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

Moon Miners' Manifesto

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

#8 OCT-DEC 2010

Above: artist rendering of Russia's PTK NP (PPTS) 6-person successor to the venerable Soyuz Capsule

Article Sections This Issue

Welcome to Moon Miners' Manifesto India Quarterly Edition #8

This issue completes the first two years! How fast time goes by when we are having fun! For us this has been a rewarding endeavor.

The growing number of articles by Indian writers, and the high quality of their contributions bodes well for the future. In the coming year (#3!), we foresee a continuing shift in contributions and a gradual "reinvention" of the MMM-India Quarterly – M3IQ – which may well include a new name and a new look as well as some shift in content.

That is as it should be. Speaking for the original editors, Dave Dunlop, Madhu Thangavelu, and myself, our job definition includes turning over the ownership – that is, "working ourselves out of a job."

The process is working well. Most of all, we are gratified to see the rise of enthusiasm within India about space and for India's future in space! *Peter Kokh.*

About The Moon Society

http://www.moonsociety.org

Our Vision says Who We Are

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

Moon Society Mission

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

Moon Society Strategy

We seek to address these goals through education, outreach to young people and to people in general, contests & competitions, workshops, ground level research and technology experiments, private entrepreneurial ventures, moonbase simulation exercises, tourist centers, and other legitimate means.

About Moon Miners' Manifesto

http://www.MoonMinersManifesto.com

MMM is published 10 times a year (except January and July. The December 2009 issue began its 24th year of continuous publication.

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

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

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

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

MMM Classics: All the "non-time-sensitive editorials and articles from past issues of MMM have been re-edited and republished in pdf files, one per publication year. A 3-year plus lag is kept between the MMM Classic volumes and the current issue. These issues are freely accessible, no username or password needed, at:

www.moonsocietyorg/publications/mmm_classics/

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About MMM-India Quarterly

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

This publication was launched with the Fall 2008 issue. This issue completes our 2nd year. 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 has now gone to the Moon!*

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

This vision was well-expressed by the former President of India, Dr. A. P. J. Abdul Kalam in a speech at The Symposium on "The Future of Space Explora-tion: 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 are available as a free access pdf file, downloadable from this address:

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

We encourage readers to share these files with others freely, and to use this publication to grow and cultivate wide-spread interest in the open-ended possibilities of space among the people of India, and to encourage the rise of additional citizen support space organizations within the country.

India
Space Front Updates

Chandrayaan-2 Report

By Srinivas Laxman

India's second mission to the moon, "Chandrayaan-2," has taken a definite shape, but certainly not before it has delivered a subtle message to countries which were looking forward to participating in the much-awaited Rs 425-crore lunar flight slated for launch in 2013.

What is this message? While announcing the initial seven payloads, which will fly in the India-built orbiter and the rover, there is undoubtedly a hidden message---India would rather go back to the Moon with Indian passengers than with foreigners to avoid any controversy at a later stage.

This preliminary plan needs to be viewed in the context of the unfortunate development in Chandrayaan-1 in which India's role in first discovering lunar water on November 14,2008, by Chace-1 (Chandra's Altitudunal Composition Explorer)—one of the three payloads which flew on the Moon Impact Probe--which crash landed on the south pole region of the Moon was completely sidelined.

The sensational find by India failed to attract any recognition both abroad and surprisingly even in this country understandably causing a lot of demoralization among scientists, some of whom never failed to vent their feelings, plucking courage to break the official code of conduct, on different websites. NASA walked away with the trophy for this discovery, which actually should have gone to India. It is well known that NASA's Moon Minerology Mapper (M3)—one of six payloads on board Chandrayaan-1-- discovered water only after it was found by the Indian instrument designed and developed by the Space Physics Laboratory at the Vikram Sarabhai Space Centre, Thiruvanathanapuram.

That is not all. When Chandrayaan-1 and NASA's Lunar Reconnaissance Orbiter (LRO) participated in a joint bi static experiment on the night of August 21 2009 over the north pole region of the Moon in search of water, Paul Spudis, who was associated with the LRO mission and also Chandrayaan-1 declared that the mission failed because Chandrayaan-1's antenna was pointing in the wrong direction. This was anything but the truth and ISRO has vehemently denied it.

Bitten sharply by this foreign experience, ISRO quite rightly might have been prompted to rethink the idea of once again laying the red carpet and welcoming foreign participation, especially NASA, in Chandrayaan-2. Maybe it did not want its scientists to feel unrewarded and once again watch the credit for its discoveries on the Moon being grabbed by another country. At the same time let us not jump into conclusions too hastily either. Let us wait for the final announcement expected a few months later. Do not be surprised if at the last moment ISRO decids to accept foreign payloads.

Principal investigator of M3 Carle Pieters told MMMIQ during the Chandrayaan-1 scientific conference at Ahmedabad in February 2010 that ``she would be willing to participate in Chandrayaan-2, but her opinion was not the official standpoint of NASA. A lot still needs to be done on the Moon,'' she said.

Chandrayaan-2 is a joint Indo-Russian mission and only the lander is the Russian contribution. But, ISRO has not ruled out the possibility of adding more payloads at a later stage depending on the mission profile. The Indo-Russian agreement for this mission was signed in Moscow on November 12, 2007 and approved by the Union Cabinet on September 18, 2008. The original pact envisaged a Russian lander and a 50 kg Russian rover. The primary mission objective of Chandrayaan-2 is to hunt deeper for water and carry out a survey of minerals on the lunar surface and do a 3-D map of the Moon

Of the five payloads in the Chandrayaan-2 orbiter, three are new and two are improved versions of the instruments which operated on Chandrayaan-1.

