event, hard to imagine.

The suggested mechanism for water ice particle accumulation at the poles is this: A volatile-rich (water-ice, carbon and nitrogen oxide ices, other species) hits the Moon anywhere on the globe. Some of the resultant vapor splashout is lost to space immediately and more is dissipated by the incessant solar wind. Some of it may reach the polar cold traps (especially if the impact is on a part of the Moon then experiencing night darkness) before the Sun (and solar wind) come up, and freezes out in the permanently shaded areas where it can build up, bit by bit over time, getting immixed with soil particles.

That we are finding what looks like solid ice or relatively high ratios of ice to soil, in thick layers, does tease the mind. How can we explain that? Someday we will know.

“The emerging picture from the multiple measurements and resulting data of the instruments on lunar missions indicates that water creation, migration, deposition and retention are occurring on the moon,” said **Paul Spudis**, principal investigator of the Mini-SAR experiment at the Lunar and Planetary Institute in Houston. “The new discoveries show the moon is an even more interesting and attractive scientific, exploration and operational destination than people had previously thought.”

Implications for Luna Base location

There has been a “bandwagon” for some time to locate mankind’s first outpost on our eighth continent at the Lunar South Pole. Both for scientific exploration and for industrial purposes, choosing a site that is surrounded by thousand of kilometers of rugged highlands has been questioned by a few. Areas along a mare/highland “coast” would give access to both major suites of moondust. The South Pole is some 2,000 km from the nearest mare, Mare Humorum. In contrast some of the ice-filled craters found by Mini-SAR near the North Pole are only a few hundred km from the northern coast of Mare Frigoris. But currently, the emphasis has been on exploration outposts, not on use of lunar resources both to support settlement and in various scenarios that could help us address intransigent problems on Earth, including energy production and the environment.

At any rate, the news is exciting! Stay tuned as we can expect more to come. For India, the significance of the Chandrayaan-1 mission becomes ever greater. It bodes well for India’s future Moon Missions.

M3IQ

The Drama of the Moon Impact Probe

By Srinivas Laxman - moonshotindia@gmail.com

Rajgopal Sridharan, was among the space scientists, seated at the Chandrayaan mission operations control room in ISRO's telemetry, tracking and command network (ISTRAC) in Bangalore on the night of November 14, 2008, along with some of the other Indian space heavy weights like U.R. Rao and G. Madhavan Nair, both former ISRO chiefs monitoring the flow of data on the big screens.

Also at the hi tech control room that historic night was none other than APJ Abdul Kalam, former Indian President and himself a rocket scientist, whose suggestion in November 2004 at the 6th International Lunar Conference in Udaipur, that India should "embrace the Moon" was now turning into a reality, thereby opening a new chapter in the nation's history.

The day is observed as Children's Day throughout the country to mark the birth anniversary of former Indian Prime Minister, Jawaharlal Nehru. As the Children's Day celebrations were drawing to a close that night, India in a few minutes would have another reason to celebrate with the bursting of crackers.

It was around 7.30 p.m. Sridharan was becoming excited. A renowned space scientist attached to the Space Physics Laboratory of ISRO's Vikram Sarabhai Space Centre, he was the principal investigator of a payload of an important instrument, which would attain a major breakthrough in a few minutes, catapulting India's space programme to greater heights. The instrument is called Chandra's Altimetrical Composition Explorer (CHACE), one of the three payloads on board the indigenous 29-kg Moon Impact Probe (MIP). MIP was one of the 11 payloads on board Chandrayaan-1, which was at that moment orbiting 98 kms above the lunar surface. MIP was heading towards the South Pole region of the Moon. CHACE had been exposed to deep vacuum for more than three weeks as the MIP flew towards the surface.



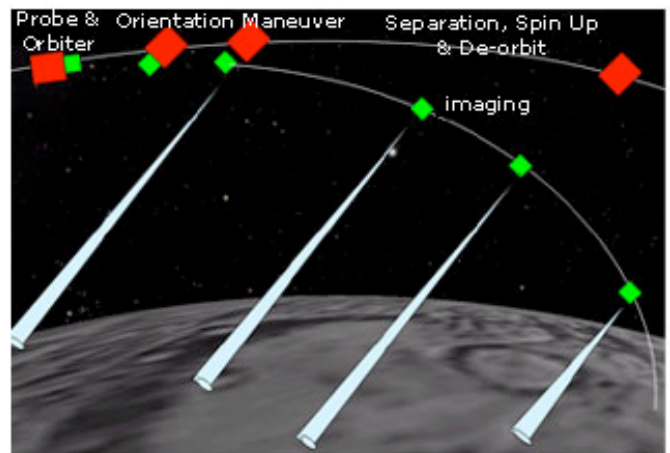
The Moon Impact Probe being prepared for launch aboard Chandrayaan-1. Note worker to left for size comparison

Not far from ISTRAC is India's Deep Space Network at a tiny village called Byalalu. Syed Maqbool Ahmed, who had played a key role in the design and development of CHACE, recalled: "That famous day, all of us gathered at the control room of the deep space network at 4 p.m. where the

big screens had been activated just a while ago. Our eyes were glued to these huge screens, and we were continuously observing data flowing in from NASA's Goldstone Deep Space Network, the Goddard Space Flight Centre and Istrac. There was a tremendous mood of excitement," he said.

"The countdown had already been initiated and at 8.03 p.m. the MIP separated from the mother craft and began zooming towards the Moon's surface. It was a pre-programmed command. At that moment, the main spacecraft, Chandrayaan-1 appeared over the Earth-facing side. As the much-awaited separation occurred the room broke into a thunderous applause," Ahmed, now with the University of Hyderabad, recalled to M3IQ.

As the MIP was heading towards the surface, Sridharan rushed from Istrac in Bangalore to the deep space network at Byalalu as the first data from the probe would be transmitted to this hi- tech complex. Said Ahmed: "Our ISRO engineers had employed an ingenious way of monitoring the flight of the MIP. They were monitoring the microwave radiated power from the MIP which was being transmitted through the main spacecraft, Chandrayaan-1. At one point it flew over the Malapert Mountains. The radiated power was diminishing slowly. At 8.27 p.m. to our delight there was an abrupt end to the power and we became aware that the probe had impacted on the surface of the Moon. We were very happy that the moment had been accomplished," he said.



Impact Probe Mission Profile

"We had to wait for 110 minutes to access the data from the MIP," said. Speaking to M3IQ, Sridharan said: "On the morning of the flight, we had carried out a dress rehearsal of the MIP mission which began at 8 a.m. and the data was available at 4 p.m. Everything went off smoothly," he recalled.

"As the MIP separated had began flying towards the Moon, certain numbers which were being flashed in the control began changing. When this ended, we knew that the MIP had crash-landed on the lunar surface. It is difficult to explain my feelings at that moment, but I did become emotional and there was a feeling of jubilation among all of us," he said.

When word spread throughout the country, that India had landed on the Moon that night and was the sixth member of the exclusive lunar club after the US, former Soviet Union, Japan, China and the European Space Agency

(17 countries), the nation broke into a celebratory mood with crackers being exploded in different regions.

The people of India became aware that the MIP was not merely ornamental with the Indian tri-colour painted on all sides, 10 months later on September 25, 2009, when Madhavan Nair, announced at a hastily-convened media meet that the probe while descending towards the Moon had discovered water. However, he did not go into the specifics, saying that the announcement was not made immediately after the landing because more data analysis had to be done.

But, the story does not end here. In March 2010, a report prepared for a prestigious British journal, *Planetary and Space Science* said that CHACE, the payload on board the MIP, was the first to detect water in a vapour form in the sunlit portion of the tenuous lunar environment through in-situ measurements. The report said that it vindicated the presence of water on the surface of the Moon in the form of ice at higher lunar altitudes inferred from IR absorption spectroscopy by NASA's Moon Mineralogy Mapper.

The report stated that the present experiment was a one-shot affair. "While analysing data, the first results from the Moon Mineralogy Mapper indicating the deposition of ice, the concentration of which showed a steady increase towards the pole, is considered to vindicate the inferences from CHACE," it said. According to the report though M3 is an imaging instrument with unprecedented spectral imaging capability, the emphasis had been on detecting water ice on the lunar surface. "On the other hand, MIP's CHACE instrument was designed to give the relative abundance of water in its vapour phase..." said the report.

"In a way, the results from CHACE and M3 are complementary as the results from the latter pertaining to solid ice could in all probability be the source for water vapour concentration detected by CHACE," the report pointed out. This report was prepared by Sridharan and his team of scientists. Sridharan told M3IQ that the significance of the CHACE's breakthrough is that it was the first time that water was found in a vapour form in a sunlit portion of the Moon. He said that the final manned mission to the Moon, Apollo 17, had carried a similar instrument, which indicated the presence of water and carbon dioxide during the lunar night time. "This was dismissed as contamination, but through CHACE data we want to reexamine that data," he added.

M3IQ

New Types of Moon Rocks Found by Chandrayaan-1

<http://timesofindia.indiatimes.com/india/Chandrayaan-1-also-found-new-types-of-rocks/articleshow/5550403.cms>

Report by M3IQ reporter and co-editor Srinivas Laxman

Moon Mineralogy Mapper Principal Investigator Carle Pieters announced that the M3 NASA instrument on board India's Chandrayaan-1 lunar orbiter had found new types of rock on the farside of the Moon. The rocks are very small and unusual. Apparently, the types of minerals in the rocks are common, but their combination is unusual.

Another Chandrayaan-1 instrument detects subsurface lunar lava tubes

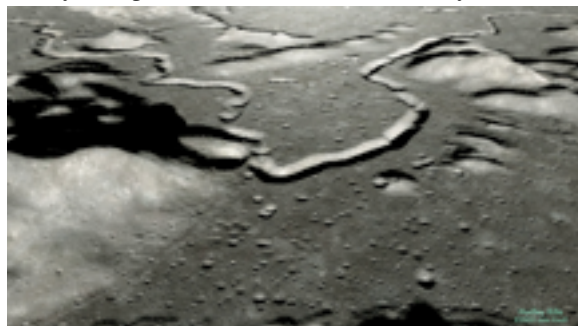
In this same report (on the 6th Chandrayaan-1 scientific meeting, organised by Physical Research Laboratory (PRL), an autonomous organisation, under ISRO.) there is mention that A. S. Arya, a scientist attached to Ahmedabad-based Space Applications Centre, told the gathering that an analysis of the high-resolution imagery of Chandrayaan-1's indigenous **terrain mapping camera** (TMC) has identified "lunar tubes." These "tubes" could be utilised for a potential human settlement in future, provide much-needed radiation protection to a human colony there.

The Times of India report did not say where on the Moon's surface these tubes were discovered. Previously, JAXA scientists in Japan had announced the discovery of a "lava tube skylight" by their **Kaguya** orbiter. M3IQ had reported on that discovery in issue #4, Fall 2009, page 8,

Ref. <http://www.planetary.org/blog/article/00002173/>

M3IQ Commentary

If this find by Chandrayaan-2's TMC instrument is confirmed, it will add more evidence about the widely expected vast network of such tubes in the lunar maria lava sheet plains. Lavatubes are a natural feature of how low-viscosity lava sheets spread. Many of the sinuous winding rille valleys observed on the Moon (including Hadley Rille (photo below) visited by the Apollo 15 crew in 1971, are apparently collapsed lava tubes of extraordinary size.



Apparently these features form on a scale that is in inverse relationship to the host world's gravity. Such tubes on the Moon may be a hundred times the width and height of those we find in lava sheets and in shield volcanoes here on Earth. Those on Mars, where seven lavatube skylights have already been discovered, would be of intermediate size.

If there is one single thing that gives the lie to the popular impression that the Moon is just a dusty rubble pile, it is these features: *the Moon's "Hidden Valleys."* Humans cannot long survive on the exposed lunar surface where there is no atmospheric blanket to protect them from cosmic rays and solar flares. However, a blanket of 2-4 meters of moon dust would provide the same service. But the roofs of intact lunar lavatubes must be 40 meters thick or more!

Within suspected lunar lavatubes there must be many (hundreds? of) thousands of square kilometers of fully sheltered space waiting to protect hectare-hungry industrial parks, ware-housing operations, archives that should preserve records and artifacts and biological specimens for many billions of years! And yes, ample expansion space for pioneer settlements.

M3IQ

Meeting Dr. J. Goswami and Learning About ISRO's Planetary Mission Plans

By David A. Dunlop

March 22, 2010 - While attending the LPI 2010 Annual Science Conference at the Woodlands near Houston Texas, I had the pleasure of meeting for the first time Dr. Janendra Goswami of the Physical Research Lab of ISRO, who was also in attendance. In addition to making presentations on the Chandrayaan-I missions at the conference Dr. Goswami hosted a special press conference on water on the Moon including members of the Chandrayaan Science team including Dr. Carle Pieters of Brown University, Dr Lawrence Taylor of the University of Tennessee Knoxville, Planetary Geophysics Institute, Dr. Paul Spudis of the Lunar and Planetary Institute, and Dr Anthony Colaprete of the NASA AMES LCROSS mission.



Dr. Goswami and I had a few moments to discuss the development of the new Moon Society India. I was pleased that he was aware of the M3IQ, and was interested to have the contact information for Moon Society India officers. I indicated the MS was in support of the All India SEDS conference last year and this year again at the Vellore Institute of Technology, and particularly of the lunar rover competition. The MS and new MS India are strong advocates for student engagement opportunities in both scientific and engineering research projects.

We also discussed the international growth of the Lunar Science Institute, which while initiated at NASA AMES, also has nodes in Canada, Israel, and Saudi Arabia. Dr. Goswami indicated that ISRO is also interested in this initiative and thought that ISRO would become a member in about a year. India's successful first lunar mission will be followed up by other missions, and its contribution to the new flood of scientific information will make it an ongoing global resource for lunar research.

One irony of the political and budgetary process in the US is that the front end efforts to acquire the political and financial support and to build and fly space missions typi-

cally get all the attention. The flood of scientific information provided by these missions, get their "15 minutes of fame" and generate a few headlines. Meanwhile, after the fact, the need to mine this treasure trove of data also requires funding for the analysis of this information and the support of scholars and students. This long-term effort is often neglected by comparison, and becomes the province of a few scientific scholars who are inadequately funded. NASA's Planetary Data System is an open information source that can be mined by scholars across the globe. The good news is that others around the world can participate so that a global community still advances knowledge.

I also discussed our Moon Society initiative to create an International Data Base of Interest in Access to the Lunar Surface and we agreed to share the efforts we are making with LEAG and ILEWG to develop a database from open sources documents which could be a tool of use to principal science investigators, those concerned with engineering demonstration projects, space agency mission planners, and potential commercial space mission entrepreneurs and investors.

Data-Mining, a Chandrayaan-1 "after mission"

It is good to see India laying the foundation with plans and facilities for similar study and analysis of its lunar missions. The Moon Society applauds the impending membership of ISRO in the Lunar Science Institute. The information provided by Chandrayaan-I will be of importance long after the excitement has diminished of seeing the mission launched and successfully concluded. The wealth of information provided by the Apollo Missions has kept scientists busy for more than 40 years and provided a foundation for later additions analysis and interpretations. This will be no less true for Chandrayaan-I's data lode. Even as excitement about the forthcoming Chandrayaan-II mission grabs our focus we will continue to learn things from the information provided by Chandrayaan-I.

Even though the M3IQ is a popular rather than a scientific journal, we hope to help our readers keep abreast of the ongoing analysis. India's first lunar mission will remain a yardstick of pride even as successive missions capture the torch of excitement.

For students of the Moon today, the study is a global enterprise. The network of international resources and cooperation in sharing information provides those with motivation and interest opportunities such as have never been greater. Global Internet access also means the cost of obtaining such information is also within the grasp of a much larger number of people. Those who are motivated and willing to dig out information can make original contributions to scholarship even if they have no national connection to the original space missions.

The community of lunar interest is destined to grow as consciousness of the Moon's economic role in Earth's future is more widely understood. We encourage our readers, and especially students with scientific career ambitions, to be aware that they are well-positioned to participate as lunar explorers if they have the ambition, and that they can distinguish themselves by such invaluable "data-mining" contributions and participation.

DD



Elsewhere in Asia

China to launch 1st Space Station Module in 2011

<http://www.tgdaily.com/space-features/48706-china-to-start-space-station-construction-next-year>

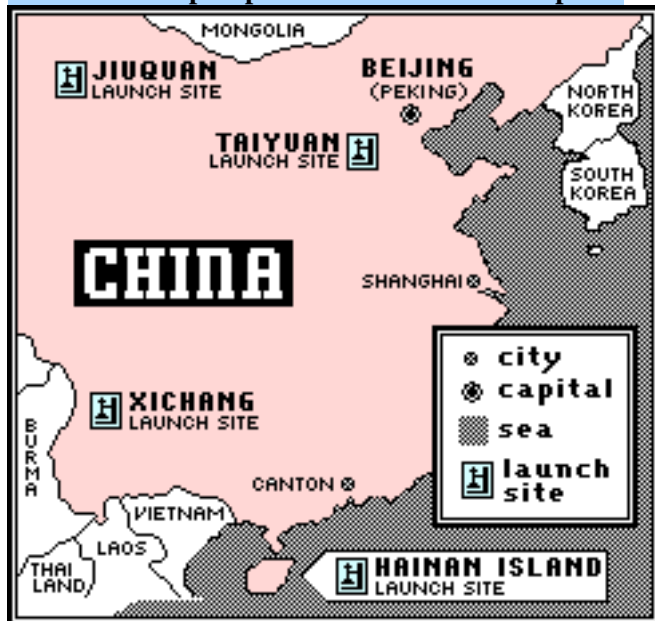


Xinhua news agency: the laboratory module, **Tiangong 1** or 'Heavenly Palace' will be launched on a modified version of the Long March 2F rocket next year instead of later this year, delayed for technical reasons. The 8.5 ton lab is about 30 feet long, and provide a 'safe room' for three Chinese astronauts to live in and conduct zero gravity research.

Tiangong-1 has already been assembled, and is about to start testing. Initially, it will serve as a docking station for other spacecraft. There are three docking missions planned for Tangong-1 in the next two years, with the Shenzhou-8, Shenzhou-9 and Shenzhou-10 spacecraft, each of which will have a crew of two or three.

China is also planning to launch its second lunar probe, **Chang'e-2**, later this year. ##

China's New Spaceport on Hainan Island: Update



The site is near Wenchang 19.617°N 110.744°E on the north-east coast of Hainan Island, and will allow boosting

heavier payloads into orbits less inclined to the equator.



Spaceport latitudes:

- Baikonur (Kazakhstan, used by Russia) 45.6°
- JFK (NASA) 28.5°
- Srikhota (ISRO) 13.9°**
- Kourou (ESA) 5.2°
- Alcantara (Brazil) 2.3°

<http://spaceports.blogspot.com/2009/09/china-starts-construction-of-4th.html> (watch Video)

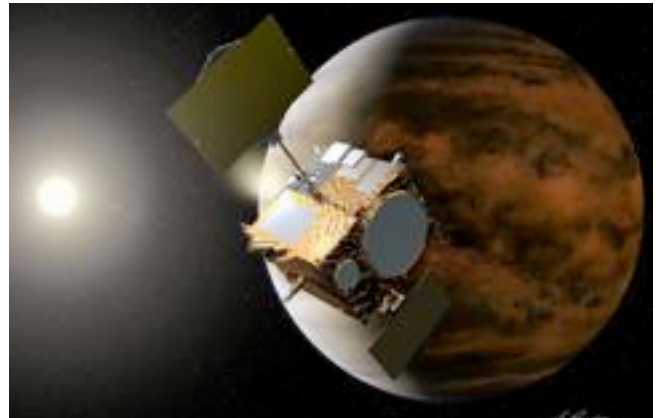
Construction began in 2009.

The site will include more than a spaceport. "The Hainan site is being built to accommodate the **Long March CZ-5** carrier rocket, which will be able to carry **larger payloads** and is slated to become the workhorse of China's manned space and space station program. Covering an area of 20 sq km, the **Wenchang Satellite Launching Center** will cover a space launching port, a space theme scientific park, a rocket assembling plant, a rocket-launching base, and the command center.