New Payloads

- **Large Area Soft X-ray Spectrometer** (**CLASS**) from the ISRO Satellite Centre, Bangalore and Solar X-ray Monitor (XSM) from the Physical Research Laboratory, Ahmedabad. Their role is to map the major elements present on the lunar surface.
- **L and S band Synthetic Aperture Radar** (**SAR**) from the Space Applications Centre, Ahmedabad. It will probe the first few tens of meters of the lunar surface for the presence of different constituents including water ice. It will provide further evidence confirming the presence of water ice below the shadowed regions of the moon. This is significant because last year Chandrayaan project director, Mylswamy Annadurai, told students at the SIES College in Mumbai that a new discovery of Chandrayaan was that the source of water on the moon was from within, and not due to an external factor like meteorites.
- **Imaging Infra-Red Spectrometer** also from the Space Applications Centre Ahmedabad. It will map the lunar surface over a wide wavelength range for the study of minerals

It is possible that the know-how for these instruments could have been borrowed from some of the international payloads like Mini-Sar and CIXS (Chandrayaan Infra Red Spectrometer), which flew on Chandrayaan-1

Improved Payloads

- **Neutral Mass Spectrometer** (Chace -2 Chandra Altitudunal Composition Explorer) from the Space Physics Laboratory, Thiruvanathanapuram, for carrying out a detailed study of the lunar exosphere. ISRO officials told MMMIQ that Chace-1 which was a payload on board the indigenous Moon Impact Probe which was one of the 11 instruments of Chandrayaan-1 operated only for 20 minutes. ``Chace-2 will be more advanced and will operate for a longer time,'' he said.

• **Terrain Mapping Camera** (TMC-2) from the Space Applications Centre, Ahmedabad for preparing a three-dimensional map oflunar mineralogy and geology.

Rover payloads

• **Laser Induced Breakdown Spectroscope** (LIBS) from the Bangalore-based Laboratory for Electro Optic Systems (LEOS), Bangalore.

• **Alpha Particle Induced X-ray Spectroscope** (APIXS) from the Physical Research Laboratory, Ahmedabad.

Both these instruments will carry out elemental analysis of the lunar surface near the landing site. The touchdown point has yet to be finalized, but indications are that it could be somewhere in the South Pole region of the moon.

Unlike Chandrayaan-1, Chandrayaan-2 aims to reach out to the younger generation because the students of IIT-Kanpur are playing a key role in the design and development of the rover. ``We do understand that first of all it is a demonstration of the Indian presence on the surface of the moon,'' Aleksandr Zakharov, a leading scientist attached to the Moscow-based Space Research Institute has been quoted telling the BBC. But, little does he realize that when the Moon Impact Probe of Chandrayaan-1 crashed landed on the lunar surface on November 14,2008, with the Indian tri-colour, it had already established India's presence on the moon, making it the sixth nation after the US, Russia, Japan, China and the European Space Agency—to become a member of the exclusive global lunar club.

Originally, when the Russian-built rover weighing about 50 kg was to fly on this mission, the weight of the Indian-built rover was pegged at 15 kg. Now that Russia has backed out of the rover project because of "scheduling pressures," and also financial constraints, ISRO is attempting to increase the weight of its rover from 15 kg. The life span of the rover is also being worked out.

Details of the orbiter's total period of operation have yet to be announced too. This is something prudent because in the case of Chandrayaan-1 it was first declared as a two-year mission, which was cut short by nearly a year following a communication failure on the night of August 29, 2009. The mission, of course, was anything but a failure because nearly 95 per cent of its scientific objectives were completed. An ISRO official told MMMIQ that one of the reasons why Russia withdrew is because it wanted to strengthen its scientific contents on the lander.

Though ISRO has not provided any details about the Russia-built lander, it is learnt from other sources that it will be first tested on Russia's Phobos-Grunt mission to Mars to be launched in December 2012. ``The lander which will fly on the Mars mission is a replica of the one which will go on Chandrayaan-2,'' said an official. The official said that the lander will consist of three manipulators.

• One manipulator will collect samples.

• The second one will pick up dust

• The third one will be used for drilling

The lander will also have a chemical analyzer.

The Chandrayaan-2 spacecraft will weigh about 2,650 kg at lift off. Of which the weight of the orbiter will be about 1,400 kg and that of the lander 1.250 kg. The total mass of the payloads which was earlier stated to be 35 kg has also not been declared, suggesting that in the next few months more instruments could be included depending upon the final mission architecture.

The flight plan envisages the lander carrying the rover flying to the moon with the orbiter and detaching itself at a certain point above the lunar surface. Thereafter, it will zoom down towards the moon and execute a soft landing on the lunar surface. In the case of Chandrayaan-1 it was a crash landing. This means that the descent will be controlled and more importantly on touchdown there will be no destruction either of the vehicle or the rover. After landing, the rover will be released to pick up rock samples or soil for chemical analysis. The data will be first transmitted to the orbiter and then relayed to the ground stations.

Three years after the successful launch of Chandrayaan-1 on October 22,2008, the country is now preparing to return to the moon once again. At all ISRO centres throughout the country activity is gathering momentum to launch the flight in 2013 from Sriharikota.

The rocket will be the three-stage Geo Synchronous Satellite Launch Vehicle (GSLV) which does not have the same excellent track record as the four-stage Polar Satellite Launch Vehicle (PSLV) which carried Chandrayaan-1. Therefore, on the day of the launch when the countdown hits the zero mark and the rocket lifts off with Chandrayaan-2 one needs to keep one's fingers crossed and pray hard for the mission's success.

The first human landing on the Moon on July 20, 1969 by Neil Armstrong and Buzz Aldrin, was the result of a lunar race by the US and the former Soviet Union. It was a political exercise rather than a scientific endeavour. Now, is there a similar race between India and Russia on one side and China on the other? A recent report in the BBC states that there now exists a modern-day space race to land an unmanned probe on the Moon between Russia and India on one one side and China on the other. The word `between' is being used because India and Russia according to BBC have teamed up on one side challenging China. ISRO officials categorically deny that there exists an Asian Moon race. ``Our mission to the Moon is purely a scientific programme. Nothing else. We are not in competition with anyone,'' said an official.

According to the BBC, Chandrayaan-2's launch is expected to coincide with China's Chang'e spacecraft landing on the Moon. So it is being interpreted as the beginning of an Asian moon race.

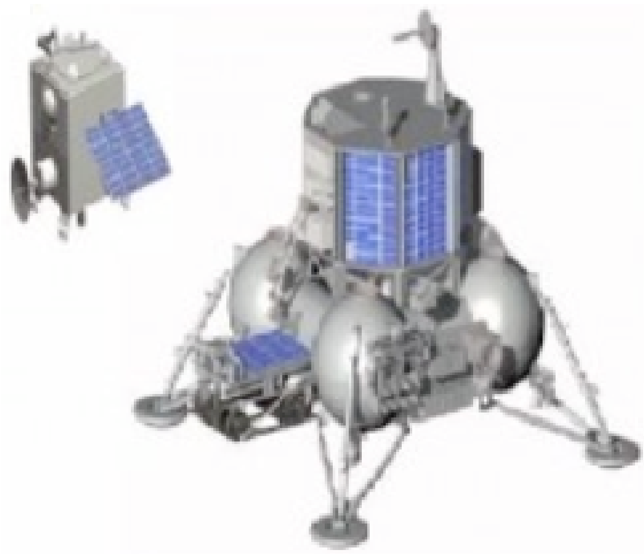
After Chandrayaan-2 what? This question is being asked by scientists and even by space officials themselves. Will India's lunar programme come to an end as it happened with the US manned mission to the Moon with Apollo 17? Or will there be a Chandrayaan-3? Recently, former ISRO chief Madhavan Nair, spoke about the possibility of an Indian manned mission to the Moon around 2020. Is this a dream or will it become a reality?

Only a tremendous public participation in India's space missions involving scientists can make many paper projects into a reality. **SL**

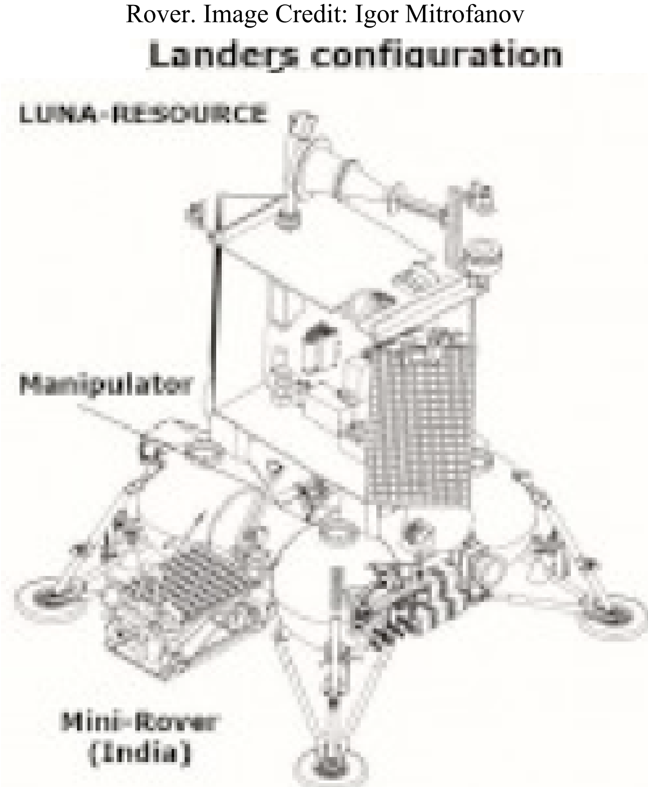
Luna-Resource (Chandrayaan-II Lander) Payloads Announced

By: Pradeep Mohandas

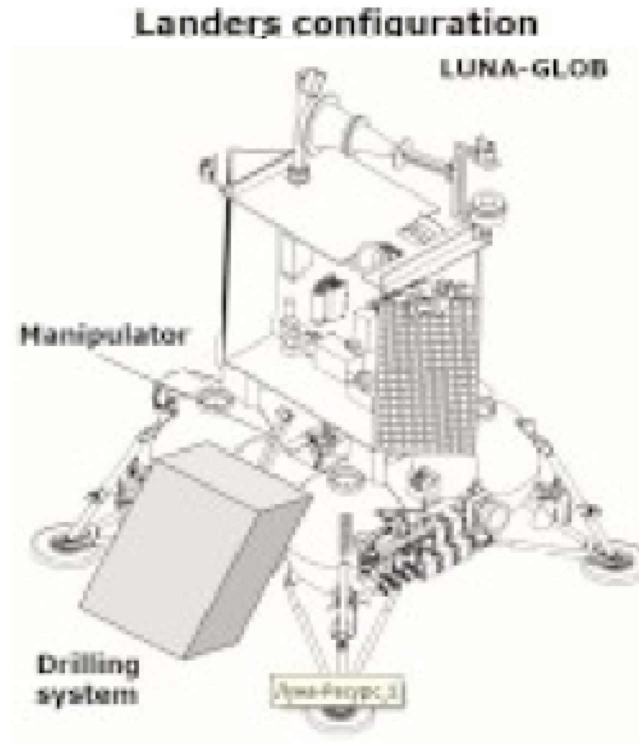
The configuration for India's second lunar mission is now clear. It carries one orbiter made by India, a lander made by Russia and a rover made by India. Russia has decided to pull out of the rover and concentrate on making the lander more scientifically rich. At the Lunar Exploration Analysis Group (LEAG) meeting, held in Washington DC between September 14 and 16, 2010, Igor Mitrofanov, Landers Mission Scientist made a presentation on the Russian Luna-Resource and Luna-Glob landers. He is from the Institute for Space Research (IKI) in Moscow.