The **space theme scientific park**, dubbed as the first-ever in Asia with an aerospace theme of, will exhibit rockets and model rockets and provide opportunities for visitors to experience zero gravity. ##

Japan ready to launch Venus Climate Orbiter

www.nature.com/news/2010/100315/full/news.2010.126.html



A. Ikeshita / Japan Aerospace Exploration Agency (JAXA)

"Why is Venus so different from Earth?"

In late January, Japan shipped its Akatsuki (Dawn) Venus Climate Orbiter to the Tanegashima Island spaceport, for a launch is scheduled on 18 May. Questions that the probe is designed to answer include: how the atmosphere of Earth's scorching hot neighbour is able to 'super rotate' at speeds as much as 60 times that of the planet itself; and why a planet with so much in common with Earth is so inhospitable. Evidence from the ESA's **Venus Express**, in orbit around Venus since April 2006, suggests that Venus might once have had water oceans. Venus is only slightly smaller and less massive than Earth, physically, a "twin planet."

The probe is expected to reach Venus in December. It will measure characteristics of different layers of the atmosphere at infrared, ultraviolet, infrared and radio frequencies. Its camera can photograph lightning strikes. ##

Final rest location of Russia's Lunakhod 2 Rover found by Canadian Scientist.

<http://story.malaysiasun.com/index.php/ct/9/cid/89d96798a39564bd/id/613016/cs/1/>



http://en.wikipedia.org/wiki/Lunokhod_2

Lunakhod 2 found on the Moon, 37 years later at end of 35 km trek

Using an atlas and the NASA Lunar Reconnaissance Orbiter images, Phil Stooke, a professor at the University of Western Ontario (London, ONT)'s Departments of Physics and Astronomy and Geography, pinpointed the exact location of the Russian rover Lunokhod 2, discovering tracks left by the lunar sampler 37 years ago after it made a 35-km trek, the longest any robotic rover has ever been driven on another celestial body, including Mars.

"The tracks were visible at once," said Stooke. "Knowing the history of the mission, it's possible to trace the rover's activities in fine detail. We can see where it measured the magnetic field, driving back and forth over the same route to improve the data," Stooke said.

And we can also see where it drove into a small crater, and accidentally covered its heat radiator with soil as it struggled to get out again. That ultimately caused it to overheat and stop working. And the rover itself shows up as a dark spot right where it stopped," he added.

The find will mean that older maps published by Russia will now need to be revised.

The only piece of hardware on another world That is owned by a private citizen

To raise money for Russia, Ownership of Lunokhod 2 and the Luna 21 lander was sold by the Lavochkin Association for \$68,500 in December 1993 at a Sotheby's auction in New York. The buyer was computer gaming entrepreneur and astronaut's son Richard Garriott.

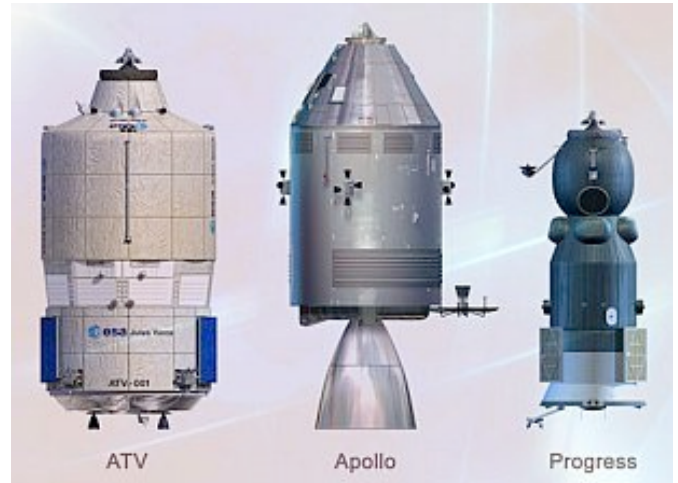
"I purchased Lunakhod 2 from the Russians. I am now the world's only private owner of an object on a foreign celestial body. Though there are international treaties that say, no government shall lay claim to geography off planet earth, I am not a government." ##

ESA's 2nd ATV (Automated Transfer Vehicle), the Johannes Kepler, scheduled for launch to ISS later this year

http://www.esa.int/esaHS/SEMXXBCKP6G_index_0.html

A third ATV has been named after the Italian physicist and space pioneer *Edoardo Amaldi*.

The 1st, the *Jules Verne*, had delivered "4.5 tonnes of food, water, fuel, supplies and equipment, and then served as a propulsion module (to boost ISS' orbit) for six . The ATVs are not designed to be reusable, and burn up in the atmosphere upon undocking and descent.

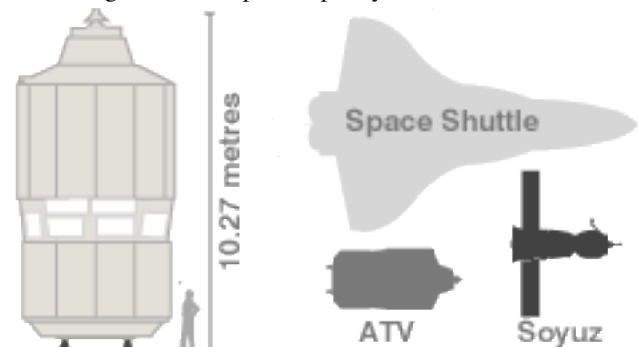


Above: ESA's ATV in comparison with Apollo (capsule and service module stack) and Russia's reliable Progress freighter

The ATV Schedule and Future Evolution

If all goes as planned, an ESA ATV will deliver 6.6 tonnes of cargo to the ISS, every 17 months. On the drawing boards is a new Advanced Reentry Vehicle. In this version, the pressurised part of the ATV would be replaced by a reentry capsule able to return cargo and valuable experiments to Earth.

Further evolution could include a crewed version, which would then boost ESA into the elite class of manned space program nations, along with (in historical order) Russia, the USA, China, and eventually India. Japan is also considering a manned space capacity.



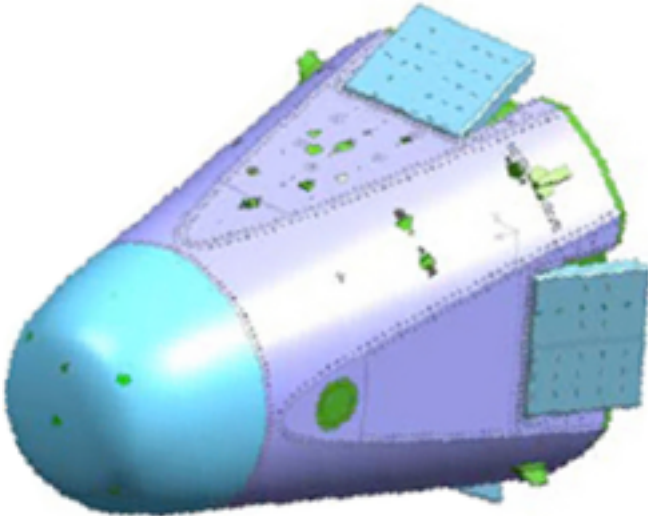
Additional size comparisons: left with person; right with Space Shuttle and manned Soyuz vehicle

ESA (European Space Agency) includes a growing list of nations, some with their own space agencies (France, Italy):

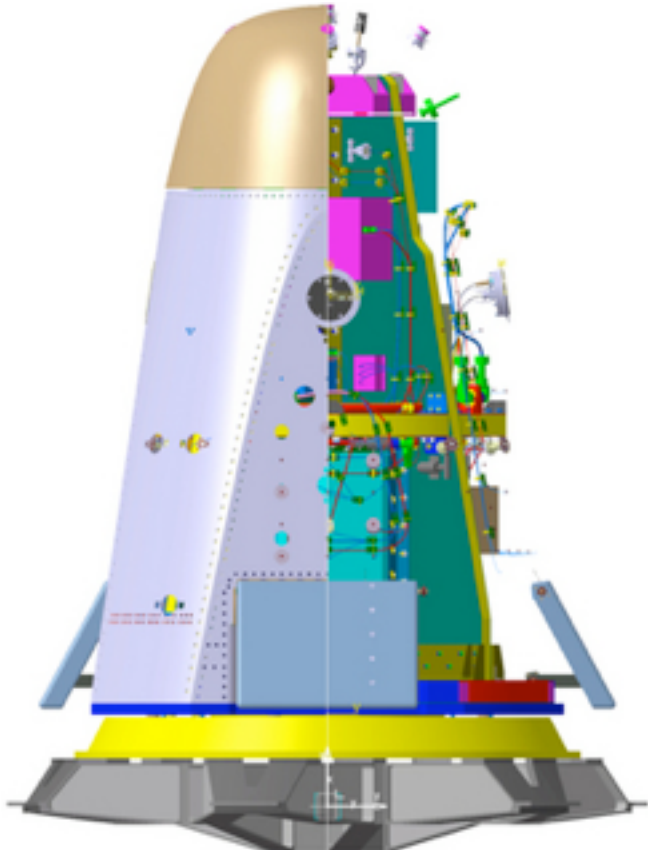
http://en.wikipedia.org/wiki/European_Space_Agency#Member_countries_and_budget ##

**ESA & Russia sign contract for EXPERT
(ESA's European Experimental Re-entry Testbed)**

http://www.esa.int/esaHS/SEMC9A7JT2G_index_0.html



[See preceding article on ESA's ATV Evolution]



Outer View and Innards

December 2, 2009 – “Under the contract the Makeyev State Rocket Centre will have the responsibility of integrating the Expert vehicle into a Volna rocket, which will be launched by a Russian submarine in the Central Pacific Ocean. They will also coordinate the Expert capsule search and recovery operations conducted by helicopter at the landing site, a Russian military test range in the Kamchatka peninsula. Expert is currently scheduled to be launched on its suborbital trajectory in **October 2010.**”

##

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

Mumbai

Formerly President of SEDS India

No, we haven't "been there, done that!"

THE LUNAR ROCK PILE

There's more to the Moon than first meets the eye
Behind "Door #1", "Door #2", "Door #3", Door #4

By Peter Kokh

Re-edited and reprinted from MMM #

Apollo 11 astronaut Buzz Aldrin and Mars Society President Robert Zubrin and others would have us all chant along in their mantra refrain "Been there, done that," to the Moon Putdown Blues. It is easy to see why. From a first quick superficial look (all the attention most people give anything,) the Moon is quite obviously a monotonously gray, rock and rubble-strewn desert of lifeless barrensapes.

"The Moon is obviously a Rock Pile.

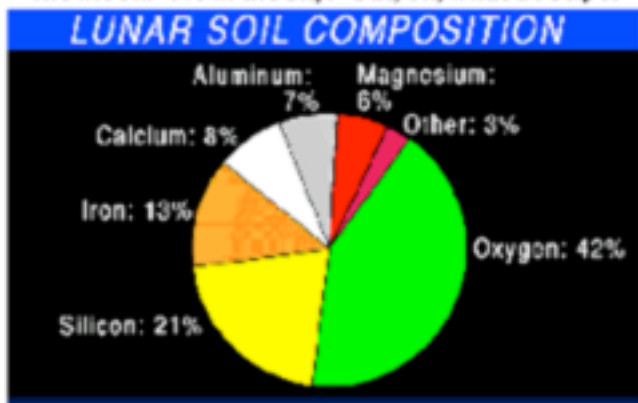
We found that out. Let's move on."

But guess what? Like the backdrop of the classic TV hit show "Let's Make a Deal!" the Moon's façade is only an apparent global dead end. It has unseen "doors" behind which lay a world of unsuspected potential. But paradoxically, what is "obvious" is not always what is "real" or "true." Appearances can be deceiving. One would think that we are all old enough to realize that. These mantra chanters disappoints us.

Behind Door #1 – Mineral Wealth: The "location" and "outline" of the first "door" to the hidden potential of the Moon was hinted at in the Apollo moon dust and moon rock samplings and their analysis. An abundance of oxygen, silicon, and calcium, plus an abundance of the four major "engineering metals": iron, aluminum, magnesium, and titanium. We've but to look through the door's peephole.

The key to open this door lies in homework we can do on Earth. We need to know how to isolate or "produce" these elements out of the complex unearthly minerals in which they are combined, more inconveniently than we'd like. Except for iron, a considerable amount of which is available unoxidized, in pure metal fines, in the "pre-mined" upper regolith, a "blanket of dust" pre-pulverized by eons of micro-meteorite bombardment. All we need to harvest this resource is a magnet. But otherwise, largely because the Moon did not undergo tectonic processing of its crust in the presence of water (hydrotectonic processing), it has no "ore veins" of concentrated metals in simple mineral combinations. The Moon's mineral wealth is not to be had so easily. *But it is there!*

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



<http://nsschapters.org/hub/pfd/MoonPieChart.pdf>

We need to do processing experiments, using simulant soils superior to those we have toyed with to date. They must resemble moon dust not just in the percentages of the elements represented, but also in the chemical mineral combinations to be found on the Moon. We have no, or little, experience extracting elements from such minerals. Yes, we have done some work on figuring out how to extract oxygen. But to paraphrase a well-known proverb, "lunar pioneers will not live by oxygen alone."

Nor is it enough to do "lab experiments." Techniques suitable on so small a scale are often unsuitable for production-processing. **Chemical Engineers** who can design factory-scale chemical processing, need to be involved.

Nor are the raw engineering metals enough. We need to develop ways to extract and isolate many elements present in lesser abundances as alloy ingredients, color pigments, or as ingredients for glass, glass composites, ceramics, cement and for manufacturing stuffs and building products in general. The "dance card" of the chemical engineers is quite full.

How can we do this homework without federal funds? We can brainstorm profitable terrestrial applications of the techniques and processes we are developing for the lunar frontier. That way we make money now and at the same time put "on the shelf" the technologies we need once we get there, paid for out of the profits of terrestrial applications, not taxes. This is the "spin-up" route.

Many still look to the rocket scientists to deliver the Promised Land. But as much as we need them to figure out how to realize "cheap access to space", it is the **chemical engineers** who will be able to tell us how to access space resources. (And without the **agricultural and biosphere engineers** and the **human factors engineers**, there won't be any "we" out there to do any thing with these resources.

If you are in search of a career that will put you at the forefront of opening the space frontier, one of the options just listed may be for you. Space is a place. Transportation just gets us there. After we arrive, we need to have opened these "doors" if we aren't just going to sit there, "stranded".

Behind Door #2 – permashade polar ice preserves:

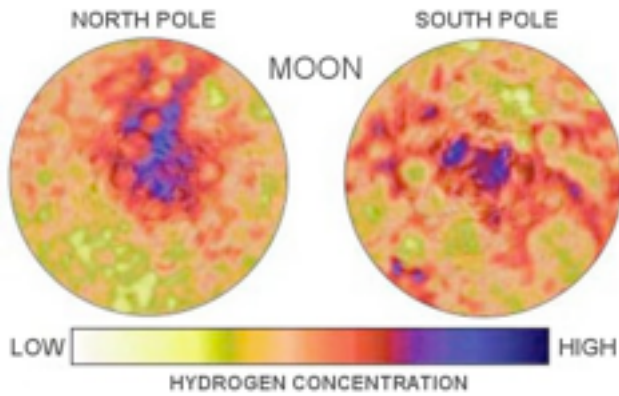
There are two clues to location of this "door":

- (1) The Moon's axis is nearly perpendicular to the plane of the Earth-Moon system's orbit around the Sun. So the Moon has no real "seasons."
- (2) As the Moon is not a perfectly smooth sphere, there must be places near both poles, in craters in which "the Sun never shines." These "permashade" areas are stable "cold traps", very frigid places where volatile elements (relatively high boiling points, with the vapor or gas easily dispersed by the incessant solar wind) might have accumulated over millions and billions of years.

In the late 1980s, NASA planned a Moon Observer, equipped to determine whether or not any cometary volatiles, dispersed in nighttime impacts with the Moon, might have reached the polar cold traps before the Sun arose over the horizon to disperse them. But this probe was a "phantom mission". The craft was to be the "backup Mars Observer". Congress, as superficial as most everyone else, convinced that there was nothing useful to learn from further Moon

missions, and in an effort to rein in Mars Observer program costs, canceled the backup craft. Almost end of story!

Scientists and space activists knew the “ice question” was important, deserving an answer. To our collective credit, **Lunar Prospector** was born and designed outside NASA. LP was available as a Discovery Mission project when the opportunity finally arose. The rest is history. Lunar Prospector’s instruments found several times the concentration of hydrogen at the poles in permashade polar cold traps as is found elsewhere.



Unlike the hydrogen to be found globally, embedded in surface soils by Solar Wind buffeting over billions of years, the polar hydrogen signal data is best explained as coming from water ice, rather than excess concentrations of Solar Wind protons. Now, more than a decade later, instruments aboard ISRO’s Chandrayaan-1 lunar orbiter and NASA’s Lunar Reconnaissance Orbiter and LCROSS probes have confirmed substantial ice deposits at both north and south lunar poles. The Moon, it seems, has major reserves of water ice. Indeed, Chandrayaan-1 found water and hydroxyl radicals everywhere on the Moon, a total surprise.

Those who want to access what lies “Behind Door # 2” need to put together a series of “ground truth” probes to ascertain the *percentage* of moisture in representative permashade ice deposits, and do tests to see *what methods of harvesting* this resource will work best.

This is something we cannot do from orbit. Perhaps there needs to be an additional, separate Google Lunar X-Prize for a private rover that lands in a permanently shaded crater at either pole and successfully takes such measurements and performs such tests. As this is a higher level of difficulty, a larger monetary prize would be appropriate.

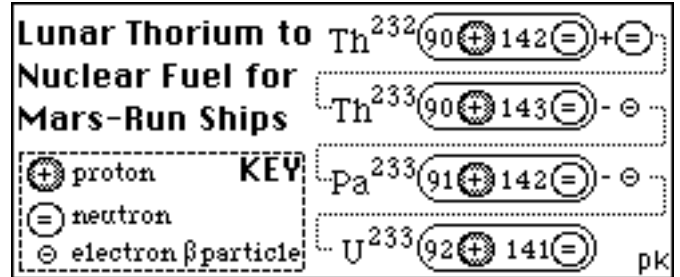
Water is essential for life support, agriculture and the biosphere in general as well as closed-loop industrial uses. It is NOT essential for rocket fuel. Liquid hydrogen is invaluable *for getting us out of the deep throat of Earth’s gravity well*. But once we are in orbit and beyond, we can do well enough with less potent fuels.

To burn up an irreplaceable resource “to get our macho masculine rockets off” - all in a one-time non-recyclable impatient exercise makes no sense.

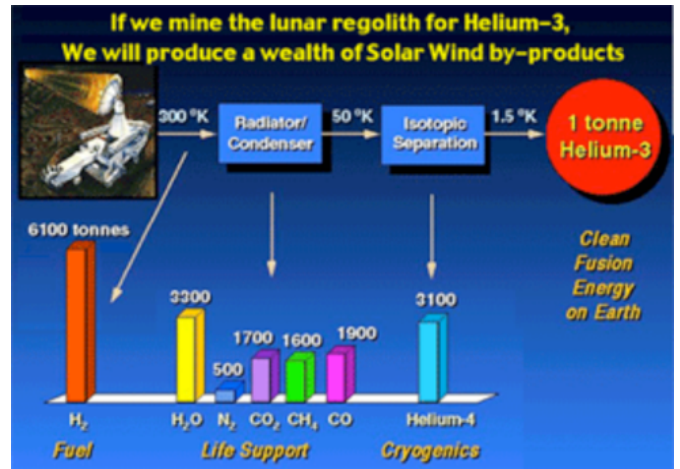
If this resource is hard to harvest because of the cold temperature, hardness, and other reasons, that may prove a blessing, as it will work to discourage the rocketeering pillagers, and thus preserve this water to support greater settlement populations.

Behind Door #3 – Nuclear Resources

Lunar Prospector mapped the lunar globe by tracking a number of elements. One of these was the radioactive element thorium. There are apparently appreciable reserves of this element in various areas of the Moon. Thorium is transmuted into fissionable Uranium 233 in a fast breeder reactor. Thus the Moon apparently has the wherewithal for a major nuclear fuels industry.



Thorium and Uranium 233 are nuclear fission fuels. They produce energy by the splitting of heavy atoms. The atomic bomb and all current nuclear plants operate on the fission principle. But the hydrogen bomb and nuclear plants built to operate on the same principle, produce energy by combining lightweight atoms (hydrogen, deuterium, tritium, helium-3). Now it turns out that the same solar wind, which has put a considerable amount of hydrogen protons into the lunar topsoil or regolith, has also endowed that layer with a wealth of Helium-3, the ideal fuel for fusion reactors, if we can overcome the engineering hurdles in making such plants a reality. Helium-3 could be the long-term cure for Earth’s stubborn energy and environmental problems.



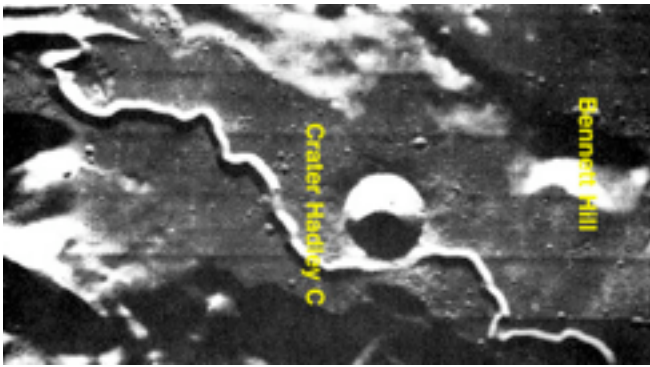
As to the fissionable Th/U233 resource, this too may be an invaluable export. Extreme environmentalists could conceivably succeed in banning the transport of all nuclear fuels through Earth’s atmosphere. While chemical rockets can support Mars exploratory expeditions of trained and dedicated crews, that real settlement, migration to Mars is most unlikely unless we have fleets of nuclear ships able to make the trip in much less time and over extended launch windows. Two plus two = .. . You guessed it! In that not improbable scenario, Lunar Thorium could fuel the opening of the Mars Frontier. I must acknowledge that Dave Dietzler disagrees with this conclusion on grounds that producing U233 from Th232 consumes more energy than burning U233 generates. I am not competent to debate this point.

Behind Door #4: The Moon's Hidden Valleys

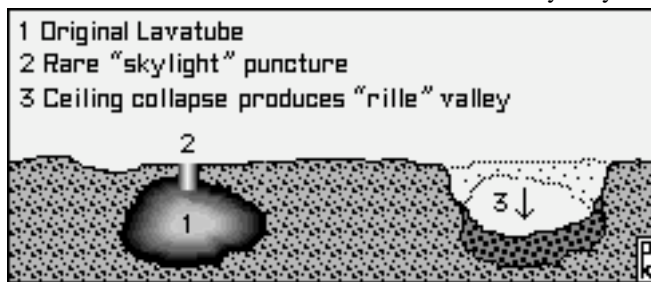
The entire surface of the Moon is exposed to the wind and waves of cosmic weather. Micrometeorites rain down incessantly *everywhere*. Intense raw solar ultraviolet washes *everything*. There is no shelter *anywhere* from the fury of Solar Flares and cosmic rays. The Moon's surface is an unbroken desolation that is as deadly as it is magnificent.

It would seem that to protect ourselves, we must build outposts on this storm-washed surface, then pile up a healthy layer of moon dust on top, to serve as a solid protective blanket in the same way as Earth's atmosphere provides a gaseous blanket to offer us the same protections.

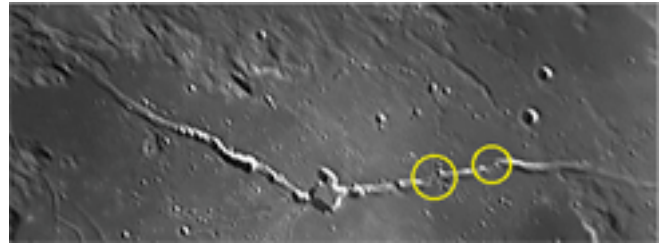
The first hint that *this is not the whole story* came with the Apollo 15 landing mission alongside Hadley Rille, a winding "sinuous" valley. Upon examination, the valley did not seem to be "carved out" by either water or lava. Instead it is the relic of a subsurface lava tube, what is left of it after the roof collapsed on top of its floor, creating the trench above.



From orbit, we've looked at similar "sinuous rilles" elsewhere on the Moon. They are a feature to be found only in the congealed lava flow "seas" called maria, usually near the "coasts" where the highlands begin or end. And lava sheets, formed by runny lava (like the kind that forms shield volcanoes) are just the kind of environment in which lavatubes form. Indeed, lavatubes are the principal means by which these sheets advance over the terrain that they bury



Have all lunar lavatubes collapsed? Do they only exist as relics? As natural ruins? Apparently not! Some such rille valleys are discontinuous. They consist of a number of sections separated by "interruptions" of apparently normal looking flat surface continuous with the surrounding host terrain. These natural bridges can only be interpreted as surfaces hiding intact lavatube sections. And where we have partially intact lavatubes it is reasonable to expect we will find some that are both wholly intact and not flood-filled by subsequent flows. Other evidence comes from rows of "collapse pits," rimless craters that are a sure sign of caverns below.



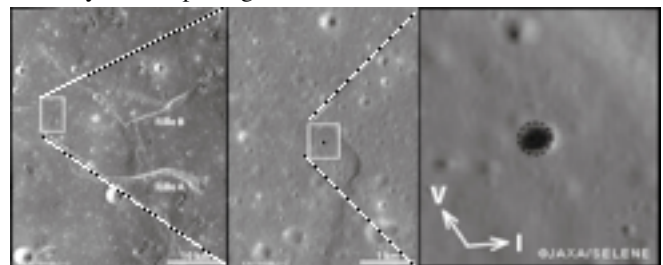
Above: "interruptions" in Hyginus Rille are in circled areas

The maria may be ridden with these tubes, and not just in the surface layer. As the mare [MAH ray] sheets built up layer-by-layer, tubes would have formed in each layer, some to be later flooded, some not. And wherever the surface-ceiling cover exceeded 40 meters or so, cave-ins and overall collapses will have been unlikely except in case of a direct hit by a sizable asteroid chunk.

These lavatubes, of immensely larger scale than those we find on Earth, thanks to appreciably lower lunar gravity, and, immensely more ancient (billions rather than thousands of years old), provide hidden but real anchorage, safe harbors not only from the cosmic elements and solar weather, but also from the extremes of surface dayspan heat and night-span cold -- *and* from the mischievous moon dust that is otherwise everywhere. They will be the safest place in the solar system for mankind to archive its history and the geological and biological history of Earth, safe for billions of years to come. to archive.

We need to map these sub-surface features, something that has yet to be attempted. Tom Billings of the Oregon L5 Society has brainstormed a two-part sleeve/core "radar flashbulb" probe design. Aimed at promising sites, the probe would be aimed to impact the surface, forcing the outer sleeve to telescope over the inner core and thus generate an electromagnetic signal at just the right frequency to illuminate any "voids" within say 8 kilometers of the impact area. The signals reflecting off the hidden voids will be readable by either a wide-array of radar telescopes on Earth, or a dedicated space radar array in near-Moon space.

Designing the probe and proving the concept is one thing. Picking the right targets is another. The plan is to use special computer software to pour over the voluminous Clementine high sun angle photographic data, looking for telltale shadows of "skylight" and "terminal" entrances to tubes. This search will take both time (possibly 18 months of run time) and money. Donations, large or small, to the Oregon L5 Society Lunar Lavatubes Locator project could help us open "Door # 4". Lunar Prospector took ten years to become real. The longer we delay the LLL project, the longer we delay a real opening of the Lunar Frontier.



Above: three inset maps locate lavatube "skylight" that was discovered by Japan's Kaguya lunar orbiter in 2009. This

round collapse hole is much deeper than it is wide, as is shown from the bottom shading from various Kaguya angles. It almost certainly connects to a lavatube below the surface. So this area in Oceanus Procellarum (Ocean of Storms) may be an ideal location to test a “radar flashbulb” instrument.

On Mars, at least seven such “skylights” have been found on the flanks of one of the great shield volcanoes, as we would expect. Martian lavatubes will be of intermediate size, significantly larger than tubes on Earth, significantly smaller than those on the Moon. Typical cross-section dimensions of a world’s lavatubes are inversely proportional to gravity. The lower the gravity, the larger will be many lavatubes.

Lavatubes provide substantial ready-built shelter for warehousing, industrial parks, archives that could last “forever”, and, not to forget, major human settlements.

In Science-Fiction literature, H.G. Wells imagined a hidden underground lunar world inhabited by strange intelligent Selenian creatures. It was all a fantasy of imagination. But in a way, everything is in place to make such a fantasy a reality, but with humans, of course. The next time you look up at the Moon, fast forward in your imagination to a time when perhaps hundreds of thousands of Lunan pioneers will have made the Moon a comfortable home. All the ingredients are there, awaiting human cooks with recipes for “world.”

Recommendations for additional Moon missions

A successful series of additional missions, some flown as NASA Discovery Mission opportunities, others in an extended Google Lunar X-Prize program, others as missions of ESA, Roscosmos, CNSA, ISRO, and JAXA would forever change how people look at the Moon. Our bonded companion world will be suddenly more than a monotonous rock pile. It will become, in the public awareness, a real world with real resources, potential mini-biospheres, safe harbors and protected “hidden valleys.”

*The Next time you hear someone say
 “The Moon? Been there, done that!”
 You will know that you at least are able now
 To see behind the rock pile face
 To the “real Moon inside” –
 A rock that can become a world,
 If only we open all the right doors.
 “No we haven’t been there!
 We haven’t done that!” PK*



These *not-so-obvious* Assets of the Moon have significant implications for Outpost Locations

An Essay on Priorities

By Peter Kokh

If the sole purpose of a proposed lunar outpost is to boast, “we are on the Moon,” then the only consideration that matters is “where is it easiest to set up shop.” Currently, there is a blind rush for the lunar poles. Like moths attracted to the lamppost, the illusion of places of “eternal sunshine” draws us there. But, alas, the sunshine is not eternal, at best 86% of the time at the best North Pole site, and 76% on the Shackleton rim. We must still bite the bullet of learning how to store power for as much as half of the lunar nightspan. So one could ask, why not then learn to store power for the entire nightspan, so that then we can go anywhere?

The confirmation of what has long been expected, that significant water ice lies in deep permanently shaded craters at extreme low temperatures, is another attraction. Yes, the water ice is there, but getting to it and recovering it is not a near-term technological “walk in the park.”

Yes, the South Pole site sits on the “edge” of the unsampled South Pole Aitken Basin, the deepest on the Moon. But why would you want to explore it from its edge instead of from the basin floor proper, hundreds of kilometers to the north? If you are afraid of the lunar nightspan, what makes you think that you can drive your exploration vehicles hundreds of miles to the north, explore, and then get back to the safety of the not-so-eternal light by nightfall?

The hidden “beyond the rubble pile” assets we covered in the preceding article, make it clear, that if we want to leverage lunar assets in any way, whether just to use them for outpost expansion, or to develop industries that can produce building materials and other products cheaper to ship to Geosynchronous Earth Orbit (giant platforms at each of the 180 slots, 2° apart, that can each hold hundreds of “satellites” and possibly giant solar power satellites), and to Low Earth Orbit for orbiting industrial parks, expansive tourist installations, etc. then it is clear that we have to set up in many locations on the Moon, because no “one” spot provides access to all the resources that we might need.

Three key assets are to be found in the nearside complex of maria: basalt, lavatubes, and easier traverses from one location to another.

Basalt

Almost universally, oxygen production is listed as the first on location (“in situ” for those who love to use Latin) resource recovery operation. Bear in mind, that moon dust is very abrasive. Then consider that one of the most abrasion-resistant materials is cast basalt. Cast basalt pipes and chutes will be basic to any industry that produces anything whatsoever from moondust. Cast basalt tiles and slabs and other products will provide walking and working surfaces that do not then need to be supported (up the gravity well) at great expense from Earth.

Lavatubes

Anywhere people are going to live *or work*, needs to be shielded. Living spaces and labs may be small enough to cover up with moondust shielding, but industrial facilities are much more expansive! And potential industrial parks!

Warehousing is another hectare-hogging operation. Some things may need to be stored out of reach of the cosmic elements that wash the lunar surface continuously. The shielding needs of industrial parks and warehousing will be prohibitive to meet by erecting endless moon-dust-covered canopies. There is a better solution: lavatubes. Lunar lavatubes are expected to be a few hundred meters across in width (and height) and many kilometers long. This storage volume is immense, and we expect to find lavatubes throughout the frozen nearside and farside lava sheets – the maria.

An ever-expanding lunar industry commonly overlooked will be archiving. Nothing can be stored anywhere on Earth where it will be sure to survive over geological time. But those lunar lavatubes that are still intact (probably the vast majority) have been so for over three and a half billion years. No atmosphere, no temperature swings, no microbes. Things stored in lunar lavatubes will long-survive our civilization, a record for any from elsewhere that may pass this way through the eons to come. Artifacts, biological specimens, records of any kind, even cemeteries.

Accessing these tubes will be an engineering challenge in itself. But, the rewards for developing lavatube access systems will be immense. The public in general is unaware of these “Hidden Valleys of the Moon.” That the “Been there, done that” crowd ignores these assets is quite discrediting.

Comparatively Easy Transportation Routes

No one location is going to be the best for producing all of the elements an industrial operation is going to need. We will need to build roads that link various industrial sites. The nearside maria complex offers the possibility of easy traverse over an area twice the size of India. There are, to be sure, obstacles: rilles, wrinkle ridges, lava sheet flow fronts, inconveniently placed post-mare-fill craters. But in comparison to highland traverses, intra- and inter-maria travel should be “a walk in the park.”

In comparison to the maria, there seems to be less mineral diversity in the highlands. Industrial sites along mare-highland “coasts” will have access to these complementary resources.

The Source of Disagreement

The constituency of those interested in human missions to the Moon is anything but monolithic. There are two main divisions: explorers and settlers.

Explorers: those interested merely in exploration to uncover not only the Moon’s secrets, but to learn from the well-preserved record of the Moon’s exposure to the solar system environment over billions of years, what conditions Earth was also exposed to in that timespan, but for which the evidence on Earth has been long-erased by its active geology, plate tectonics, biological activity, and weather.

Settlers: those who realize that some of Earth’s most intractable problems can better be managed by tapping lunar resources – *not because they are different than terrestrial resources, but because they require only a twentieth the energy expenditure to get them where needed:* LEO & GEO.

To most people, it is only natural that the prospect of pioneering such a desolate and unforgiving frontier seems preposterous. When has it not been so All through human

history, at any time, most people remained where they were and where they knew how to handle whatever nature threw at them? It is always the few who have the courage to leave, to go somewhere else where they may have to learn a whole new set of tricks to handle a new set of conditions and a new set of resources: pioneering. Yet that is how we changed from an African species to an Intercontinental one. It will only be through the similar bravery and courage of a relative few that we will take the next step, from being a Terrestrial-Intercontinental species to a Solar Interplanetary species. It does not matter whether most people will shrink in abhorrence from the idea of pioneering the Moon. It only matters that there will be enough who have the courage and the resourcefulness to take the step.

In Earth’s past, it was never put to a vote among those who had no intention of moving anywhere, to support the migration of those who wanted to start somewhere else, on the ground floor – except when a minority was being encouraged to leave. But this time, there is a major and significant reason why those who have no intention of going anywhere, should support creation of a lunar frontier. Earth’s own environment-linked economy will require it.

Earth’s economy already has a major space component. In 2008, the amount of economic activity anchored in LEO and GEO, if together they were considered to be a “nation” would have put it in 50th place among the world’s economies. And this rank will keep going up and up. It won’t be long, if GEO had a government, that it would have to be admitted to the G-20. Geosynchronous Earth Orbit is seven times the diameter of Earth itself. Earth’s “Econosphere” is already much larger than Earth itself. And if lunar resources are accessed, it will become far more significant.

We do need the scientific explorers! First we need even better topographical maps than provided by Kaguya. We need something like 10-meter vertical resolution to begin planning logical transportation routes over the lunar surface.

We need to fly instruments, such as Tom Billings, Lunar “radar flashbulb” Lavtube Locator. It is not enough to be certain that lavatubes are there. We need detailed maps.

We need mineralogy-mapping missions to detect the best concentrations of scarce but vital elements such as copper, lead, platinum.

We need many “ground-truth” missions to verify, quantify, and qualify what we detect from orbit: polar water ice-preserves; unsampled but suspected mantle material extrusions (central peaks of some craters, as well as *the central region* of the farside South Pole Aitken basin. We should support and encourage expansion of the Google Lunar X-Prize program to make inroads on this list.

Settlement in support of industries to supply Earth’s growing econosphere requires more than bravado, more than engineering know-how. It requires more in depth knowledge of the Moon. Planetary scientists may care less about all this, but we do need them, and must support their missions. Yet we also have a need to rank mission scientific priorities and lobby for them. Some things are more application-sensitive than others. Choosing missions on the basis of readiness and cost, in this light, clearly is not the most productive way to select missions for funding.

<PK>

LARS-India

A Lunar Analog Research Station in India

By Jayashree Sridhar

The **Lunar Analogue Research Station (LARS)** Programme is an international effort spearheaded by The Moon Society to establish a network of prototype research centers where scientists and engineers can live and work as if they were on Moon, to develop the protocols and procedures that will be required for human operations on Lunar, and to test equipment that may be carried and used by human mission to the Lunar exploration.

Although 12 astronauts have landed on Moon, the the lunar surface is still a strange world that we are far from fully understanding. Before exploring the lunar surface, if we don't perform terrestrial analogue research missions we risk encountering situations we are not prepared to handle. Analogue research missions can help us, in improving our knowledge about Lunar environment, cutting the exploration risk down, and ensuring that our goals and objectives are effectively achieved. There is the start of a movement in India, amidst enthusiasm after the launch of Chandrayaan-1 lunar orbiter and the announcement that India will start a Manned Space Program, to brainstorm a **Lunar Analog Research Station in India**.

Operational goals

The primary goal of the LARS programme is to research the operational environment of a base on Moon. As such, the programme is specifically geared towards answering a wide range of key questions about living and working on Lunar, including:

- How well do support systems and equipment function "in the field"?
- What are the best designs for EVA suits?
- How easy is it to maintain equipment in isolated temperature conditions?
- How are group dynamics going to operate in such a closed environment?

LARS teams will:

- Perform a wide range of EVA and scientific experiments of the kind that will be performed on MOON.
- Test communications equipment, EVA suit designs, portable life support facilities and other elements crucial to a human expedition to Moon
- Learn to conduct extended EVA sorties using vehicles such as unpressurised ATVs and analogues of pressurized rover vehicles that can operate away from the main base for days at a time
- Find out the optimum means of carrying out surface investigations – how many people need to be on an EVA mission in order to make it effective, etc.

In order to achieve these goals, operations at the Habitat Units are performed under "Lunar simulation" conditions. This means that once a crew is in a unit, they live and work as astronauts would on Moon:

- They cannot leave the unit without donning a simulated space suit

- They cannot communicate directly with anyone outside of the unit without a built-in time delay in the communication
- They can only use the equipment, tools and food available to them inside the habitat

Each crew spends between 2 weeks and a month living in a habitat unit, performing the kind of work astronauts will be expected to carry out on Moon, collecting samples from the surface and examining them back in the habitat; conducting life science experiments; studying the local geology and geomorphology, Human Factors Psychosocial Study, Space/EVA suit Ergonomics Test, Dust Control Study, Complex Closed/Semi-Closed Systems (CICCS) study and so on.

Proposed Sites

- The desert in Rajasthan is one of the most fascinating and intriguing features of this state. One of the biggest deserts in India, the Thar Desert is also known as the Great Indian Desert. The total area of the Thar Desert is around 200,000 square kilometers and is located partly in India and partly in Pakistan. The desert is surrounded by Indus Valley in the West, Rann of Kutch in the South, plains of Punjab in North and northeast and the Aravali Range in the southeast. The landscape of the desert is marked by barren hills, sandy terrain, and sand dunes of different shapes and sizes. Most of these sand dunes keep changing their sizes and shapes. However, some sand dunes have evened out and rise upto a height of around 500 feet. Rainfall in the desert is very erratic and the maximum rainfall that the desert receives varies between 100-500 mm. The monsoons hit the desert during the months of July to September. The desert is dotted with salty lakes here and there.