Colour picture of Chandrayaan-II Lander, Orbiter and Rover. Image Credit: Igor Mitrofanov



Detailed line drawing: Luna-Resource by Igor Mitrofanov



Detailed line drawing of Luna-Glob by Igor Mitrofanov

It is for the first time that we have colour and line drawings of the lander, rover and orbiter. Although, I think the rover as it looks in these images is only representative.

The 12 payloads for the lander have been selected on the basis of the scientific objectives, which are:

- Investigation of the composition of the surface and subsurface and its formation processes.
- Investigation of interaction of the cosmic particles and lunar surface and the exosphere over the lunar poles.

Along with this, the scientists at IKI also selected instruments which had a Technology Readiness Level of greater than 6, which indicated instruments which were at the sub-system or system design stage or higher. The subtraction of the lunar rover may lead to the inclusion of more instruments. It is worth waiting and watching.

The first instrument that Mitrofanov mentions in the presentation is a Radio Beacon. Although it's description seems to imply that it will only be present on the Luna-Glob, I have included it here for a purpose. If this beacon is carried by the Luna-Resource as well, Russia will have a distinct advantage. If I understand the mission architecture correctly, Luna-Glob will be a twin of the Luna-Resource that will fly to the opposite lunar pole. This means that Russia may have two radio beacons on the North and South Polar regions of the Moon.

Scientifically, the instrument would study internal motions of the Moon with help from Ground based Radio Telescopes and investigate lunar gravity field by studying relative motion with the orbiter.

The second instrument is the TV for field of operations. Mitrofanov does not provide details but it would be an interesting video feed to watch of the Indian Rover working on the Moon!

The third instrument is the Ultra Violet Optical Spectrometer Imager. It has an imager to image the landing surface in three optical bands, perform photometry at 9 narrow spectral bands and perform analysis using Ultra Violet light.

A prototype of the Radio-Beacon instrument from the Phobos-Grunt mission. Image Credit: Igor Mitrofanov.

Ultra Violet Optical Spectrometer Imager: Igor Mitrofanov

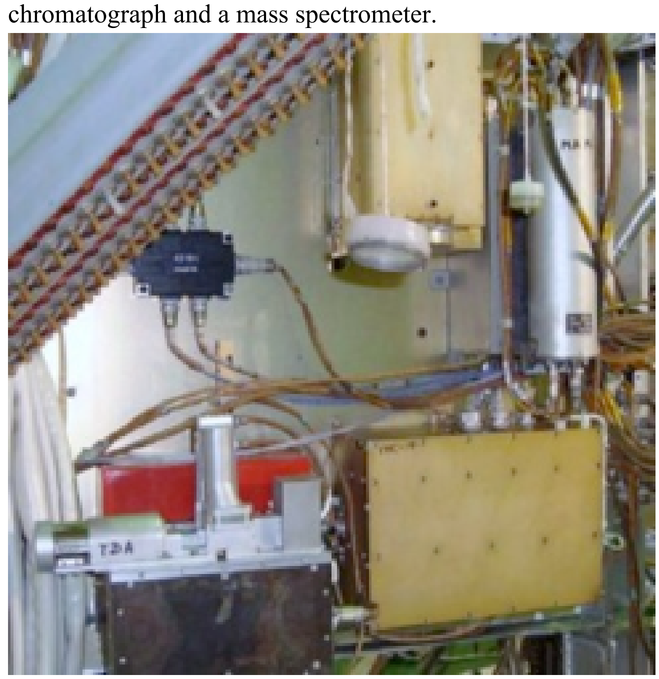
This suite of instruments will help it to image the manipulator's field of operations and study the mineralogical composition of the lunar regolith (soil on the Moon is called regolith), nearby stones and top layers.

The fourth instrument is called the Lunar Infra-Red Spectrometer (LIS).

Lunar Infra Red Spectrometer. Credit: I G Mitrofanov

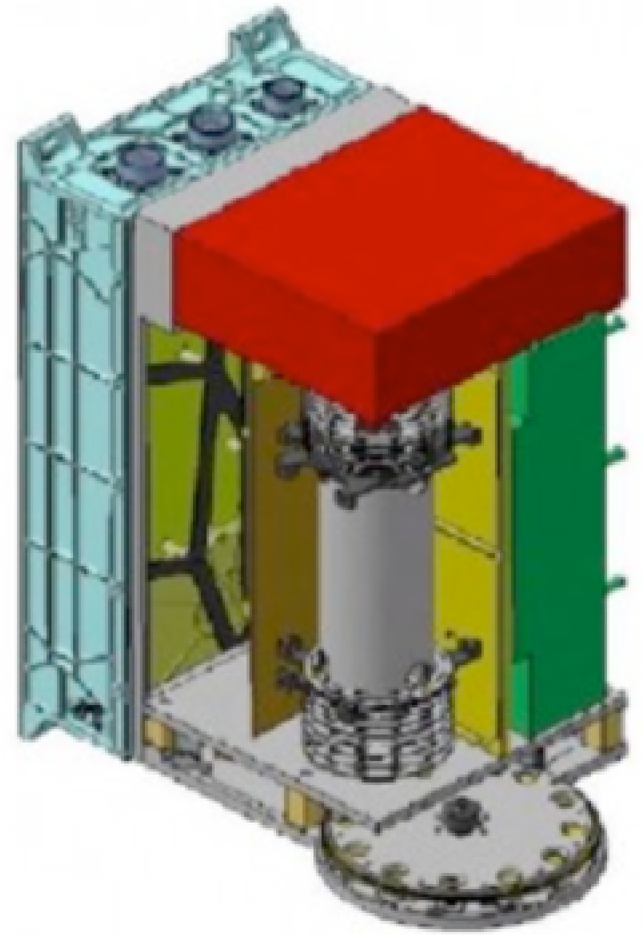
This instrument will measure hydroxyl ion and water molecule content in the top layer of lunar regolith. It will also test how water-rich the top layer of regolith is and understand loss of water when the top layer is removed and the rate of such loss.