- Rohtang pass in Himachal Pradesh. It's one of the coldest regions. This can also be apt for projects like LARS



Animals for Lunar Exploration

Before humans actually went into space, one of the prevailing theories of the perils of space flight was that humans might not be able to survive long periods of weightlessness. For several years, there had been a serious debate among scientists about the effects of prolonged weightlessness. American and Russian scientists utilized animals - mainly monkeys, chimps and dogs - in order to test each country's ability to launch a living organism into space and bring it back alive and unharmed. Tests can also be done by using animals like rats and mice's, since they have a anatomy similar to that of the human's.

Layout: modeled after the Mars Society Habs in Utah, US and Devon Island, Canada) Floor plans ==>

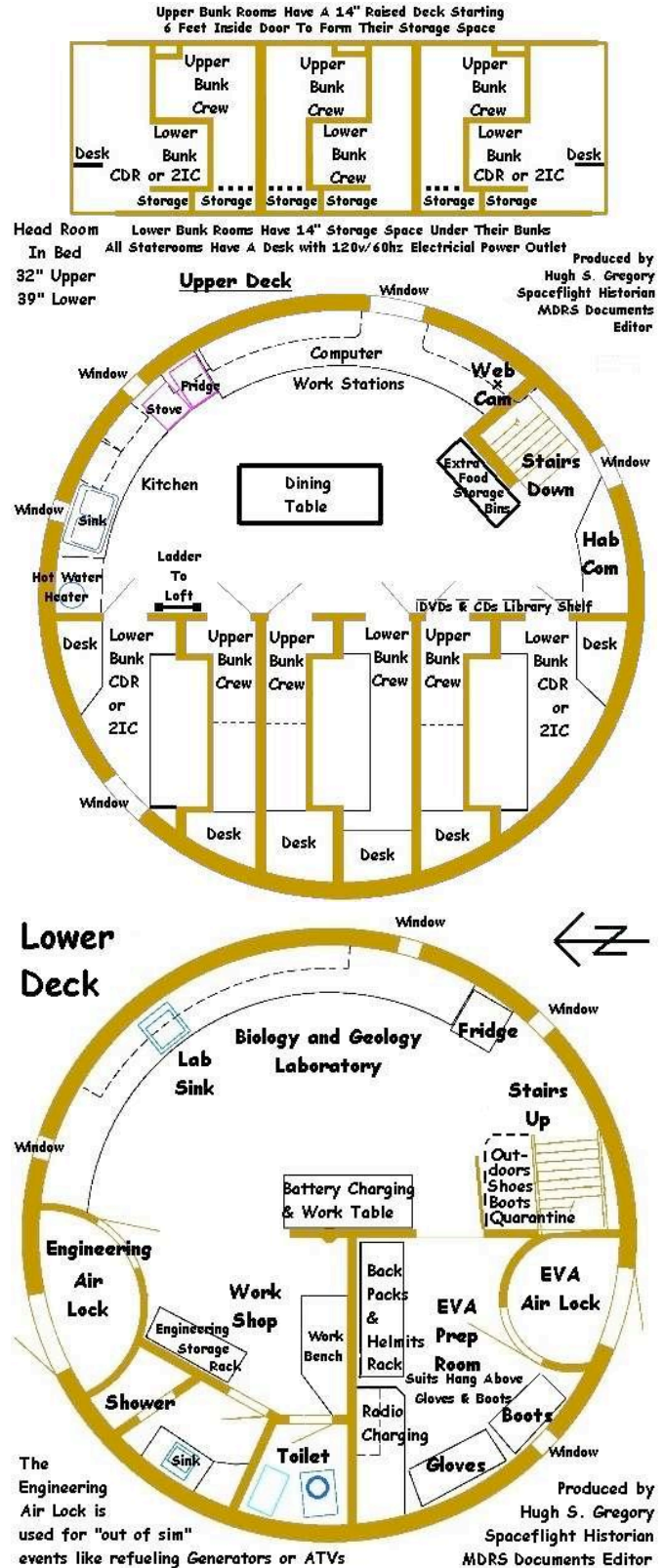
The Station would be constructed with upper and lower decks. The upper deck is divided into two halves: one is given over to individual sleeping cabins that provide visiting crew members with a bed, personal storage space and privacy when they need it. The other half of the upper deck is devoted to a common work area / dining area / food preparation area. In the ceiling space above this is the unit's large water tank, containing all of the habitat's usable water (this is resupplied from an additional tank outside of the unit. However, on a real mission, the water would be recycled after use, and possibly augmented by water).

The lower deck contains an open-plan work area where a variety of science and engineering tasks can be performed. It also contains the main hygiene area (toilet, washbasin and shower), and contains the main power distribution system for the habitat and the heating system. Heat and power are supplied by external generators, but on a real mission they would most likely be supplied using a combination of nuclear and possibly solar power. However, due to the extremes of dust contamination, solar panels will not supply sufficient energy to power a Habitat on their own. Also on the lower deck there are airlocks and the Extra-vehicular Activity preparation room (EVA prep room). The uppermost desk contains sleeping quarters for the 6-person crew, and storage space for on-board systems and / or additional equipment

- The mid-deck provides a dedicated communications centre / solar storm shelter, a galley, exercise area, storage bins and a living / working area, and hygiene facilities
- The lower deck provides two micro laboratories, a main repair / medical treatment area, 2 airlocks and an EVA preparation area.
- Additional equipment and technology, such as water recycling systems.

Our goal is to determine the environmental influence on low-grade life's abundance and diversity; make genuine discoveries about life in extreme environments that can be applied to future Lunar and Mars Missions; and test how to close simulate the lunar surface environment. We hope to promote more young talents for this project and make this project a big success.

Note: this layout does not include space for growing a portion of our food needs, nor for exercise.



Editor's Note: While this layout has worked well for the Mars Society, it has this drawback: a tall vertical configuration is difficult to shield. We may want to cover our LARS with dirt or sand bags (i.e. moon dust) to simulate radiation protection, and allow the interior to be warmer at night and in winter, and cooler in the day and summer. A horizontal plan may serve those purposes better. Perhaps a design competition is in order! It would also stimulate interest in LARS-India.

A Simple, Inexpensive, Roomy Space Station



← Left: Orion-Bigelow Hybrid Crew Craft

An interesting concept by Gaetano Marano of Italy. **Top:** Orion capsule & attached deflated Bigelow module. **Bottom:** Orion with the Bigelow module fully inflated.

The idea is applicable to basic space stations and spacious moon ferries: lighter, requiring less fuel, more elbowroom. The thick envelope provides excellent thermal and radiation.

www.gaetanomarano.it/articles/016_BigelowOrion.html

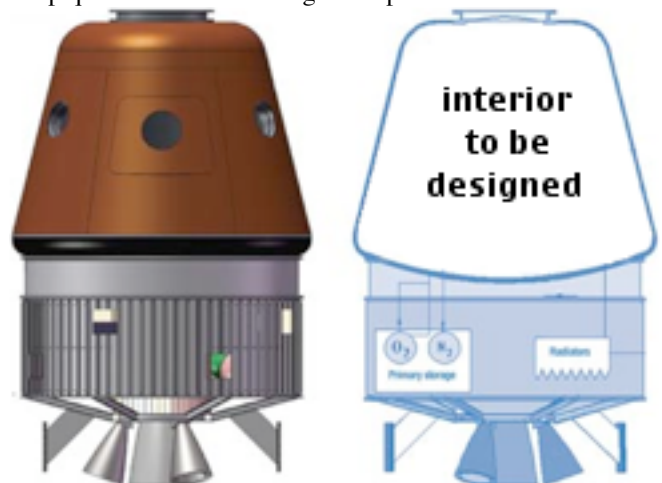
Adapting this concept for an ISRO Space Station

By Peter Kokh

Substitute ISRO's crew capsule now in development, and you have an exciting possibility. The capsule and attached Bigelow Aerospace 330 inflatable unit would ride to space without a crew. Instead the capsule would be stuffed with equipment to control the complex's: air, temperature, and power systems, and access to them. This would mean that the entire BA 330 volume, larger than all that of all the modules now on the ISS, would be available for crew berths, ward room (eating, meeting, game playing) areas. These are simple things, that might be included as pop-ups and pull-outs in the BA unit. Crews in a manned capsule would dock with this station, and install workstations, a toilet and other things not included, but *designed to pass through the docking port*.

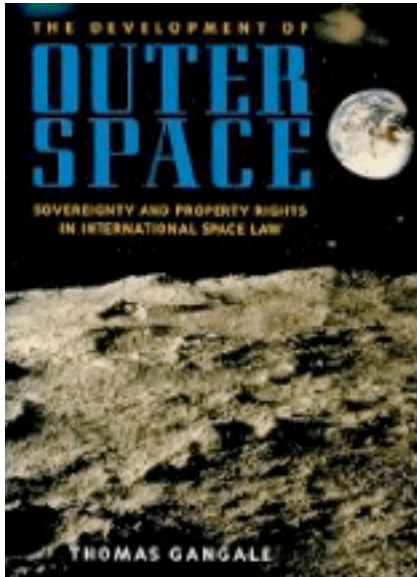
The competition could be divided into three parts: design and outfitting of interior of capsule; design of pre-outfitted parts of interior of inflatable; design of components to be added and which must pass through the hatch from visiting vehicle. There could be separate winners for each category.

This would be quite a challenge to design, but what can be more fun and more productive than an engineering design competition at university level. Even if ISRO at first shows no interest in this "far-fetched" idea and sees too many showstoppers; and even if ISRO is not interested in having its own space station, the exercise is bound to be productive, gather much needed publicity, earn corporate sponsorship, and pique the interest of the general public.



Such an engineering design competition might even stir the formation of additional SEDS and Moon Society (India) university chapters. The top results could be published online and perhaps even in a book, to spur additional such efforts.

<PK>



OUTER SPACE

PUBLISHER:
Praeger/ANC-CLIO,
Inc.
130 Cremonia Dr.,
Santa Barbara, CA
93116, USA
(www.abc-clio.com)

DATE: 2009

ISBN
978-0-313-37823-2
(hardback and
softcover editions);
317 pages

Review by Phil Harris

When the Soviets first landed unmanned spacecraft on the Moon (*Luna 9*, February 3, 1966), U. S. President Johnson became very interested in international treaties relative to extraterrestrial territory. Now that America's national space policy calls for a permanent return to the Moon, President Obama should be seeking further clarifications with other spacefaring countries and their space agencies on cooperative lunar development. After all, the European Space Agency, Russia, China, Japan, and India also have lunar plans and missions underway. Previous United Nations space agreements have stated that outer space and its celestial bodies are the *common heritage of mankind*, thus precluding national claims of sovereignty beyond planet Earth.

That is why Thomas Gangle has produced a timely and needed volume on *The Development of Outer Space*. The author's principal concerns are evident in its sub- title, *Sovereignty and Property Rights in International Space Law*. Thus his main focus is upon reviewing space law, and international agreements relative to the ownership and governance on the Moon and other offworld bodies (e.g., planets and asteroids). This aerospace engineer's pragmatic and deft approach to complex subjects is both informative and engaging as wades through, as Dr. Albert Harrison noted, *the labyrinth of incomplete and conflicting space treaties*. While demolishing existing arguments on property rights on the Moon and beyond, this scholarly book offers a **space policy strategy** for global public and private sector collaboration in the utilization of space resources for the benefit of all humanity.

The ten chapters of this work cover a range of topics from the promise of space, space and property rights, Moon agreements and myths, to space settlement proposals, interplanetary political economy, and the cosmic rationale for pursuing space exploration and exploitation. Especially

relevant is the chapter on China's rise and aspirations as a space power. The author offers valuable opinion and insights on critical space issues, as these quotations illustrate:

- *It is time that the United States ratified the Moon Agreement, so that the international community can follow suit and in due course get on with Negotiating Moon Agreement II which will define and establish the regulatory Regime.* * [See note below]
- *A number of space enthusiasts tout free enterprise as the wave of the future in space development...Yes, government programs are expensive because of the extraordinary engineering challenges to getting into space on the cheap.*
- *On Earth, the best we can look forward to is a future of husbanding limited resources, some renewable, other inexorably dwindling Although reaching beyond Earth is a sustained effort ..it opens possibilities as yet unfathomable. The promise of space, although easy to oversell and challenging to fulfill, is impossible to abandon.*

That last quote is the message of Marsha Freeman's *Krafft Ehricke's Extraterrestrial Imperative* (Apogee Books, 2008). It certainly is in harmony with this reviewer's position that in the current world recession, national debt and deficits will only be removed for future generations by utilization of space resources.

Gangle is also to be commended for including:

- (1) The published positions of prominent space attorneys;
- (2) Documentary appendices of five United Nations' resolutions, declarations, treaties, and conventions;
- (3) Useful tables, citations and references. But I was disappointed in the amount of text he devoted to schemers and schemes on lunar property rights and settlement (e.g., see index for Dennis Hope and Alan Wasser) In the previous UN negotiations about space development, there seems to be a consensus that some sort of International Regime needs to be established.

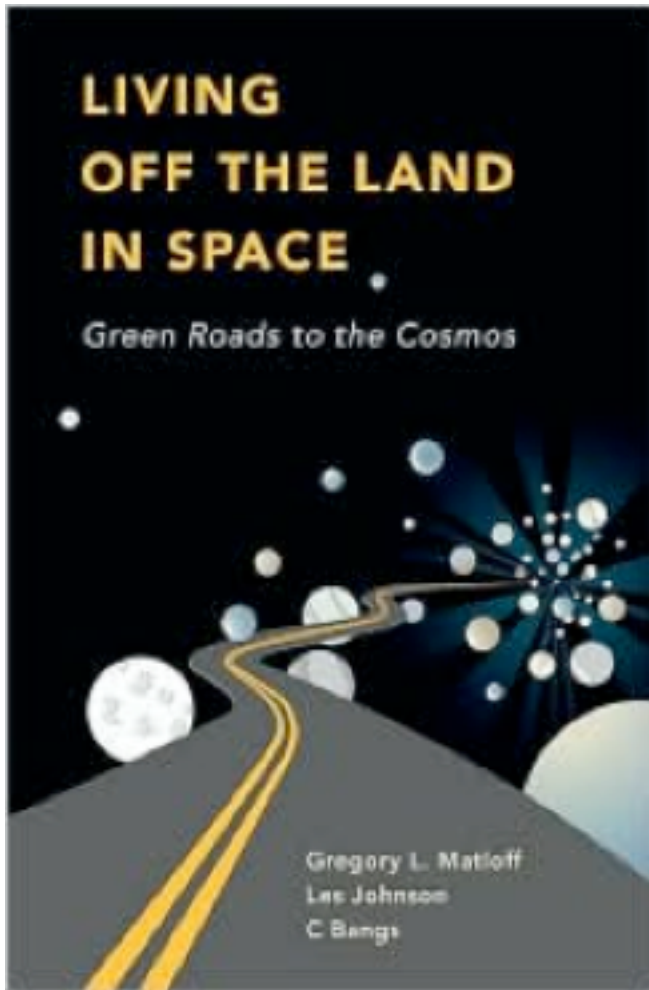
Two innovative strategies to this end are not mentioned in this treatment, however:

- (1) The 1990's articles on formation of a **Lunar Economic Development Authority** by Philip Harris and Declan O'Donnell; and its
- (2) The 21st century revised version for a **Lunar Infrastructure Development Corporation** by Buzz Aldrin and Thomas Matula. ####

About the Reviewer:

Philip R. Harris, Ph.D., is a management/space psychologist and author. Among his 48 published books, the most recent are *Space Enterprise* and *Toward Human Emergence*. For five years, he was editor of the journal *Space Governance*. (www.drphilipharris.com or philharris@aol.com),

Note: The L5 Society, predecessor to the National Space Society, successfully fought to get the US Senate to reject this treaty on the grounds that it does not establish a regime by which property rights on the Moon could be established, thereby preventing development of lunar resources. The Moon Society (International) joins NSS in this opposition.



**Living off the Land in Space:
Green Roads to the Cosmos**

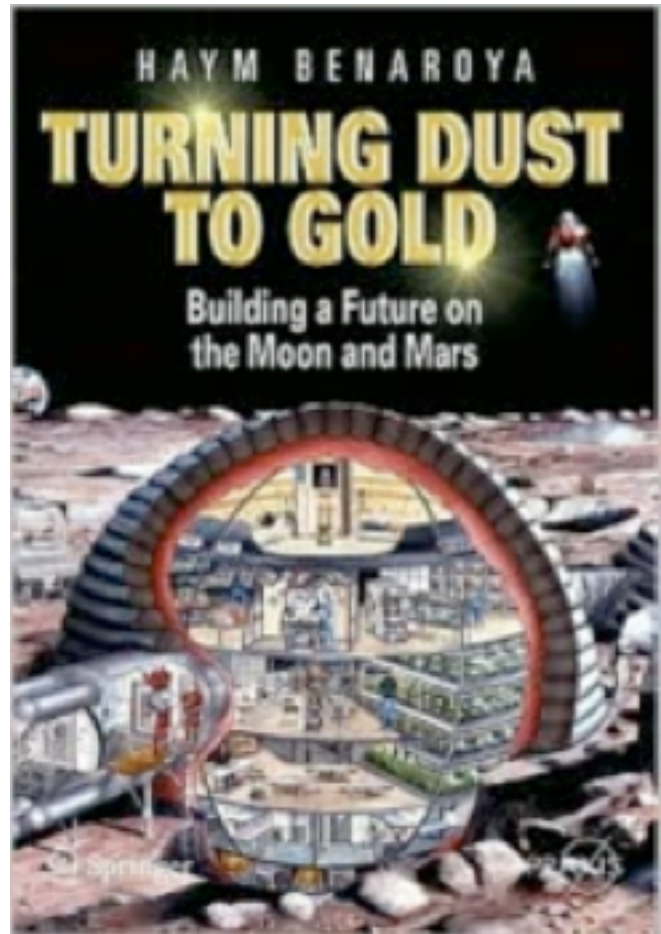
by Gregory L. Matloff, Les Johnson, C. Bangs
Published June 2007: Publisher: Springer-Verlag, New York
Format: Hardcover, 247 pages
ISBN 13: 9780387360546 ISBN: 0387360549

Synopsis (Barnes & Noble)

<http://www.barnesandnoble.com/>

“Human civilization has evolved to the point at which we can consider tapping space resources and expanding beyond Earth’s atmosphere. The Introduction surveys possible motivations for large-scale human emigration to space. Since our early ancestors began to move out of Africa, humans have constantly expanded their range. Today, the pattern of human settlement extends from pole to pole. Humans regularly visit the upper troposphere and ocean floor and technology has enabled a few to even reside above the atmosphere in space stations.

“For the next few millennia at least (barring breakthroughs), the human frontier will include the solar system and the nearest stars. Will it be better to settle the Moon, and/or Mars, and/or a nearby asteroid, and what environments can we expect to find in the vicinity of nearby stars are questions that need to be answered if mankind is to migrate into space.” ###



**Turning Dust to Gold:
Building a Future on the Moon and Mars**

By Haym Benaroya

Pub. Date: March 2010

Publisher: Springer-Verlag New York, LLC

Format: Paperback, 400pp

Series: Springer Praxis Books / Space Exploration Series

ISBN-13: 9781441908704 - ISBN: 1441908706

<http://search.barnesandnoble.com/Turning-Dust-to-Gold/Haym-Benaroya/e/9781441908704/?itm=1&USRI=turning+dust+to+gold>

From the author:

Dear Friends and Colleagues,

This book is a bit different than other books on space exploration since it is written from the perspective of the year 2169, 200 years since Neil Armstrong’s walk on the Moon. It is based in today’s reality and extrapolates to a possible future in space for humanity. There are 19 interviews, including one with Neil Armstrong. I hope that you will find it interesting.

Haym Benaroya, Professor

Department of Mechanical & Aerospace Engineering

Rutgers University

98 Brett Road

Piscataway, New Jersey 08854-8058

732 445 4408 office

haym.benaroya@gmail.com

<http://coewww.rutgers.edu/~benaroya/>

Lunar Thermal Wadis

MMM-India Special Report by Peter Kokh

Lunar Thermal Wadis and Exploration Rovers

NASA Lunar Surface Systems Concepts

February 25-27, 2009

http://www.nasa.gov/pdf/314555main_AIAA-2009-1339-125_Thermal_Wadi.pdf

“wadi” is an Arabic term common in Syria and Northern Africa for a watercourse that is only intermittently flowing with water, and is otherwise dry, often with wet soil below a dried surface. An oasis. The Sudanese city of Wadi Haifa gets its name from such a feature.