The fifth instrument is the heaviest payload on the Luna-Resource at 10.4 kg called the Gas Analytic Complex (GAC). It contains a differential thermal analyser, a gas chromatograph and a mass spectrometer.



Together the instrument will measure volatiles (eg: water ice) present in lunar regolith and also provide isotope ratios.

The sixth instrument is the Laser Mass Analyser (LASMA). It has a laser evaporating system of testing samples and a mass spectrometer.



LASMA instrument. Image Credit: Igor Mitrofanov

This will also perform the same activity as the GAC, but using different technique and perhaps for a specific set of volatiles.

The seventh instrument is called ADRON. It consists of a neutron generator and post-pulse neutron and gamma ray detectors. You may know that a gamma ray is produced as a result of neutron interaction, hence the presence of a gamma ray detector.

Andron’s neutron detector will help scientists study the hydrogen content in the top layers of the lunar regolith while the gamma ray detector will help scientists study the composition of lunar regolith itself. I think combining results from ADRON and LIS will help scientists understand formation of water molecules on the Moon since they study hydroxyl and hydrogen ions respectively.

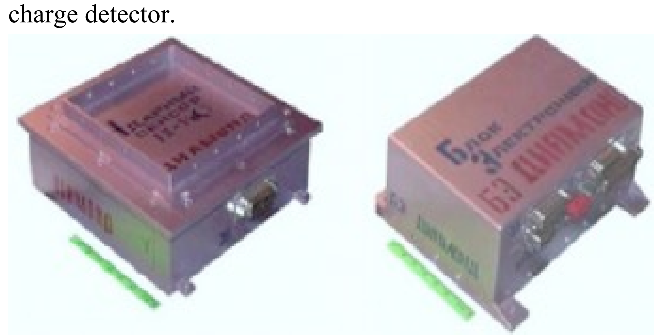
The eighth instrument is called the Radiometer Thermometer. It plans to measure radiations from depths of 2.5, 3.3 and 5 centimeters and temperatures upto depth of 1 metre at every 15 centimetre with a resolution of 1 degree Kelvin.

Radio-Thermometer instrument. Credit: Igor Mitrofanov

This instrument will help understand temperature variations on a daily and annual basis. It will also help study the supposed dielectric nature of lunar regolith.

The ninth instrument is the contact thermometer. Mitrofanov has not provided much details and it seems to be going with the penetrator arm expected to fly on board on the Luna-Glob mission only.

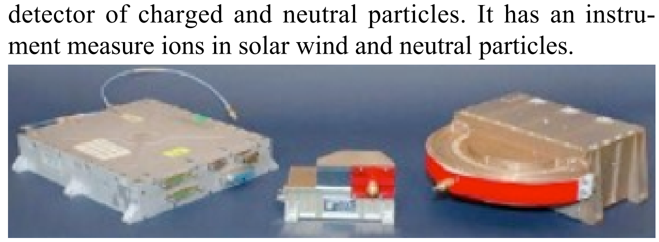
The tenth instrument is simply called the PmL-Dust Detector. The instrument contains a dust detector and a charge detector.



The PmL Dust Detector. Credit: Igor Mitrofanov

The instrument is expected to enhance our understanding of the lunar dust through flux, mass and charge distribution studies. It will also detect micrometeorites and foriegn particles in lunar regolith.

The eleventh instrument is called LINA. It is a detector of charged and neutral particles. It has an instrument measure ions in solar wind and neutral particles.



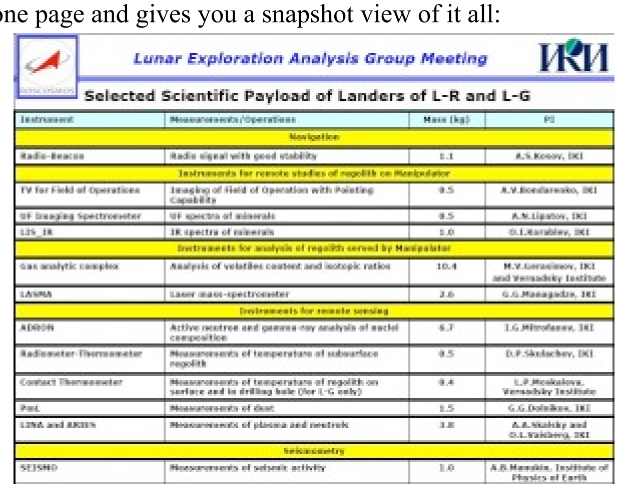
With these detectors, the instrument will study interaction between solar winds and the lunar poles and also the creation and transport of various particles in the lunar exosphere (atmosphere).

The twelfth and the last instrument called ARIES, a panoramic energy mass spectrometer of ions.

ARIES instrument. Image Credit: Igor Mitrofanov

ARIES fulfils the same requirements as LINA but provides a wider range and better resolution over a wide range.

This slide by Mitrofanov has all the instruments on one page and gives you a snapshot view of it all:



Lunar Exploration Analysis Group Meeting

Selected Scientific Payload of Landers of L-R and L-G

Instrument	Measurements/Operations	Mass (kg)	PI
Navigation			
Radio-Beacon	Radio signal with good stability	1.1	A.S.Kosov, IKI
Instruments for remote studies of regolith on Manipulator			
TV for Field of Operations	Imaging of Field of Operation with Pointing Capability	0.5	A.V.Bondarenko, IKI
UF Imaging Spectrometer	UF spectra of minerals	0.5	A.N.Lipatov, IKI
LIS_IR	IR spectra of minerals	1.0	O.I.Korablev, IKI
Instruments for analysis of regolith served by Manipulator			
Gas analytic complex	Analysis of volatiles content and isotopic ratios	10.4	M.V.Gerasimov, IKI and Vernadsky Institute
LASMA	Laser mass-spectrometer	2.6	G.G.Managadze, IKI
Instruments for remote sensing			
ADRON	Active neutron and gamma-ray analysis of nuclei composition	6.7	I.G.Mitrofanov, IKI
Radiometer-Thermometer	Measurements of temperature of subsurface regolith	0.5	D.P.Skulachev, IKI
Contact Thermometer	Measurements of temperature of regolith on surface and in drilling hole (for L-G only)	0.4	L.P.Moskalova, Vernadsky Institute
PmL	Measurements of dust	1.5	G.G.Dolnikov, IKI
LINA and ARIES	Measurements of plasma and neutrals	3.8	A.A.Skalsky and O.L.Vaisberg, IKI
Seismometry			
SEISMO	Measurements of seismic activity	1.0	A.B.Manukin, Institute of Physics of Earth

India will also be looking forward to the success of Phobos-Grunt which flies to Phobos in 2011 for a sample return mission. This is because the Radio-Beacon Transmitter, Gas Analytic Complex, Laser Mass Analyser, ADRO, PmL Dust Detector, LINA and ARIES are flying on the Phobos-Grunt.

In addition, ADRON is also flying on NASA's Mars Science Laboratory! **m3iq**

A video **J N Goswami** on the
Water on the Moon and other solar system bodies:
http://www.youtube.com/watch?v=VqOksC3ijJ0

Dr. A.P.J. Abdul Kalam Speaks in Toronto, Canada on Global Green Energy Initiatives

David A, Dunlop

A Global Challenge and Initiative

On Thursday September 30, I had the privilege of hearing Dr. Abdul Kalam address a meeting at the historic and prestigious Albany Club in Toronto, Canada on the topic of Green Energy. At a global level Dr. Kalam called for a decreased dependence of fossil fuels and the development of "green energy a global initiative for use in residential, transportation and industrial contexts. This challenge is one of making the planet sustainable for future generations while providing energy security and insuring an adequate supply for development. In the near term we face the challenge of creating a transition strategy to total freedom from fossil fuels and controlling the gases our energy production puts into the atmosphere. In India's case at present it is 87% dependent on fossils fuels, 6% dependent on nuclear, 6% on hydro, and 1% on other alternative energy supplies such as solar and wind.

He noted the positive example of Iceland in pioneering the use of hydrogen fuels for its transportation fleet. He also cited the progressive example of the Maldives, an island country which has dedicated itself to the development of a carbon neutral economy and which is expending $130M a year toward this objective. The development of carbon neutral cities is an objective and a metric Dr. Kalam identified as a means of transforming the national economies of countries now dependent on fossil fuels.

Promising Technologies

He called for the replacement of fossil fuels with bio fuels which can be grown on "waste land" not suitable for agricultural production. This bio fuel production would not therefore compete with land used the production of food or increase food prices through land use competition.

Another initiative he called for is more research to enable the production of fossil fuels from algae and indicated that India's climate was well suite for this type of alternative fuel production.

A thrust toward the develop "hydrogen fuels" is also important to this goal. He noted progress toward hydrogen storage in metal hydrides, and high pressure hydrogen storage in nanotube structures. There is also work on hydrogen generated from ammonia.

An Indo-Canadian Partnership

Dr. Kalam also promoted the idea of an Indo-Canadian Clean Energy partnership in a number of areas including:

1 Energy Technology Development

2 Research and Development on sustainable energy production.

3 Focus on quality of energy and impacts on energy use and technology on the quality of the environment

4 Energy and Environmental legislative initiatives in British Columbia and Ontario are setting the stage for Green Energy Policy.

5 Focus on a Canadian India Nuclear Reactor Development coming out of the Candu Thorium program. Indian is a big market for clean nuclear energy technology and Canadian development efforts to advance clean nuclear power generation offer a large opportunity.

6 India is looking for partnerships in developing 500 mega watt solar power stations to meet its energy requirements.

Moon Society & Moon Society India Give University of Luna Award to Dr. Kalam

By Peter Kokh, David Dunlop, Pradeep Mohandas

On September 30th, the Moon Society presented its University of Luna Award to Dr. A.P.J. Abdul Kalam for his vision and advocacy of space solar power to meet global requirements for clean energy, economic develop-ment, and environmental restoration. David A. Dunlop, Moon Society Director of Project Development and our unofficial roving Ambassador, made the presentation at the prestigious McDonald Club in Toronto, Ontario after a two-day drive from his home in Green Bay, Wisconsin, stopping at the Milwaukee home of Society President Peter Kokh to pick up the award.