Here the term is applied by analogy.

Source: Analysis of Solar-Heated Thermal Wadis to Support Extended-Duration Lunar Exploration

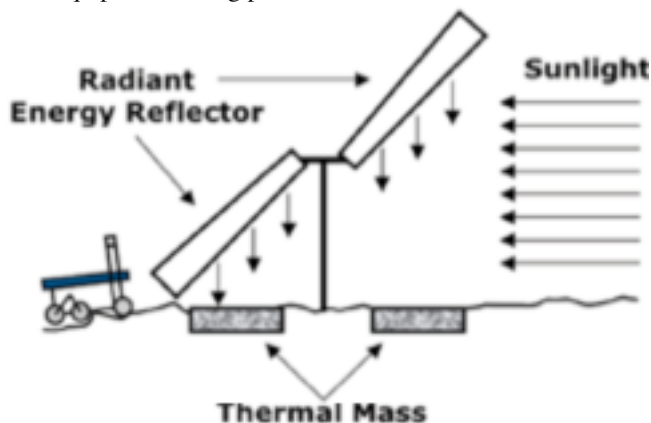
AIAA 2009-1339

Excerpt from the above:

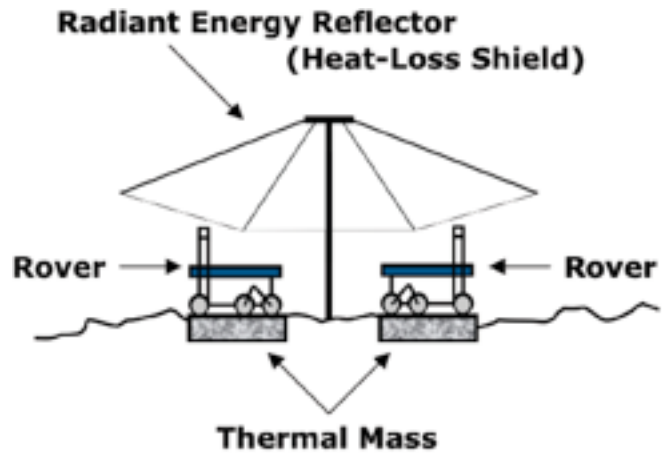
“Among the many challenges that renewed exploration of the Moon is the survival of lunar surface assets during periods of darkness when the lunar environment is very cold.

“Thermal wadis are **engineered sources of stored solar energy using modified lunar regolith as a thermal storage mass** that can enable the operation of lightweight robotic rovers or other assets in cold, dark environments without incurring potential mass, cost, and risk penalties associated with various onboard sources of thermal energy.”

“Thermal wadi-assisted lunar rovers can conduct a variety of long-duration missions including exploration site surveys; teleoperated, crew-directed, or autonomous scientific expeditions; and logistics support for crewed exploration. This paper describes a thermal analysis of thermal wadi performance based on the known solar illumination of the moon and estimates of producible thermal properties of modified lunar regolith. Analysis was performed for the lunar equatorial region and for a potential Outpost location near the lunar South Pole. The results are presented in some detail in the paper and indicate that thermal wadis can provide the desired thermal energy reserve, with significant margin, for the survival of rovers or other equipment during periods of darkness.”



Above: a sun-tracking reflector directs sunlight onto a thermal mass during periods of solar illumination while rovers conduct lunar surface operations.



Above: rovers are thermally coupled to the thermal mass to stay warm during periods of darkness, and are further protected by a heat-loss shield to limit radiative losses to space.



Above: The setting sun illuminates a rover parked on its prepared pad of heat-retaining compacted soil under an umbrella that retards heat radiation to the cold black of space.

Excerpt: “The thermal property values of the thermal mass are critical to the effectiveness of the thermal wadi. In its native state, lunar regolith is a poor material for thermal energy storage. Due to its very low thermal diffusivity, ... per measurements made during the Apollo program, heat does not penetrate the lunar surface very deeply and is lost rapidly due to radiation during periods of darkness. It is this property that accounts, in part, for the large surface temperature swing during the Moon’s 27-day diurnal cycle.

“However, the regolith contains the elemental materials needed for a reasonable thermal energy storage medium, and experiments on Earth have demonstrated that solar and/or microwave energy can enable the necessary conversion processes. Examples of regolith processing methods that can produce thermal masses with improved thermal properties include:

- Compacting and sintering
- Melting processed or unprocessed regolith, then solidifying the melt into a solid block
- Incorporating hardware and/or materials with high-thermal conductivity and/or high-thermal capacity.
- Reducing regolith, by thermochemical or electrochemical means, to produce a metal-enriched product.

The paper goes into details on the relative merits of these options, the practicality of their use, and makes recommendations. Using the moondustry’s own assets to combat the harsh lunar environment, is a win-win option. **M3IQ**

Moon Society, India Progress Report February, 2010

From: Pradeep Mohandas, Secretary moonsocietyindia@gmail.com

It has been three months since we made the announcement of the formation of the Moon Society here in India.

1. We have been in the process of framing bye laws. The first draft of the bye laws is now being circulated for the comments of the Executive Committee here in India and our advisors. Once we finalise a draft of the bye laws, we will circulate the same to the leaders list. There are generally three drafts before the final draft is made. It is circulated so that there is shared responsibility for the writing of the bye laws.

2. An 8-member Executive Committee is the minimum suggested by Indian law. We have therefore composed, subject to finalisation by the Executive Committee, 8 posts:

- President
- Vice President
- Secretary
- Treasurer
- Joint Secretary (Projects)
- Joint Secretary (Events)
- Joint Secretary (Outreach)
- Joint Secretary (PR)

President Jayashree Shridhar is in the process of appointing the remaining members of the founding Executive Committee, which already has the four primary officers.

3. We cannot conduct any activities that require money till we are registered since the bank account for the Society is permitted only after the formation and the first meeting of the Society. We therefore think that we should begin with the technical projects and the online blog.

Moon Society, India Quarterly Report: January-March 2010

The process of adding members to the Executive Committee is in full swing. Following this process, each member of the Executive Committee will have to raise concern about the bye laws and add them to the document, following which, a second draft of the bye-laws will be prepared. The Secretary has made a note of the concerns/issues raised in the first draft, he will discuss and resolve these issues in the second draft.

The President, Jayashree Shridhar has raised the issue of rising interest in becoming a part of the Moon Society by several students in India. This will be tackled by providing provisional memberships to the Moon Society, along with addition to an online group where activities and project discussions can take place. Over the next two issues, we may consider adding some member articles to the Moon Miners Manifesto India Quarterly as well.

Moon Society (International) is providing \$200 worth of support for the events in SEDS India National Conference 2010. The Conference is to be held at VIT University, Vellore on April 10-11, 2010. Two members of our executive committee, Jayashree Shridhar and Srinivas Laxman will be giving talks at large at the Conference. The Society hopes to encourage students from SEDS to undertake research and engineering activities related to the Moon. The Secretary will make a formal report on the events in the next Moon Society, India report.

Moon Society, India has also started a **Moon Book Drive**. The idea behind the drive is to provide resources for the new India chapter, which it is likely to require in education and outreach. It will also serve as reference for journalists and student projects. The Drive envisages collection of books in the United States of America during the International Space Development Conference 2010 to be held in Chicago, May 27th - 31st.

The report for the first quarter of 2010 gives us hope in building resources required by the Society for its growth and development.

Thank you.

Pradeep Mohandas
Secretary, Moon Society, India
+91-897-625-3586
moonsocietyindia@gmail.com
<http://parallelsprings.blogspot.com>

NASA's New Direction: "The Destination is Mars" makes sense even for us those of us more interested in Lunar Outposts and Settlements

Opinion Piece by Peter Kokh

Many Moon base enthusiasts are disappointed, even to the point of being bitter, that, according to Charles Bolden, the new NASA Administrator, "**the destination is Mars,**" not the Moon. But if you are one of these, you need to take a wider look.

In Moon Miners' Manifesto # 191, December 2005, our In Focus Editorial read "Dear Santa: 'a Moonbase made for Mars.'" If you did not have a chance to read this, here are the main points, with some further elaboration.

Here is what we "Lunans" would stand to get, if, and only if, "the Destination is Mars."

- **A Biological Life Support System that went beyond umbilical-cord-style "resupply, rescue, and repair"**, but which instead had to operate without relief for extended periods of time, two years or more. This most likely would involve a considerable greenhouse food-growing operation, something that had already been dropped by NASA from the Bush Moonbase-only program, given the inevitable budget pressures. NASA had taken upon itself to redefine Bush's "permanent moon base" as a "permanent structure" that could be visited from time to time. As biological life support would not be needed in this case, NASA could close down all biological life support research to direct money to the Constellation rocket program.
- **An outpost structure design that takes "shieldability" into account**, because the long-stay times on Mars demand such protection. On the Moon, in contrast, you can do without shielding if you rotate crews frequently enough. Tall multi-floor designs may travel well, but do not lend themselves easily to shielding by moon dust overburden.
- **A robust machine shop and repair facility**, because, on Mars, one might have to fabricate a critical part if the last spare had been used.
- **Development of an adequate power system not reliant on "eternal sunshine," something that is not available on Mars.** We might end up with a power system that would let us operate anywhere on the Moon, not just in the polar cul-de-sacs of illusionary "eternal sunshine."
- **Inclusion of a superior medical facility that with aid of the latest computer software programs from Earth would allow treatment of almost any medial emergency.** In a Moonbase-only operation, we'd have emergency transport back to Earth as a crutch on which to fall back.
- **Quicker development of Expansion Architectures that rely as much as possible on locally produced building materials, modules, and parts.** In a Moonbase-only operation, we'd continue to rely on shipment of made-on-Earth modules (hard hull, inflatable, or hybrid) and parts.
- **Living spaces that include the perks and amenities needed to ensure sustained crew morale and productivity over yearlong plus stays.** In a Moonbase-

only operation, we'd make do with submarine style living standards, or less. Such perks are an essential step towards the introduction of optional re-upping, signing up for continued stay duty - one small step on the road to the first "settler."

- **New rocket propulsion technologies: to cut the long trip times to Mars that entail extended vulnerability to solar flare storms and cosmic rays,** NASA would be motivated to renew nuclear thermal rocket engine research (the NERVA program abandoned decades ago) and/or fund the VASIMIR engine research. Such rockets could cut trip time to Mars from 6 months to 6 weeks, and to the Moon from 3 days to 1. We would all benefit.

I am sure there are still more points to make!

The one thing that would be Lunar and Martian pioneers both don't seem to get, is that while Mars offers an atmosphere rich in oxygen, carbon, and nitrogen, plus a hydrosphere of unknown size, and a more day-like rotation cycle, plus other amenities, it remains initially a much harder nut to crack, because it lacks the one thing that the Moon offers: "location, location, location."

Ironically, however, that "location benefit" has served as a crutch that has allowed NASA bean counters and government politicians to restrict full development of any government (national or multinational) lunar outpost to the bare minimum needed to allow us to boast that "we have a one." Do they think that we are so shallow?

Look, it's really simple.

Mars is a much more difficult goal, and by pursuing it, we are bound to get a much more robust technology development program from which all destinations can benefit, including the Moon.

We Lunans only seem to be the losers. But if we were to successfully oppose "Mars is the Destination," we surely would end up as "the" losers.

And if you want to look decades into the future, neither frontier, Moon or Mars, has much of a chance of becoming economically viable by itself, without a close trade partner relationship with the other.

Meanwhile, other nations – Russia, China, Japan, and India can pioneer the Moon, using the more robust technologies NASA develops to pioneer Mars.

It looks like a "win-win" situation for all of us.

New M3IQ readers are encouraged to download the first issue, and read the article on pages 13-14. **The Human Expansion "Triway" into Space** which attempts to show that the seemingly diverse paths pursued by those concerned with protection from "killer asteroids," those concerned with opening a second human world on Mars so that not all human eggs are in one basket, and those concerned with the possibility that lunar resources could help save our own planet, are really quite complementary. We are all driven by the desire to save Mother Earth and Humankind. We do not need to choose. These are not either/or options. We need to pursue them all. Trying to gain support for one direction by dismissing the others, is not only immature and childish, it will be suicidal. If the US wants to set "Mars" as "the Destination," that is just fine. It can work for all of us. **PK**

The Positive in NASA's New 2011 Budget

By David A. Dunlop

March 23, 2010 - At the LPI [Lunar & Planetary Institute] Annual Science Conference, Jim Green of NASA's Science Mission Directorate [SMD] and Laurie Leshen of the Exploration Systems Mission Directorate [ESMD] presented information on the 2011 NASA budget. I am providing some highlights that I think are significant.

First NASA's budget in a budget era most difficult for the US as a whole is being increased! Some \$6B dollars was added to the NASA budget over the next five years. While the Constellation Program was canceled the charge to the ESMD is to extend human presence throughout the solar system with multiple destinations including: The Moon, Asteroids, Lagrange Points, Mars and its Moons

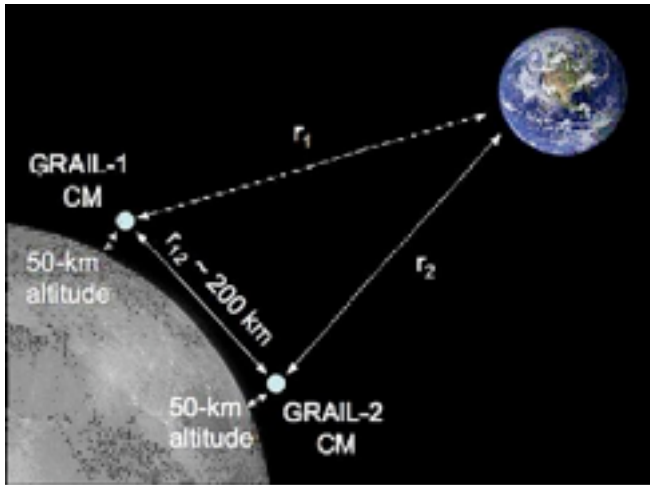
The SMD budget is \$ 512M

The Lunar Quest Line Item is alive and well. Unlike Mars the Moon did not have its own line Item until a year or two ago. While the Constellation Program which was mostly in the ESMD directorate has been canceled the Lunar Science Exploration Program is more robust than before.

The Lunar Quest Line Item projection is as follows:

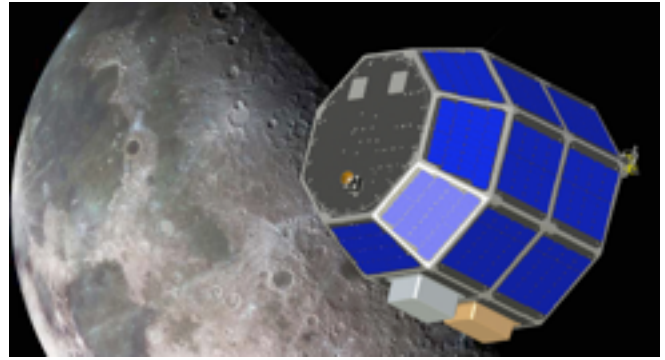
2010	\$103.6M	2011	\$136.6M	2012	\$136.4M
2013	\$131.7M	2014	\$109.7M	2015	\$110.5M

- The new budget provides for the operation of **Lunar Reconnaissance Orbiter**, which switches from the ESMD for its first year of operations to the SMD for the remaining two years of projected operation.
- The budget also provides for the **GRAIL** mission, which is scheduled for launch in September 2011 and for the **LADEE** mission, scheduled for launch in May 2012.



GRAIL = Gravity Recovery And Interior Laboratory - gravity measurement model of two lunar orbiting craft
<http://discovery.nasa.gov/grail.html>

GRAIL, will fly twin spacecraft in tandem around the Moon to precisely measure and map variations in the Moon's gravitational field. This detailed information will reveal differences in density of the Moon's crust and mantle and will help answer fundamental questions about the Moon's internal structure, thermal evolution, and history of collisions with asteroids.



LADEE: Lunar Atmosphere and Dust Environment Explorer - <http://nasascience.nasa.gov/missions/ladee>

The mission will also test a new spacecraft architecture called the '**Modular Common Bus**' -- being developed by NASA as a flexible, low cost, rapid turn around spacecraft for both orbiting and landing on the Moon, other deep space targets. Such a capability may enable the Agency to perform future science goals for reduced cost.

The Significance of What we Do Not See

Of note is the fact the **ILN [International Lunar Network] missions** are not reflected in these projections. No announcement was made of their cancellation and discussion of continuing work was evident at the LPI conference. Initial considerations of a \$100M cost cap for these ILN missions have changed since their announcement in December of 2008. Now these estimates have doubled to \$200M. In this budget climate I suspect that the doubling of projected costs in this brief period of time for the ILN missions was not included in the outlying years projections. Four ILN landers have been discussed and initial projection for launch of the first two was not until 2013-2014. A second pair was projected for launch in the 2016-to 2017 period.

One notes the absence of any ILN commitment in the Lunar Quest line item. I doubt that these missions will be canceled because of international commitments to do so, but in this budget climate I think NASA felt it was prudent to keep a lower profile and focus on getting LRO completed, and launching both GRAIL and LADEE. Lunar landers will reflect a high science priority on many grounds and there is a considerable uncertainty about the new direction the Obama Bolden Administration is taking for NASA in Congress. Many on the Republican side of the isle are unhappy about the cancellation of Constellation and the Ares I and Ares V. This will have a major negative impact on some of the "red" states such as Texas, Alabama, Mississippi, and Florida.

New Nukes Anyone?

Also of significance for lunar missions, are cost-sharing provisions for **RTG Radioisotope Thermoelectric Generators** in NASA's budget, which complement the main budget for these items, which is in the 2011 budget for the Department of Energy. The ILN missions will require a continuous energy supply for operation and heat during the cold lunar nights. Congressional approval of both DOE and NASA's budget would allow production to move forward.

Follow the Pea? Follow the Moon!

However, in the New Budget for ESMD, we have a new budget category for **Robotic Precursor Missions**. With

the cancellation of Constellation Program [Ares I, Ares V, Orion Crew Capsule, Altair Lunar Lander] one might ask Precursor to What? Well, the Moon, of course, and other destinations such as L1 and Near Earth Objects {NEOs}

We also have a new ESMD budget category for:

- Robotic Precursors \$ 3B
- Flagship & Critical Technology Demonstration \$7.8B
- Heavy Lift Propulsion \$3.1B
- Commercial Crew and Cargo,
- Human Research
- Closed Loop Life Support
- In orbit propellant transfer and storage
- ISRU (utilization of resources *on location*)
- Automatic Landing
- Lightweight Inflatables
- Automatic Rendezvous and Docking

It may be that like a game of trying to find the pea under rapidly moved thimbles. I wonder if the new NASA administration was instructed to make a budget without using the word "Moon." Perhaps, therefore, one has to cleverly track future lunar missions without saying the word Moon.

Any Presidential Administration attempts to put its own stamp on its budget and administration. Just rolling over the old Bush Administration NASA program with its lunar focus and "Apollo on Steroids" apparently would not do. While this may seem a little cynical I do indeed support the changes this new administration has made because they seem to really want to move the ball forward in technology and cost feasibility. *And virtually all of these items moves us forward toward a human presence on the Moon.*

Jim Green indicated that the three finalist candidates for the next Explorer Class Mission are:

- **Moon Rise:** Sample return mission to South Pole-Aitken Basin [SPA], Brad Jolliff, Washington University St. Louis Principal Investigator
- **ISIRIS REX:** A mission to an Asteroid, Mike Duke
- **SAGE:** A Venus Lander mission

More money has been into upgrading facilities and infrastructure at the NASA centers as well. Of great significance is a focus on international cooperation through Office of Space Exploration working Group [OSEWG], including 13 Space Agencies; On the agenda is a "Lunar Architecture Reference process" that aims at a rational alignment of the lunar program architectures of all countries involved.

The Lunar Science Pipeline

Not reflected numerically in this NASA budget but of interest and potential future budget impact is the fact that of some 25 mission Candidates for consideration in the NASA, NSF, NRC Decadal Survey Process, only three concern the Moon:

- **Moon Rise** as noted above
- **Lunar Polar Volatiles** from APL
- **Lunar Network Mission** from JPL

Oops! That embarrassing Moon program thing just keeps popping up again. Well much more could be said but one can find the Full Monty on NASA's budget at:

www.nasa.gov/budget

DD

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/>

Astronautical Society of India Student Chapter
175 Bussy St, Pondicherry 605 001 175, India.
Phone: +91 0413 3246999,
email: mail@indianspace.in

Fax: +91 0413 3000222.