When we received word that Dr. Kalam would be in Canada, a quick search showed that we had one certi-ficate frame ready to go. If it had been a special order taking a week plus, this opportunity would have been lost.

Dr Raghavan Gopolaswami a distinguished scholar on India's energy economy was able to arrange the schedule for the presentation of the award in Toronto and Dunlop had the pleasure to present the award to him after he spoke on the topic of Green Technologies Initiatives at the Albany Club, a historic club founded by Canada's first Prime Minister. His presentation there to a select group of Ontario's business and political leaders was sponsored by Camden Salon's Azmi Haq and Dr. Steven Andrews of Borden Ladner Gervais.

Dave, already tall, was standing on the steps, making Dr. Kalam appear shorter than he actually is.

The Award Reads "to Dr. A.P.J. Kalam,

for his vision and promotion of
space solar power as a solution
to global requirements for clean
energy economic development,
and environmental restoration.

The award was also proudly given on behalf of Moon Society India.

Moon Miners' Manifesto #205 May 2007 featured a three-page article about Dr. Kalam's vision. More recently, MMM # 237, August 2010, featured a two-page article about Dr. Kalam's Space Solar Power Challenge to the NSS and to the World, an address delivered via telecom at the 2010 ISDC in Chicago this past May.

Unframed certificate prior to signing by Dave Dunlop
Artwork, Space "University" by Pat Rawlings, personally signed by the artist

But Dr. Kalam's credits go further. As President of India, he suggested to the Indian space agency, ISRO, that they carry a Moon Impact Probe with the idea of permanently placing the Indian flag on the Moon.

ISRO complied with the request and made the sides of the MIP (The Moon Impact Probe released by the Chandrayaan-1 Orbiter) of a special material which was meant to withstand the crash landing and it's sides was to fall apart rather than break. The scientists also considered putting scientific instruments in MIP which led to the first detection of water vapor and carbon dioxide along with heavier elements (e.g.. Iron) in the lunar exosphere (this was before the Moon Mineralogy Mapper was switched on, and hence was much before M3 (NASA's Moon Mineralogy Mapper aboard Chandrayaan-1) found water on the Moon's surface).

President Kalam has also suggested carrying a penetrator with Chandrayaan-II, so that we can touch the lunar water ice.

Dr. Kalam is an ISRO (Indian Space Research Organization) "rocket scientist" who rose to prominence and was President of India 25 July 2002 to 24 July 2007.

Links: http://en.wikipedia.org/wiki/A._P._J._Abdul_Kalam

Dr. APJ Abdul Kalam - A Site for Inspiration and Nation Building - http://www.abdulkalam.com/

Indians Play Prominent Role in Upcoming Head of Space Agencies Summit of International Academy of Astronautics

http://iaaweb.org/content/view/388/544/

On the occasion of its 50th anniversary of the founding of tne International Academy of Astronautics (IAA) by famous space pioneers, including Von Karman, Oberth, Von Braun, Halley, Van Allen, Keldish, Sänger, Draper, Mueller, Gagarin, Armstrong, Aldrin, Sedov, Broglio, Curien, the Academy is convening a “Heads of Space Agencies Summit for Humanity” to be held on Novemenber 17, 2010 in Washington, DC USA. Four Indian Scientists will play key roles.

The Chair of this prestigious event will be current IAA President **Dr. Madhavan Nair**, the former Chairman of Indian Space Research Organisation (ISRO) and Secretary to the Department of Space, Government of India since September 2003. He is also the Chairman of the Space Commission, and acts as the Chairman of Governing Body of the Antrix Corporation, Bangalore.

http://en.wikipedia.org/wiki/G._Madhavan_Nair

Dr. Shri Koteswara Rao, of the Astronautical Society of India is one of the eleven members of the Summit Steering Committee.

The summit will have four working groups, and an Indian is chair of two of these.

Ranganath Navalgund will chair the Disaster Management / Natural Hazards Working Group.

Jitendra Goswami will br onr ogf two co-chairs of the Planetary / Lunar Exploration Working Group.

The other two working groups are:

- Climate Change / Green Systems Working Group
- Human Spaceflight Working Group

Elsewhere in Asia

China launches Chang’e 2 to the Moon and Beyond – Other Plans

October 4, 2010 - Chang’e 2 is launched

http://www.spacedaily.com/reports/Change_2_Heads_For_Moon_999.html

“It is China's first unmanned spacecraft to be boosted from the launch site directly to the earth-moon transfer orbit, greatly reducing the journey time from that of its predecessor Chang'e-1.

“Chang'e-1 took about 13 days to travel to a lunar orbit after orbiting the earth in a geosynchronous orbit and then transferring to the earth-moon transfer orbit.

“Chang'e-2 is expected to travel for about 112 hours, or almost five days, to arrive in a lunar orbit.

“To acquire more detailed moon data, Chang'e-2 will enter a lower lunar orbit about 100 km above the surface, compared with the 200-km altitude of Chang'e-1, according to the control center.