Head Office: ISRO Satellite centre, Airport Road,
Vimanapura, Bangalore - 560 017. India.
Phone: +91 080 25205257. Fax: +91 080 25082122.

SEDS-India - <http://india.seds.org/>

(Students for the Exploration & Development of Space)

National Headquarter - SEDS VIT,

C/O , Dr. Geetha Manivasagam,
Room No. 403 , CDMM Building ,
VIT University,
VELLORE-632014, Tamil Nadu
Phone No. : +91-9952281231
Anmol Sharma (Director, Chapter Affairs)

President: Sabyasachi Bhowmick
bhowmick.sabyasachi89@gmail.com

SEDS-India Chapters:

SEDS VIT (Vellore)
SEDS Veltech (Chennai)
SEDS Savitha (Chennai)
SEDS Warangal (Warangal)
SEDS GGITM (Bhopal)
SEDS KCT (Coimbatore)
SEDS ISM (Dhanbad)
SEDS NIT Trichy (Trichy)
SEDS NIT(Nehru Institute of Tech, Coimbatore)
See map on last page of this issue



Salvaging Google Lunar X-Prize “Also-Rans”

By David A. Dunlop,
Moon Society Director of Project Development

Google Lunar X-Prize

www.googlelunarxprize.org/lunar/about-the-prize/introductory-video

www.googlelunarxprize.org/lunar/about-the-prize

www.googlelunarxprize.org/lunar/about-the-prize/rules-and-guidelines

www.googlelunarxprize.org/lunar/teams

Opportunities, Incentives, and Tools For New Lunar Science Missions

Google Lunar X-Prize Teams

- Twenty teams are now vying for Google Lunar X-Prizes. While only two teams at best will win the 1st and 2nd prizes, the other team programs may offer potential options for further development. If so, their investments to date should not be wasted.
- Their merits with regard to technological innovation or cost-efficient models should be not go untested simply because they were not the first or second to land on the Moon. The ideas being developed by the teams that lose the first or second GLXP may or may not be more technologically innovative and cost effective than the teams that happen to win the stated prizes. The winning teams may win because of such factors as having started first, having access to more money resources, and having partners with more technology resources that could advance the team process more quickly.
- The GLXP competition limits the amount of government support that can be involved in these missions. Once the GLXP first and second prizes have been won the remaining teams would most likely be open to continuing their missions to a successful lunar landing if increased national space agency financial participation were to be available in the absence of further GLXP incentives.
- GLXP teams that do not win 1st or 2nd prize will require incentives and support to continue advancing their projects to flight readiness status and actual flight to the Moon.
- These also-rans may present opportunities to “re-purpose” their lunar landers to deliver needed or desired science payloads to lunar surface.

- The money spent can be looked at as a preliminary private investment that can be cost efficiently used by NASA and/or other national space agencies (ESA, Roscosmos, ISRO, CNSA, JAXA, ...) to address their public science, engineering, and education priorities. When NASA for example selects a proposed mission for funding it requires efforts to be organized into a series of funding stages: Phase A, Phase B, Phase C. These phases would have to meet design review and project schedule milestones. It is a reasonable assumption that many of these teams will have through their own efforts done what would be equivalent to Phase A, B, or C level development.
- Evaluation of a team’s design should be made in terms of
 - Risk reduction,
 - Technical feasibility
 - Cost efficiency
 - Suitability as platforms for lunar science missions that should be supported by the various national space agencies for those teams open to a follow-on incentives program to the original GLXP program.
- NASA and ILEWG (International Lunar Exploration Working Group) partners should support lunar program approaches and incentives that foster both international and commercial collaborations.

Incentive Science Contracts are an example of how this could work

- \$50M incentives should be offered for delivery of ILN (**International Lunar Network**) science packages:
 - # laser retro-reflector cube
 - # seismometer
 - # lunar radiation monitors
 - # heat flow probes –

<http://nasascience.nasa.gov/missions/iln>

Technology Incentives

- NASA and DOE should offer RTG technologies as a missions-enabling technology incentive to lunar rover missions that deliver long duration sorties on the models of Pathfinder, Spirit, and Opportunity, and which address high priority science objectives. This should be jointly competed by ESMD (NASA Exploration Science Mission Directorate) and SMD (Science Mission Directorate). http://en.wikipedia.org/wiki/Radioisotope_thermoelectric_generator
- Incentives should be created for technology demonstrations that use non- nuclear techniques to survive the lunar night cold temperature cycle, such as **Lunar Wadis** [p.18]
- Incentives should be offered and competed for principal investigators and teams which can demonstrate achievement of *science goals that are on lunar science road map* so that the process of lunar science missions development is more “granular” and financial “assets can be brought to the table” in consideration of lunar missions proposals by science investigators and teams whose instruments have been competitively qualified.

Additional scientific and technological goals for “re-tasked” Google Lunar X-Prize contending teams could come from an open-source database of desirable lunar surface missions, such as proposed below. **DAD**

Developing A Tool for the International Community of Those Interested in Lunar Surface Access

A Common Open-Source Database of Desired Lunar Surface Missions: Landers, Rovers, Ground-truth Probes

By David A. Dunlop

The Model of a Lunar Mission Development

Last November (2009) at the annual LEAG meeting at the Lunar and Planetary Institute I had lunch with Rob Kelso, of NASA's Office of Lunar Commercialization... and Dr. Paul Eckhart, of Boeing to discuss how a more commercial approach to lunar mission development might take place. Today there is not a real market with "buyers" that wish to deliver instruments or experiments to the lunar surface and "sellers" who provide the transportation and logistics support. There is instead a government monopoly, which both finances the transportation and selects and organizes the instruments and experiments. This system has worked well in that many missions have been successful however the high cost of such missions has prevented the operations of market forces. Only the governments have had the funds to develop such missions. They have been very low frequency events, which require much engineering development. Few economies of scale apply to such missions. Many missions are one-time events. Industrial economies and efficiencies, which result from mass production, do not apply and hence lunar and other space missions maintain very high price points.

The Trend and Potential for a Commercial Lunar Mission Model

The market place for lunar missions has gone from one in the 1980s (Hiten) to two in the 1990s. (Clementine and Lunar Prospector, to five in the decade 2001-10 (SMART-1, Kaguya, Chang'e-I, Chandrayaan-I, and Lunar Reconnaissance Orbiter. The 2010s may see as many as 15 missions as international interest in lunar exploration gains momentum. These projected missions represent a collective multi-billion dollar multi-national expenditure. Yet recent discoveries about lunar water resources may invite an even higher rate missions rate as multiple landing will be required to establish ground truth about the extent of lunar volatiles, the effectiveness of technology, which can sustain operations in the lunar environment, and test techniques, which provide for utilization of in situ resources.

With this projected trend line it may well be that a commercial market can reduce the price point of such missions because the size of the market is growing. Reduced unit cost may occur because of the savings from economies of scale. Competitive forces may reduce unit cost and enable economies of scale because of the economic feasibility of an increased flight rate.

If such economies of scale occur the amount of lunar science and exploration conducted will increase. If commercial products such as fuel production, fuel delivery are in demand private investments in addition to government

funds may increase the capital invested in the lunar transportation enterprise system.

The question arises of how such a market can evolve from the current government monopoly system. One partial answer is to develop tools, which can assist a more entrepreneurial style of planning in, which fully informed buyers and sellers set prices. The tendency of most national space agencies is to favor national sourcing of supplies for the missions they finance. However with a growing international market for both science and commercial investment a more genuine market might evolve.

A Tool for Facilitating a Lunar Market place

One such tool is an open source and international Database, which lists the number of investigators and the instruments and experiments that they wish to perform on the lunar surface. A database of this sort would provide several practical advantages.

Advantages of a Lunar Surface Delivery Database

A first advantage is simply a measure of the size of the community of international interest in lunar access. From preliminary inquiries it would appear that this database would involve several hundred entries. A combined list is a very tangible demonstration that the potential market size for lunar surface delivery is formidable. The size of the potential market is a measure of the "critical mass" of interest on the part of investigators even though this level of information is only a measure of unfunded demand.

A second advantage of understanding the potential size of the market is that this information is a critical indicator for both the development of business plans and their evaluation by business investors.

A third advantage of a database is that it makes explicit the communities and sub-communities of interest in the lunar surface market. This improves the ability to communicate and can improve the flow of information, and the potential for creative exchange within the community. The information provided by a basic database, should be developed in spreadsheet format, so that the spreadsheet can be customized by the addition of additional information by the community.

A fourth advantage is that if some basic information of weight and power requirements for proposed instruments and experiments is part of the database it is possible to look at potential combinations of payload within the context of a specific lander system. This potential allows many ideas about mission formation to be explored.

A fifth advantage is that a measure of potential funding might be attached to a specific instrument or experiment. A national space agency for example might look at its own cost for a lunar mission and allocate costs involved for each instrument in the payload. This method could be used to set a price the agency would pay to deliver that instrument or experiment to the lunar surface. This level of financing might then be pre-approved in the sense that the principal investigator would have that amount of capital to bring to the table in discussion of potential mission participation in the context of commercial missions of as a participant in an international mission proposed by another national space agency. This is a

much more “granular” approach to mission proposals and planning. It is a market model where buyers and seller negotiate prices to mutual advantage.

By the same token the providers of transportation must cover essential costs and allocate them on some rational basis. The price point per kg of mass delivered to the lunar surface is a very basic comparative price point for potential customers. This is of course a simplification but an illustration of encouraging the development of a basic market approach and potentially of utility for international commercial companies such as Boeing, Lockheed-Martin, Antrix, Mitsubishi, EADS, Odyssey Moon, Astrobotics, Space X, etc., which have the capability to provide lunar surface transportation and/or technical integration of such mission proposals.

As of March 2010, I am not aware of any such open database on the web. However, the Google Lunar X-Prize competition may provide an opportunity to utilize this database in consideration of utilizing those GLXP teams, which do not win first or second place prizes, for the purpose of delivering the instruments of national space agencies and supporting a more commercial mission paradigm. These teams have already started to utilize a commercial development model with varying levels of support and success.

Growth in Interest in Lunar Surface Investigations

A second wave of lunar exploration missions those currently identified is likely as a result of new discoveries about water on the lunar surface, the identification of lava tube openings, the new to explore a full range of the varieties of lunar highland and volcanic terrains. New ideas and proposals are sure to emerge in the coming months and years. The level of scientific interest and associated proposals should increase in momentum as international interest grows in the Moon.

A commitment to develop even one permanently occupied lunar base on the lunar surface would increase this level of traffic yet again with a mix of robotic landers and equipment with tele-operational capacity and human missions.

Recent Discussion and Activities

Since the November lunch I have had occasion to discuss this open database model with a number of individuals. At the LPI conference I spoke to both Clive Neal who chairs the LEAG group, and to Bernard Foing, about an open-source consolidated list. Both liked the idea. I presented this idea at both the town meeting of LEAG on Wednesday and at the ILEWG town meeting on Thursday. At the LEAG meeting it emerged that several potential sources of such a combined database exist.

- 1 Rob Kelso of NASA Lunar Commercialization Office and Gregg Schmitt, Deputy Director of the Lunar Science Institute, developed what they call the LOFT list (Lunar Orphan Flight Test) This has about 60 entries. At present this list is not publicly released but will be to LEAG, which is an official NASA advisory group.
- 2 Dr Pamela Clark of Catholic University in Maryland has developed her own database on potential lunar instruments, which has several hundred entries.

- 3 Dr. Bernard Foing of ESA put out an RFP for lunar payloads for the ESA MoonLite Mission. He received some 189 responses.
- 4 The International Lunar Exploration Working Group (ILEWG) (of which Dr. Foing is Executive Director) has several documents, which are open source literature on lunar instrumentation and experimentation proposals.
- 5 The Decadal Survey white papers of NRC [National Research Council] and NASA contain ideas for lunar science mission objectives.

LEAG adapted this idea at their executive board meeting that afternoon. They will publish Dr. Clark's list on the LEAG web site to start this development. Dr. Foing also agreed to work on the preparation of a consolidated database and have this ready for the ICEUM conference in Beijing so that ILEWG can endorse and contribute to this idea. Specific invitations to participate in this process were provided to Dr J. Goswami of ISRO and Dr. Jingshan Jiang of the Chinese Academy of Sciences.

I was very gratified so see this idea so quickly endorsed. I have to follow up with Dr. Clark and refine on the basic elements the Database format so that consolidation of these lists is practical. I would like this list to be formatted in a spreadsheet format so that individuals are able to customize the list so that it can be used to meet individual needs for a multiplicity of purposes.

As a representative of the Moon Society it has been enjoyable to play a small role in promoting both the philosophy of commercial market development and collaborating with others sharing this philosophy to create what hopefully can become a useful tool in the development of an open market proposal for the community of interest in lunar surface missions.

DD

In Perspective [From the Editor]

The whole purpose of this exercise is to enable the lunar community to go about hacking away at our growing collective pile of questions about the Moon, its origin, its makeup, its history, its potential resources, and its role in humanity's future *in a methodical way*.

It is already becoming clear how inaccurate and premature our post-Apollo understanding of the Moon has been. The effect on our current, rapidly morphing picture of the Moon is becoming revolutionary!

Sorry, Buzz, but

***We haven't been “there” except superficially!
The “that” which we have done
has barely scratched the surface!”***

***What we are finding is an unexpected world
that begs to become the next frontier.***

*“The more you know,
the more you realize how much you don't know.”*

“Every answer generates more questions.”

*“The wise man is the one who realizes
how ignorant he is.”*

The “Lunar Decade” is becoming a time of wonder!

Solving The Moon's Water Puzzles



By David A. Dunlop

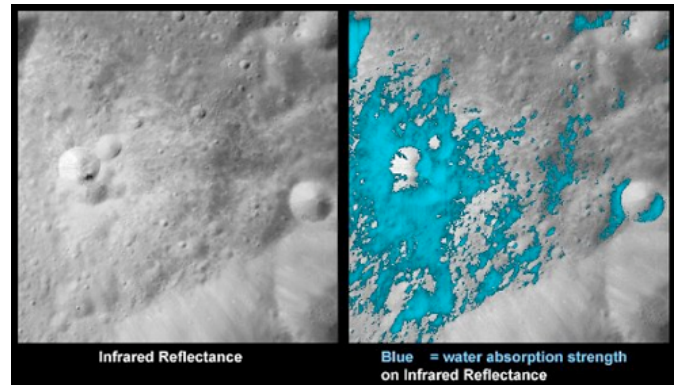
The “once dry Moon” has surprised its observers by being wetter than previously thought. As new evidence mounts up the picture of lunar water also becomes more complex and nuanced. The 2010 Annual Science Conference of the Lunar and Planetary Institute had many presentations that addressed this issue.

The Old Dry Moon is Dead! Long Live the New Wetter Moon!

The post Apollo picture of the Moon prior to the recent lunar orbiters and impactors was one in which the Moon was found to be extremely desiccated, but with the potential for the trapping of volatiles (including water delivered to the lunar surface by cometary impacts) in the cold traps of permanently dark craters. The post Apollo theory of lunar formation by the impact of a large Mars sized object into Earth explained how the desiccated Moon formed from the volatile rich proto-Earth. (1Neal) (These impact ejecta were flung into an orbit around the Earth where the volatiles escaped into the surrounding vacuum and were driven away by the solar wind. A “magma ocean” melting the upper portion of the newly formed Moon would also have continued the process of volatile losses to account for the observed dry Moon found by the Apollo expeditions.

Now the newly found amount of water, and its distribution on the lunar surface call for a revision of theory and a reconsideration of the role of water in the formation of the rocky planets of the inner solar system.

Three spacecraft, Chandrayaan-I (M3 Moon Mineralogy Mapper), VIMS instrument on NASA Cassini, and EPOXI on NASA's Deep Space Impact mission have observed excess lunar hydrogen, as had Lunar Prospector in 1998-9. The Chandrayaan-1 Moon Mineralogy Mapper showed a far wider distribution of hydrogen than was expected with much greater concentration on the poles. (2 McCord, T.B.)



Chandrayaan-1 Moon Mineralogy Mapper Photoset

As previously thought indeed some water on the Moon has been found to have Hydrogen/Deuterium ratios which are not characteristic of the Earth but rather of cometary ice. Also as previously thought there seems to be evidence on both lunar polar regions of higher hydrogen concentration associated with permanently shaded craters.

However, things are more complex than that based on the temperature profile of the lunar surface. David Paige reporting on the results of the LRO [Lunar Reconnaissance Orbiter] Diviner instrument has shown that the distribution of water signatures is associated with the temperature profile of the lunar surface. (3 Paige) He reports that a temperature of 106 Kelvin and below is the point of stable cold trapping of water and other volatiles. The thermal inertia of the lunar surface seems to be the critical factor in the retention of frozen volatiles. The area with this low temperature profile is considerably larger than just the permanently shaded crater areas. This could increase the potential amount of the lunar water harvest. His report currently in press in Space Science Review provides more details. More LRO Diviner results and download information can be found at <http://diviner.ucla.edu>

A Richer Brew Than Water

The LRO Diviner instrument has shown that not only water ice but also many other frozen volatiles are held in these cold trap regions. Other molecules identified include:

S, SO₂, H₂S, OCS, CS₂, CH₂O, CO₂, NH₃, CH₃OH, C₂H₆OH, Hg, Na

These frozen volatiles provide a much richer brew for a world otherwise depleted in water, carbon and nitrogen. Dr. Paul Spudis said in a LPI Press conference on Lunar Water, chaired by ISRO's Dr. Goswami, that the new findings about water and associated lunar volatiles present a picture that made sustainable human presence with indigenous lunar resources a feasible consideration. For the Moon Society and other organizations promoting lunar settlement and economic development, that is a statement of major significance.

A New Mechanism of Lunar Surface Water Formation

William Farrell indicated that the Moon might be a more reactive substrate in conjunction with the solar wind than we thought. (4 Farrell, W. M.) Perhaps defect sites in lunar minerals caused by the radiation flux enhance adsorption of H and OH. It is now thought that the solar wind interactions with the lunar surface produce H and OH molecules, which can migrate by hopping along the surface until they are captured in cold traps. The high UV environ-

ment can induce photo-dissociation in such molecules but modeling suggests that such molecules might endure 20 hops along the lunar surface before photo dissociation occurs. So now there is a whole new mechanism for the consideration of water formation and migration on the lunar surface and other NEO object subjected to the flux of the solar wind. The migration of water molecules also opens the door for consideration of the movement of water produced from indigenous volcanic vents of the lunar interior into the cold traps.

Igor Mitrofanov reported The LEND instrument on LRO detects epithermal neutrons. (5 Mitrofanov I.) The presence of H₂ moderates this neutron flux. The LEND instrument had its best coverage of the polar regions and measured 78 permanently shadowed areas in the South polar region and 48 permanently shadowed areas in the North polar region. He reported the only reliable detection between 500ppm and 700ppm was at Cabeus Crater.

The LRO orbiter mini RF Instrument was similar to that flown of Chandrayaan I and took data in strips 2000km long by 19km wide. (6 Bussey, M.S. Its results showed no enhancement of ice at Cabeus Crater.)

LRO Mini-RF results may be found as <http://www.nasa.gov/mini-rf>

These findings should remind us that the findings of hydrogen concentration on the lunar surface may not always be synonymous with water deposits and that putting together all the puzzle pieces together to create a full coherent understanding of lunar water is yet to come.

More interesting yet is the remote sensing spectrographic information, which shows increasing Christiansen features wavelengths, associated with Si-O silicate polymerization of the soil mineralogy as one moves from

- Quartz • Feldspar
- Pyroxene • Olivine

The mineral content of the lunar surface is yet another variable to factor into the understanding of lunar water.

Water from the Lunar Interior

At the 2009 LPI Conference, Alberto Saal from Brown University reported finding water in the interior of lunar pyroclastic glasses at rates ranging from 240 to 745 ppm. This finding, of course, conflicts with the theory of complete desiccation of the lunar interior as the Moon condensed from a debris ring surrounding the Earth to a solid satellite. *The fact seems to be that the giant impact resulted in incomplete devolatilization.* At this year's 2010 LPI conference, McCubbin reported the detection of structurally bound hydroxyl in the mineral apatite from Apollo Mare basalt sample 15058.

(7 McCubbin F. M.) Apparently hydroxyl can substitute for F or Cl in Apatite.

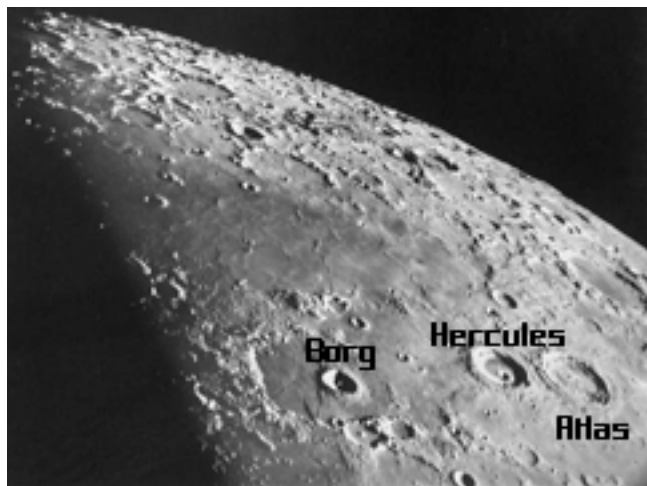
H₂O was reported at concentrations as high as 6000ppm.

Cl was reported at 1340-3460 ppm

S was reported a 310-460 ppm

L Gaddis reported on Lunar Pyroclastic volcanism at Atlas Crater. (8 Gaddis L.) This crater's diameter is 87 km and it is located at 45N, 45E, between the SE edge of Mare Frigoris and the NE edge of Lacus Somniorum. MAP Gaddis

also reported that this crater has pyroclastic deposits twice as big as prior estimates with units that may possibly have multi-fire fountains source vents.



Some seventy-five such areas have been mapped and characterized. One wonders what “mature” pyroclastic soils with such interior water would yield in overall water content when consideration is also given to adsorbed H and OH from the solar wind. It might well turn out that pyroclastic deposits might be among the richest lunar sources of water including polar cold traps.

The Cry for More “Ground Truth”

These pieces of the lunar water puzzle only tantalize the lunar science community, which calls for more surface lander-rover missions. But just landing again to get the answers is not so simple. The lander has to collect and measure volatiles samples. It is ground-*truth* that is needed. Yet this ground-truth may not be so easy to come by.

Engineering Challenges for Lunar Sample Missions

Operations in lunar cold traps for example will not be easy. Lunar landers looking for ground truth in areas that have been identified as thermally stable will be subject to cold soaking at temperatures of 106K and below and their equipment will require mature Radiogenic Thermoelectric Generators (RTG) to withstand the extreme cold. Fortunately new generation RTGs are in the works and the Department of Energy with complimentary NASA support has in the new budget bill funds and authorization for their production. (9 Green J.) Hopefully for lunar science what the Obama Administration proposes in the 2011 budget will be supported by Congress and will permit the production of RTG powered equipment which can sustain successful operations in these extreme cold environments.

Coring or trenching activities may well dislodge some adsorbed volatiles. Low rotational velocity coring may be critical to accurate measurements of surface samples. Measuring with fidelity the in situ concentration of frozen volatiles at ppm levels of concentration will require the ability to take small samples from the surface, weigh them, confine them in a vacuum chamber, drive off the volatiles by heating to over 700C, and then measuring with accuracy the volume of a variety of gas species. The systems developed for the Mars Phoenix lander and Mar Science Lab are technology prototypes.

The movement of lunar surface samples into a vacuum chamber confronts the problem of contamination and compromise of test chamber seals by pervasive lunar dust particles. A coring tool will fling minute regolith particle everywhere in the vicinity of the sample. Movement of sample containers into sealed chambers threatens the dislodgement of regolith particles. Dr. Lawrence Taylor of the University of Tennessee, Knoxville Geophysical Institute has shown the magnetic attraction of nanophase iron can be an asset in the management of regolith. Magnetic filter systems may provide an answer to in situ testing. Dr. Hiroyuki Kawamoto of Waseda University in Japan has demonstrated impressive electrostatic systems for surfaces, which have self-cleaning capabilities for lunar simulant dust particles.

<http://www.kawamoto.mech.waseda.ac.jp/kawa/>

The fact that lunar mineralogy is shown to be a significant variable associated with water content means the identification of the minerals in the samples tested will also be a requirement. Laser ablation and ion spectrometry to characterize sample's sample mineralogy would therefore seem also to be part of system requirements for the obtaining ground-truth.

While asking for ground truth is easy, providing engineering solutions is not. In situ observations, sample isolation, sample preservation, and sample characterization are all needed. Providing instruments that are reliable at those cold temperature conditions and their maintenance will also challenge the state of art. There is also the question of curation of new lunar samples. In situ sample curation in lunar cold traps may be an unsuspected requirement of lunar science and may call for a new paradigm of telerobotic laboratory design and operations.

In Situ Analysis Capabilities versus Terrestrial Lab Capabilities

The analysis of lunar pyroclastic glasses for their water content by Dr Alberto Saal was a matter of extreme precision in the preparation glass beads for electron probe measurement. Such measurement will require sample return to Earth. Perhaps other in situ measurement techniques can be developed. The survey of lunar pyroclastic deposits for water content demands a capacity for long distance traverses, sample collection, and either the return to Earth or new techniques with adequate precision that can be performed in situ. Perhaps some of these promising pyroclastic sites for the acquisition of water will demand either a very expensive Mars Science Lab class of rover or a human /robotic synergy of collection and analysis which will begin with robotic precursors for collection and wait until a human presence is established on the lunar surface for return to Earth for analysis. If so it may be awhile before we get our answers.

Untying A Gordian Knot of Exploration

The Puzzles of Water and other frozen volatiles on the Moon tease us for the present. Our questions demand answers not easily obtained. Recent discoveries however are reheating the interest and challenge of the Moon as a target for international exploration and collaboration. It will take both time and money.

The maturity of the technology to address these challenges is also in play. The engineering needed to work in the extremes on the Moon also make the Moon a newly recognized portal for exploration in the cryo-environments of the moons of the gas giant planets, and of Kuiper Belt Objects.

Moon advocates have long argued the Moon is the logical and practical portal to Mars. Now we also argue that the Moon is also the logical and practical portal to the rest of the solar systems for reasons we did not previously suspect until the lunar cold temperature environments were revealed. Some (including, embarrassingly, Buzz Aldrin) say of Moon Exploration, "Been there and done that". [See Peter Kokh's essay, "The Lunar Rock Pile" **pages x-x**- above] They do not appreciate that the Moon continues to astonish and surprise and that the complete mysteries of the history of solar system are still held as *lunar secrets*. She beckons us to come back for a more full understanding of how the solar system really works.

References:

- 1 Neal, Clive, New Views of the Moon
- 2 McCord, T.B. , LPI 2010 Annual Science Conference, Water in the Solar System : Moon, Origin of OH/Water on the Lunar Surface Detected by the Moon Mineralogy Mapper (#1860).
- 3 Paige, David, LPI 2010 Annual Science Conference, Lunar Reconnaissance Orbiter Results, Diviner Lunar Radiometer Experiment: Early Mapping Mission Results (#2267)
- 4 Farrell, W. M., LPI 2010 Annual Science Conference, Water in the Solar System: Moon, The Case of Reactive Surface Geochemistry at the Moon, (#2228)
- 5 Mitrofanov, I, LPI 2010 Annual Science Conference, Lunar Reconnaissance Orbiter Results, LEND Experiment on board LRO: Testing Local Areas with High Concentrations of Hydrogen at the Lunar Poles, (#2250)
- 6 Bussey, D.B. J., LPI 2010 annual Science Conference, Lunar Reconnaissance Orbiter Results, Initial Results from Mini-RF: A Synthetic Aperture Radar on Lunar Reconnaissance Orbiter, (#2319)
- 7 McCubbin, F.M. , LPI 2010 Annual Science Conference, Detection of Structurally Bound Hydroxyl in Apatite from Apollo Mare Basalt 15058, 128 (#2468)
- 8 Gaddis L., LPI 2010 Annual Science Conference, Special Session: A New Moon: Lunar Volcanism and Impact Chronology, Lunar Pyroclastic Volcanism at Atlas Crater as Viewed by LROC, (# 2050)
- 9 Green J., LPI Annual Science Conference, Special NASA Night Budget Presentation) **DD**



Houston, you aren't going to believe this, but ... Well, not quite! But it is still a very promising discovery!

A LUNAR UNITED NATIONS SUMMIT HQ, HUMANITY CENTRE & RETIREMENT COMPLEX

Madhu Thangavelu - thangavelu-girardey@cox.net

Abstract

Trends and recent events in humanity's quest to access and operate space on a routine basis suggest that before long, enough number of people will be able to directly enjoy the various aspects of being and working in the final frontier. Several concepts have been put forth for possible uses of outer space and extraterrestrial settlements.

- **One idea** that has been suggested in past years is the potential for using zero and partial gravity conditions for rehabilitation of the physically handicapped.
- **Another** is the idea that the elderly might benefit from being in an aesthetically refined, serene, low gravity environment with all the creature comforts and amenities offered together with the finest care for the elderly and health maintenance programs available today.

Since there are common elements in both the ideas above, it may be worthwhile to combine both programs to create a more synergetic and economically viable concept. A Lunar Rehabilitation Facility and Retirement Complex, to meet the needs of the steadily growing elderly population of planet Earth, is depicted as an integral part of a larger Lunar Humanity Centre. The economics of the project is further enhanced by augmenting the facility with an Advanced Centre for Physical Rehabilitation.

New Millennium World View

The nations of the world are more prosperous than ever before in history and organizations, both government and corporate, continue to invent new and more efficient ways to conduct business. Growing numbers of high net worth individuals (HNWI) wield more wealth, power and influence in shaping our destiny than ever before in history.

The progress in information and communication technologies of the past few decades continues to bring the peoples of the world closer together. Global trade, international financial markets, the internet and the worldwide web, along with ever faster modes of physical transportation allow people and cargo to access the farthest, remotest regions of the world in a matter of hours.

The Graying World Population

People all over the world are living longer, healthier, more productive lives. The percentage of older people is increasing. In addition to the vast professional and life experience they contribute to society, there has always been a natural inclination among many within this worldwide group to ponder the deeper philosophical, cosmic, and metaphysical roots of our origins, the universe, and our role in it.

The growing older population is also investing and saving in new ways, enhancing their retirement years. Meditation, Fine Art, Gardening and Horticulture, Travel and Tourism are cherished activities during retirement years. The older population, beyond normal reproductive age, is considered less susceptible to the effects of radiation. One-sixth Earth's gravity on the Moon would compensate for the physical limitations brought on by natural deterioration of the human physiology.

Geriatric Medicine and Care of the Elderly are sophisticated areas of medical practice. Rehabilitation of the Physically Handicapped is a mature, well-funded and highly innovative field in modern medicine. Terrestrial gravity imposes certain limitations on several therapeutic procedures and exercise regimens. Counter balancing weights, sophisticated inclined beds, neutral buoyancy exercises in specially designed pools and a range of prosthetics are employed to offset the gravitational force and to train and rehabilitate the patient. Many of the specialized equipment used for the treatment of the physically handicapped also see application in the care of the elderly. Therefore facilities could share both equipment and expertise.

Evolution of A Lunar Retirement Facility

Prephase 1 activity includes the deployment of various science and technology platforms. Past, ongoing and proposed science and technology missions fall in this category. This is a global lunar activity and sites are chosen according to the needs of the science to be conducted.

Phase 1 establishes an evolutionary Earth-Moon World-Wide-Web based interactive Humanity Archives on the Moon that can be accessed round the clock. [Fig 1]



Fig. 1 The New Millennium Humanity Archives on the Moon would be the centerpiece of the United Nations Headquarters. Peoples of the world would interact with this world-wide-web based robotic facility that is updated periodically by countries and cultures around the world.

Phase 2 Erection of the Lunar United Nations Summit Headquarters on the Moon. The concept is all about the Moon being the only "visible" continent for all of humanity on Earth. Since the Moon orbits the Earth, people all over the world look up and see it, recognize it and adore Luna ! In fact, she is also the first celestial

object that children imprint when they leave their mother's bosom and look up at the heavens. So, the Moon has tremendous significance of romance, affection and spirituality, above and beyond those yearnings of the scientist and technologist. (Note that we cannot see California or New York or Amsterdam, nor Beijing or New Delhi or Dubai from our homes, but all of us can see the mares and craters on the Moon, everyday! Aptly then, the Moon is perhaps the only truly international, globally "visible" continent, the eighth continent of the Earth-Moon bi-planetary system, that builds on UN/CHM and the Law of the Sea [see editor's note at bottom], and draws lessons from Antarctica. More importantly, our Moon imprints on the collective, primal imagery of our species. So, it is only fitting that the United Nations have a Summit Hq. facility there. (Yes, we can expect architects from all over the world to put their heads together with the various space agencies and compete for the first place design !)

Phase 3 Develops on building a series of "Great Religions of The World" buildings and structures that are sponsored by various faiths with assistance from nations and their governments. Establishment of an international lunar government organization, as projects become ever more complex, and demands on-site administrative support and supervision.

Phase 4 Commissions a lunar Sports Stadium and Recreation Centre. Phase 4 would also see the building of a large community center for the elderly.

Phase 5 Ancillary facilities consisting of tourist resorts, hotels and other recreation would spring up around the complex.

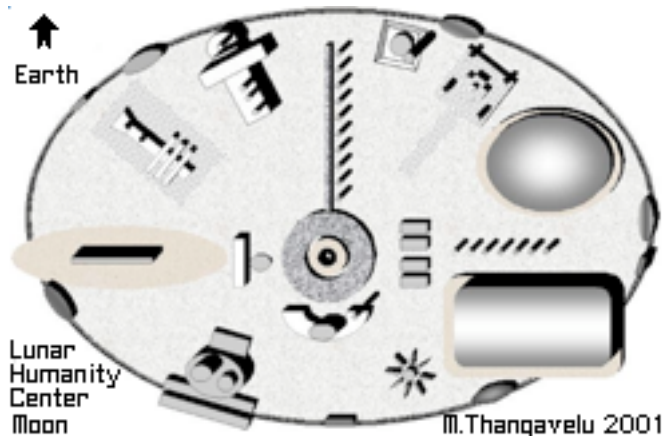


Fig 2. Shows the site plan for a Lunar Humanity Centre and Retirement Complex; and some facilities and activities that are possible.

The UN Headquarters is in the middle surrounding the Humanity Archives.

The large dome and vaulted structure to the right are the Lunar Olympics Stadium and the Athletics Centre.

The Retirement Center is below left, and a variety of cultural and great religion structures.

A monorail along the oval connects all the facilities including the towering Crystal Monument dedicated to the Heroes of the Lunar Continent.

Conclusion

Populations of the world, helped by continuing advances in modern medicine and healthcare, are living longer healthier lives. Despite the present global economic downturn, the wealth of nations and HNWI numbers also continue to grow. India, China and South Korea lead the world in economic development and associated increase in HNWIs. By complementing an "out-of-the -Earth" life style with other elderly retirement activities and pursuits, the Moon might offer a unique setting for geriatric care and senior citizen activities in the 21st century.

References

1. Thangavelu. M., Siting The Millennial Time Capsule And Presidential Library, Engineering, Construction and Operations In Space, Proceedings of the ASCE Conference, Albuquerque, NM, 1998.
2. Merrill Lynch et al., HNWI Report 2002. Sixth Edition.
3. Clarke, A.C., Smith R.A (Illustrator) The Exploration Of The Moon, Harper and Row New York, 1954
4. Thangavelu, M., Discussion and personal correspondence, United Nations Program For the Aging, United Nations Headquarters, New York, 2001.
5. Schrunk, D., et al., The Lunar Railroad, Proceedings of Space '96, ASCE Conference, Albuquerque, NM 1996.
6. Merrill Lynch/Capgemini World Wealth Report 2008 Capgemini US LLC 2010. **MT**

Editor's comment re "Law of the Sea" in Phase 3 above.

http://www.un.org/Depts/los/convention_agreements/convention_historical_perspective.htm Many space advocates are absolutely opposed to using this as a model for lunar development. Development of ocean-bottom resources ground to a halt after this treaty was adopted, because *no company or government will spend money developing resources that then must be shared with other nations that are making no investment.* Cf. NSS position paper: <http://www.nss.org/legislative/NSS-LoST-WhitePaper.pdf>

The editor would personally also oppose adoption of a Moon Treaty patterned verbatim after the Antarctic Treaty, which essentially would prevent any commercial or industrial activity on the Moon, as it has in Antarctica.

Here we think that a more positive step would be first to define various lunar areas that should get various levels of protection, such as designation of Lunar International Parks, Monuments, Historical Areas and then defining areas where various levels of commercial and industrial concessions might be allowed. A first draft of such a plan will be printed in the summer issue of Selenology Quarterly (American Lunar Society.) The extremes are zero protection, which has had catastrophic results here on Earth, and total prohibition, which paralyzes everything.

Such treaties [LoST and Antarctic] applied to the Moon would mean essentially that no part of the proposed UN Lunar Complex could be built with lunar materials, making everything enormously more expensive, and the scenario put forth in The Moon: Resources, etc. that Madhu Thangavelu co-authored, impossible. We would have to import the tracks for the lunar railroad that was to be the backbone of the resource development plan! **PK**

GREAT BROWSING

“At least” 600 M tons of ice on Moon’s North Pole!

<http://phoenix.lpl.arizona.edu/blogsPost.php?bID=180>

NASA, DARPA hold conference on Space Debris

<http://www.space.com/news/091208-space-junk-cleanup-meeting.html>

A new market for suborbital spaceflight

<http://www.thespacereview.com/article/1525/1>

Wikipedia list of private spaceflight companies

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

Space Tourism Essential to Future of Spaceflight

<http://www.thespacereview.com/article/1514/1>

Why more lakes at Titan’s north pole than south?

<http://www.physorg.com/news178724806.html>

To Deflect an Asteroid, Try a Lasso, Not a Nuke

<http://www.wired.com/wiredscience/2009/12/asteroid-deflection-tether/>

Space Station 2010 Calendar: Decade of Research

http://www.nasa.gov/pdf/402659main_2010%20ISScalendar.pdf

Sandtrapped Rover Makes A Big Discovery

http://www.marsdaily.com/reports/Sandtrapped_Rover_Makes_A_Big_Discovery_999.html

NASA's latest manned Mars mission plan available

<http://www.flightglobal.com/blogs/hyperbola/2009/12/nasa-as-latest-manned-mars-mission.html>

AIAA Bibliography of Space Architecture Papers

<http://www.spacearchitect.org/pubs/pub-biblio.htm>

SpaceShipTwo and the modern imagination

<http://www.thespacereview.com/article/1529/1>

Review: Krafft Ehrlicke's Extraterrestrial Imperative

<http://www.thespacereview.com/article/1526/1>

CAMSAT (China Amateur Radio Satellite) is up

http://www.camsat.cn/index.php?option=com_content&view=article&id=56&Itemid

Glint of sunlight confirms liquid lakes on Titan

<http://story.malaysiasun.com/index.php/ct/9/cid/89d96798a39564bd/id/578898/cs/1/>

Detecting past comet strikes on Earth

http://www.innovations-report.com/html/reports/physics_astronomy/kansas_scientists_probe_mysterious_comet_strikes_145574.htm

Ganymede & Callisto twins in size, but that’s all

<http://www.space.com/scienceastronomy/jupiter-moons-comet-impacts-100125.html>

Lunakhod 2 found on Moon 37 yrs, 34 km later

<http://story.malaysiasun.com/index.php/ct/9/cid/89d96798a39564bd/id/613016/cs/1/>

Potential landing sites on Phobos photographed

<http://news.yahoo.com/s/space/newphotosshowpotentiallandingitesonmarsmoon>

Japan to launch Akatsuki Venus probe

<http://www.nature.com/news/2010/100315/full/news.2010.126.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

Moon Colonies

Thomas Pickens – 3 parts

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

The Lunar Greenhouse

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

Refuelling Depot in Orbit

<http://gaiaselene.com/GASteroid/GASteroid.html>

Space Solar Power

<http://gaiaselene.com/Solar/Solar.html>

Visionaries:

Arthur C. Clarke on the Space Elevator

Buzz Aldrin on the Space Race

Buzz Aldrin on Asteroid Danger

Elon Musk on Commercial Rockets

<http://gaiaselene.com/Visionaries/Visionaries.html>

Peak Oil - Matt Simmons – 5 parts

<http://gaiaselene.com/Peak%20Oil/PeakOil.html>

NASA Regolith Challenge

http://gaiaselene.com/Regolith_Challenge/RegolithChallenge.html

ASSORTED SPACE VIDEOS

Bigelow Aerospace Inflatable Modules (3 parts)

http://www.space.com/common/media/video/player.php?videoRef=060607SNTV_Bigelow_pt1

http://www.space.com/common/media/video/player.php?videoRef=060607SNTV_Bigelow_pt3

http://www.space.com/common/media/video/player.php?videoRef=060607SNTV_Bigelow_pt3

Did Mars once have life then lose it?

http://www.space.com/common/media/video/player.php?videoRef=SP_090915_mars-show1

Space Music Videos

<http://www.youtube.com/watch?v=3Pee4JQxb7g>
and 13 more on the same page

Russian Nuclear Rocket to Mars

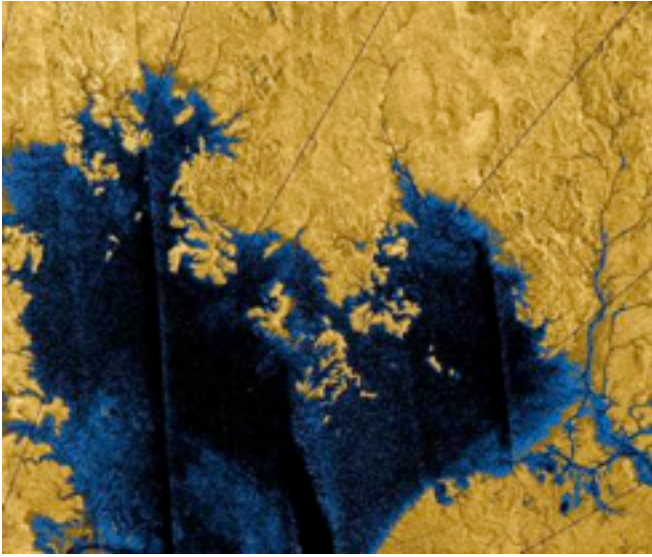
http://www.youtube.com/watch?v=5DQZOB6JSY&feature=player_embedded

Are you a fan of Space Settlements?

Read Clarke’s Rendezvous with Rama?

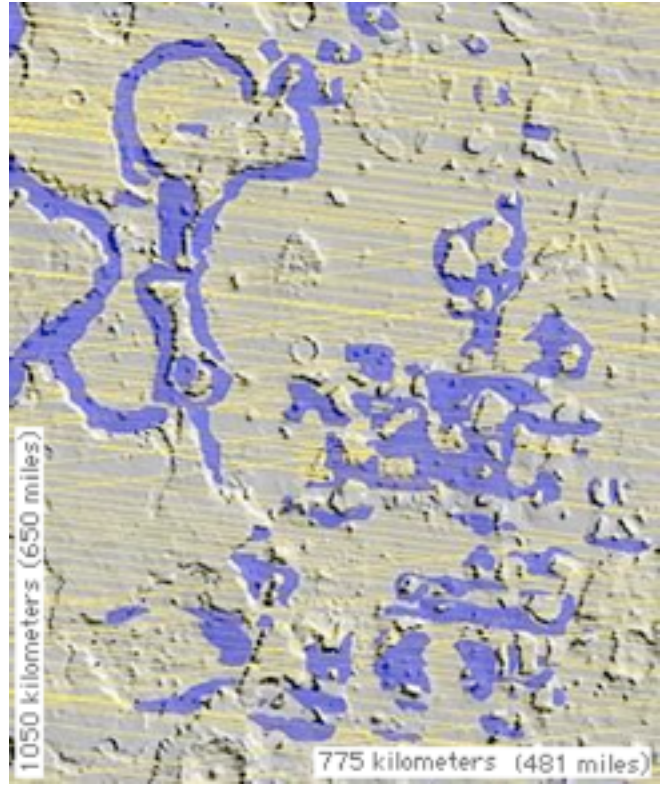
<http://www.youtube.com/watch?v=zBIQCm54dfY&feature=related>

M3IQ PHOTO GALLERY

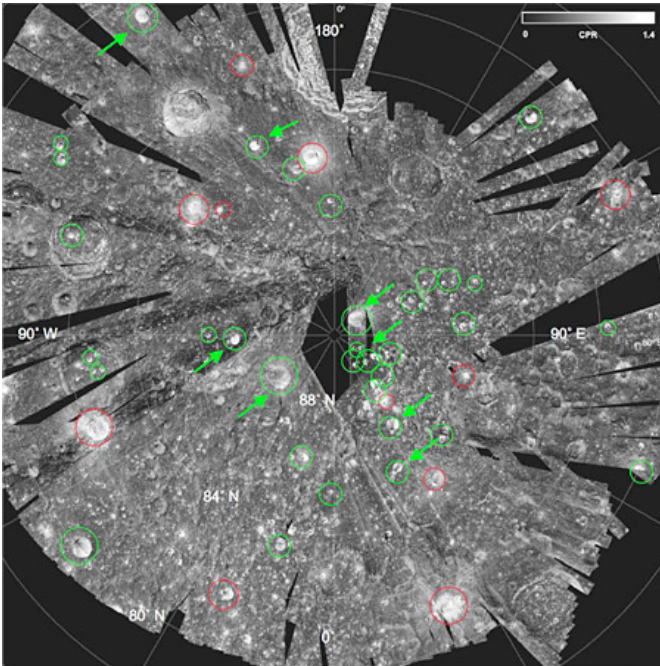


Titan's Lakes are in the News

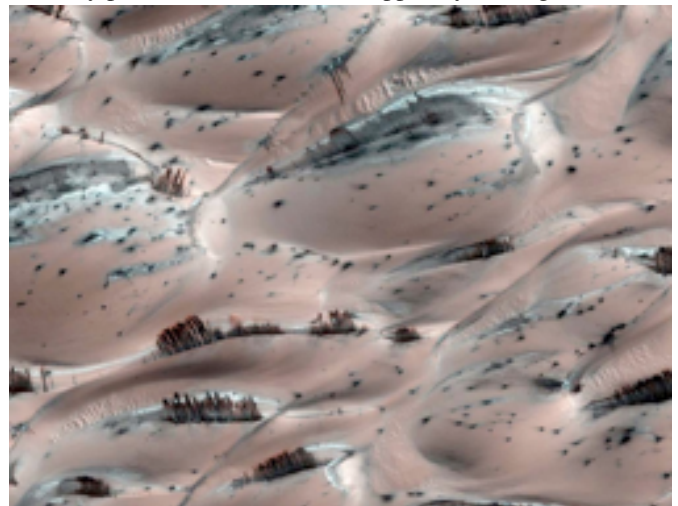
<http://news.discovery.com/space/a-look-at-titans-lake.html>



Thick masses of buried ice are quite common beneath protective coverings of rubble in the middle-latitude region of northern **Mars** according to Shallow Subsurface Data [Italy's SHAROD] gathered 2 years ago. While Mars geologists are excited about such findings, this knowledge is of major significance for human settlements on Mars, as they indicate that on many places, water-ice can be tapped by drilling down.



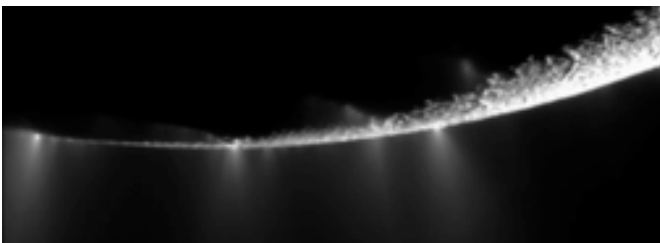
Green-circled craters near Moon's North Pole have ice!



No, groves of trees have not been discovered on Mars! The Martian "trees" are actually dark basaltic sand pushed to the surface of sand dunes by sun-heated solid carbon dioxide ice, or dry ice, sublimating directly into vapor.

www.space.com/scienceastronomy/mars-tree-photo-illusion-100113.html

But wouldn't we all like to see something like this "for real" someday? That is, vegetation growing on the Martian surface? That is the "Holy Grail" of the "Redhousing Project."



At least 5 ice geysers are seen shooting simultaneously from Enceladus' south polar area in this Cassini photo, dramatic proof that this small moon of Saturn is continuously active, and probably has a sub-ice-crust ocean, much as does Jupiter's much larger moon Europa.

<http://www.solarviews.com/eng/enceladus.htm>

[http://en.wikipedia.org/wiki/Enceladus_\(moon\)](http://en.wikipedia.org/wiki/Enceladus_(moon))



SEDS All India Conference 2010
Vellore Institute of Technology
April 10th, 11th 2010

<http://59.145.99.5/events2010/sinc10/os.html>

The Moon Society (International) and the newly established Moon Society (India) are once again pleased to co-sponsor the SEDS India Conference at Vellore Institute of Technology.

Building on the success of last year's conference, which had participants from seven universities, this year some ten universities will be represented by their SEDS chapters.

Conference Program

Nakshatra 3.0 This is a platform where you can use all your wacky theories and creative ideas to resolve technical conflicts. Nakshatra is the Paper Presentation Event of SINC'10. And for the first time, it brings to all the biology students topics on astrobiology. Abstracts for Papers are invited on the following topics:

1. Environment friendly rocket propulsion

Be the pioneers of eco-friendly rocket propulsion in India! Every launch leaves a huge cloud of exhaust and nasty chemicals in its wake. Environment-friendly rocket fuels have made a number of advances in recent months. So come up with your own ideas of designing an alternative and economical rocket propulsion system. Fuel a cleaner, more efficient rocket launch!

2. Disaster, detection, mitigation and management through space technology: Space technology plays a central role in providing early warnings to the risk-prone communities. Propose innovative ideas that use space technology-based solutions to increase awareness build national capacity and also develop solutions that are appropriate to the needs of the developing world.

3. Extra terrestrial mining

Develop a mechanism for active identification and mining of planetary bodies, for commodities ranging from metals to water, those which may be realized from a dormant comet or any other heavenly body.

4. Advanced material used in space technology

Potential space structures of the future will have extremely demanding goals in performance, reliability, and affordability. Give details of advanced materials, which may be able to tolerate extreme conditions in space and can be used in futuristic space applications.

5. Astrobiology A wide and general topic that focuses on issues such as the possibility of life on other planets, health and nourishment of astronauts in space, growth of flora and fauna in space and effect of zero/micro gravity on growth of living cells. Let your imagination run wild and come up with feasible ideas that are proportionate for mankind's future dominance of space!

Star Hunt: For the first time a space hunt on computer.

Participants will be provided with a set of questions. The answers to these questions can be found using Stellarium. All you have to do is get the right answers and find the celestial object's azimuth angle in the night sky using the stellarium software. This will check your astronomy knowledge.

Ornithopter

What is an ornithopter? An ornithopter is a device that flies by flapping its wings - just like a real bird. How is it different from an airplane or helicopter? These machines are driven by *rotating* airfoils. In an ornithopter, the driving airfoils have an *oscillating motion* instead. This imitates nature, because no animals have any rotating parts. In fact, most ornithopters produce lift in the same way as an airplane, relying on their forward motion through the air. Also like an airplane, lift and thrust functions are separated. Flapping wings are potentially more fuel-efficient than rotary-driven aircraft.

The Event: This is a workshop being conducted for the first time in SINC. We will provide you **hands-on experience** of building an ornithopter. Videos of ornithopters built around the world will be screened, after which the basics of flight mechanisms will be taught, along with details about the various kinds of materials used, the procedure for assembling all the raw materials together with necessary video grabbing and footage. All in all, a wholesome interactive session, eventually making you the proud owner of your own flying ornithopter!

Galileoscope 2.0 This workshop will explain the basic construction and working of various telescopes. The only requirements for this workshop are your interest, enthusiasm and curiosity, and we will provide you with knowledge and advice to help you **make your own telescope!** This workshop is being conducted by experts from the Bangalore Astronomical Society.

Rock-it! 2.0

Problem: Design, build, and launch a water jet rocket. It should return its payload (a raw egg) to Earth safely.

Introduction:

1. The four basic parts of any transportation system are: guidance, propulsion, payload and recovery techniques.
2. Newton's Third Law of Motion says, "For every action there is an equal, but opposite reaction."
3. Aerodynamics is the study of how things are affected by the flow of air around them.

Note: Participating teams are supposed to test their rockets before launching them at the conference

•The maximum number of participants in a team is 3.

Specifications:

1. It should be a Water Propelled Rocket. Electronics might be used for payload detachment.
2. The protection for the egg should have maximum thickness of 5mm.
3. The result must be a space transportation vehicle capable of carrying a payload (the egg).

4. The vehicle must include guidance, propulsion, payload, and recovery systems.
5. The team is also supposed to develop its own launch pad.
6. The rocket must launch as one complete unit, but may come down as separate pieces.
7. On launch day, the rocket will be launched once and it will be judged on the time of flight. When the rocket is recovered, the payload will be inspected for damage.
8. The maximum working pressure of the rocket is 8atm(0.8megapascals)(120psi).
9. The weight of the rocket should not exceed 1000 gm (dry weight).
10. The dimensions of the nozzle would be updated on the website soon

SAFETY CODE:

- (i) The rocket would be tested for 150% of the specified pressure limit in the design a day before the event. If it fails to meet the specification mentioned, the team would be disqualified.
- (ii) High Pressure cylinder (N2) with pressure regulator will be provided for filling.
- (iii) Participants should bring their own protection gadgets.

Moon Specific Events

Visionary India: Chandrayaan-2 Student Payloads

This is an inimitable event, in which participants are required to present their own ideas for a payload for Chandrayaan-2. With Chandrayaan-1 completing 95% of its mission objectives (detecting evidence of water on the moon being the most sensational) it opens the door for newer possibilities of India's venture into space. Come up with ideas and design of a payload for exploring the lunar surface. Among the varied types of payloads that can be deployed think of the most innovative and futuristic one, think differently!!

Lunar Trek 2.0

Extolling the thumping success of the Indian Space Program (ISRO), this has further consolidated its esteemed position in the global space race and with future in perspective; SEDS-India announces the second National Level Moon Rover Competition.

This calls for all 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. SEDS-India takes pride in contributing to the vision of Mr. Madhavan Nair whose vision to launch a rover to the Moon bore fruit in the form of Chandrayaan-2 (two landers based on a Russian design).

Some of the most challenging chores for the rover are maneuvering the rough and unknown terrain, rock samples collection and analysis, transmitting and receiving data, etc. In this scenario, a rover's efficiency is tested in transporting a rock sample to a designated spot through the uneven course.

Problem Statement: The rover is required to steer through the uneven terrain to place a rock sample (3 cm on a side) that it is carrying in the predefined test facilities where they shall be analyzed.

NOTE: Apart from this we will have many guest talks and presentation. One of these will be a presentation on a Lunar Analog Research Station by Moon Society (India) President Jayashree Sridhar. **M3IQ**

Look for us at the Conference!



Jayashree Sridhar

President Moon Society India



Pradeep Mohandes

Secretary Moon Society India

Former President SEDS India

Co-founder, SEDS India, Co-editor M3IQ



Srinivas Laxman

Space Writer

Co-editor, M3IQ

Moon Miners' Manifesto Resources

<http://www.MoonMinersManifesto.com>

MMM is published 10 times a year (except January and July. The December 2008 issue will begin its 23rd year of continuous publication.

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

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

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

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

MMM Classics: All the “non-time-sensitive editorials and articles from past issues of MMM have been re-edited and republished in pdf files, one per publication year. A 3-year plus lag is kept between the MMM Classic volumes and the current issue. **As of 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.moonsociety.org/publications/mmm_classics/

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

www.moonsociety.org/publications/mmm_themes/

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

www.moonsociety.org/publications/m3glossary.html

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

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

Help Wanted !

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

If this publication is going to help spread the word about Space in India, among the public at large, and especially among the students and younger generation, it must become a truly Indian publication. We need people from many fields in India to join our team

If you think that you can add to the usefulness and vitality of this publication, in any of the ways listed above, or in fields we had not thought of, write us at:

mmm-india@moonsociety.org

[This email address goes to the whole editorial team]

Tell us about yourself; your interest in space, and how you think you can make this publication of real service in the education of the public in India, and in the education of young people on whom the future of India and the world will rest.

Guidelines for Submissions

This publication is intended for wide public distribution to encourage support for space research and exploration and development.

It is not intended to be a scholarly review or a technical journal for professional distribution.

Submissions should be short, no more than a few thousand words. Longer pieces may be serialized

Editorials and Commentary, reports on actual developments and proposals, glimpses of life on the future space frontier, etc.

Articles about launch vehicles, launch facilities, space destinations such as Earth Orbit, The Moon, Mars, the asteroids, and beyond, challenges such as dealing with moon dust, radiation, reduced gravity, and more.

Help Circulate *MMM-India Quarterly*

If you know someone who might enjoy reading this publication, send us their email address(es) so that they receive notice when a new issue is published.

Readers are encouraged to share and to distribute these issues widely, either as email attachments, or via the direct download address (for all issues):

<http://www.moonsociety.org/india/mmm-india/>

MMM-India Quarterly will remain a free publication.

We will set up an online subscription service so that each issue is emailed to your email box directly, if you wish.

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

If anyone in India wishes to become a Moon Society agent and publish and mail hardcopies of *MMM-India Quarterly* to addresses on a paid-subscription basis, please contact us at mmm-india@moonsociety.org

MMM-India Quarterly #6 – Spring 2010 Index - Table of Contents

- p. 2 About The Moon Society
About “Moon Miners’ Manifesto”
About “MMM-India Quarterly”
- p. 3 India Space Front News items
- p. 4 600M Tonnes Water Ice at Lunar North Pole
- p. 5 Drama of the Moon Impact Probe
Srivas Laxman
- p. 6 New types of Moon Rocks Found
- p. 7 Meeting Dr. Goswami: ISRO’s Planetary Mission Plans – *David Dunlop*
- p. 8 Elsewhere in Asia
- p. 10 Moon Society Editors
- p. 11 The Lunar Rock Pile: Hidden Assets
Peter Kokh
- p. 16 LARS-India: an Indian Lunar Analogue Research Station – *Jayashree Sridhar*
- p. 18 A Simple, Inexpensive, Roomy Space Station
Peter Kokh
- p. 19 Book Reviews (3): • Outer Space • Living of the Land in Space: Green Paths to the Cosmos
• Turning Dust to Gold (on Moon & Mars)
- p. 21 Lunar Thermal Wadis – *Peter Kokh*
- p. 22 Moon Society India Quarterly Report
– *Pradeep Mohandas*
- p. 23 NASA’s “Destination Mars” can work for Moon Advocates also – *Peter Kokh*
- p. 24 What’s Positive in NASA’s New Budget
David Dunlop
- p. 25 Student Organizations in India
- p. 26 Salvaging Google Lunar X Prize “also rans”
David Dunlop
- p. 29 Solving the Moon’s Water Puzzle
David Dunlop
- p. 32 A Lunar United Nations Humanity Centre & Retirement Complex – *Madhu Thangavelu*
- p. 34 Browsing Links – Video Links
- p. 35 MMM-India Photo Gallery
- p. 36 SEDS All India Conference Program
- p. 38 MMM Resources; M3IQ Help Wanted

If this publication has been forwarded to you by someone else,

and you would like to add your email address to our new-issue-ready announcement list,

Write mmm-india@moonsociety.org

Put “Subscribe” in the subject line of your email.

Include any comments you would like to make!

Feel free to send us email addresses of others
Individuals and/or organizations or lists.

*“Do not go where the path may lead.
Go instead where there is no path,
and leave a trail.”* - Mongolian proverb

*“Single Planet Species don’t last.
Multi-World Species ‘live long and prosper.’”*
- Astronaut John Young

*“The cure for boredom is curiosity.
There is no cure for curiosity.”*

- Ellen Parr

“There is no try, just do!”

- Yoda, in Star Wars: The Empire Strikes Back



Key: ■ ISRO Centres; ■ Moon Society; ■ SEDS; ■ NSS



Moon Society India

www.moonsociety.org/india/

Engage! And Enjoy!