“The satellite will eventually be maneuvered into an orbit just 15 kilometer above the moon. At that point, Chang'e-2 will take pictures of moon's Bay of Rainbows area, the proposed landing ground for Chang'e-3, with a resolution of 1.5 meters. The resolution on Chang'e-1's camera was 120 meters, said Wu Weiren, chief designer of China's lunar orbiter project.” - Source above. ###

China sees its exploration of the Moon as part of its responsibility to Mankind

http://www.spacedaily.com/reports/Lunar_Probe_And_Space_Exploration_Is_Chinas_Duty_To_Mankind_999.html

“The most fundamental task for human beings' space exploration is to research on human origins and find a way for mankind to live and develop sustainably,” said Qian Weiping, chief designer of the Chang'e-2 mission's tracking and control system. ###

China Eyes Extending Chang’e-2 Mission Beyond the Moon to the Earth-Moon Lagrange Points

http://www.spacedaily.com/reports/China_Eyes_Extended_Mission_Beyond_Moon_999.html

“The upgrade to the more powerful Long March 3C rocket does produce its advantages. It leaves Chang'e 2 well stocked with fuel. One option for an extended mission for Chang'e 2 could be to explore the Lagrange points in the Earth-Moon system.

Most space and sci-fi fans know the Lagrange points. They are a series of imaginary points in space where the gravitational fields of two large bodies are produce stable regions for spacecraft. There are five points, named L1 to L5, for any two-body system such as the Earth and Moon. Right now, two NASA spacecraft are exploring the L1 and L2 points of the Earth-Moon system. ###

China expands lunar lander plans

http://www.spacedaily.com/reports/Four_Chinese_Lunar_Landers_Mooted_999.html

"A small fact table published in the Global Times, a state-run newspaper aimed at an international audience. The table spoke of Chang'e 3 and 4 as being part of the second stage, or "landing" missions and Chang'e 5 and 6 as the third stage, or "returning". Despite this, the article that accompanied the table did not explicitly state that four landers were being planned. The evidence was intriguing, but tentative."

"China will probably elect to wait at least a year before launching the second lander. This will allow time to evaluate the scientific data from the first mission, and make plans to build on it."

"We expect that the first lander will fly around the year 2012. Chinese media statements have been cautious about the timetable in recent years, suggesting a launch in 2013. However, the case for a 2012 launch seems to be getting stronger. Phrases such as "before 2013" or "around 2012" are appearing. It would seem that the development of the landing platform and its rover are fairly on-track."

China scouts landing sites

http://www.space-travel.com/reports/China_Scouts_Moon_Landing_Sites_999.html

"One task [for Cang'e 2] is highly practical. China is using the spacecraft to scout landing sites for future Chinese Moon missions."

"The resolution of the Change'e 1's camera was around 120 metres, which means that hazardous objects such as boulders won't show up. Chang'e 2 carries a more powerful camera which, according to one recent Chinese statement, boasts a resolution of ten metres. Other statements have spoken of resolutions of seven metres, or 1.5 metres, or even one metre. That's a lot of variation. It's partially a result of the fact that the resolution of the camera will vary with distance."

"China has recently revealed that Chang'e 3 is targeted for the Bay of Rainbows [Sinus Iridium, **below**], a lava plain on the Moon. It's easy to see why. This area is remarkably flat and featureless in low-resolution images. It's also large, allowing plenty of room for rough navigation in the descent. A close look should confirm its suitability.'

Japan, three Triumphs, one Disappointment?

The Akatsuki Venus Climate Orbiter (original code name "Planet-C") was launched on May 22, 2010 and is en route to Venus, all systems go. On arriving at Venus, the craft will go into a highly elliptical retrograde orbit so that it co-rotates with the planet's winds. The nominal high point is 79,000 km (13 Venus radii) and low point 300 km. The craft should arrive at Venus this December for a 2-year mission.

Akatsuki is Japanese for "Dawn"

Mission overview: www.stp.isas.jaxa.jp/venus/E_plan.html

"Akatsuki is the first **'meteorological satellite'** of a planet other than the Earth," said Seiichi Sakamoto, director for space science outreach at JAXA's Institute of Space**The** and Astronautical Science. "Detailed study of Venus will provide us with breakthroughs in atmospheric science."

http://www.space.com/missionlaunches/japan-venus-wrap-100520.html

The Ikaros Solar Sail hitchhiked a ride to space with the Akatsuki Venus Climate Orbiter, but its ultimate destination may lie far, far beyond – the legendary **Alpha Centauri**, the closest star of note to our Sun. Its eventual cruise speed could be between 10-20% of the speed of light. But that is generations off.

http://www.icarusinterstellar.org/blog/solar-sails-icarus-mission/

Hayabusa Sample Return Mission to and from asteroid Itokawa. Despite a number of technical failures, Japan succeeded in coaxing the crippled craft homewards after its encounter with the asteroid. The sample return capsule made it safely through Earth's atmosphere, landing intact.

According to The Japan Times, JAXA said it is taking more time than originally expected to collect the particles because they are smaller than it was assumed they'd be. This provides some hope, however, that there is actually something of interest in the container.

Originally, JAXA had hoped to publish a report by September, but now it's looking like ***December or later.***

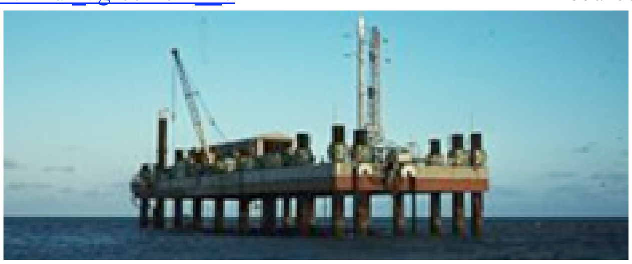
It is feared that the craft was not aimed correctly at the asteroid when the pellet was released to create a cloud of dust some of which should be recovered. *Stay tuned!* ###

Commonwealth News Stories

Italy and Kenya extend the Malindi Agreement

Ocean Platform, inactive since 1988 may see launches aiding environmental and climate change studies.

http://www.asi.it/en/news_en/italy_and_kenya_extend_the_malindi_agreement__0 source

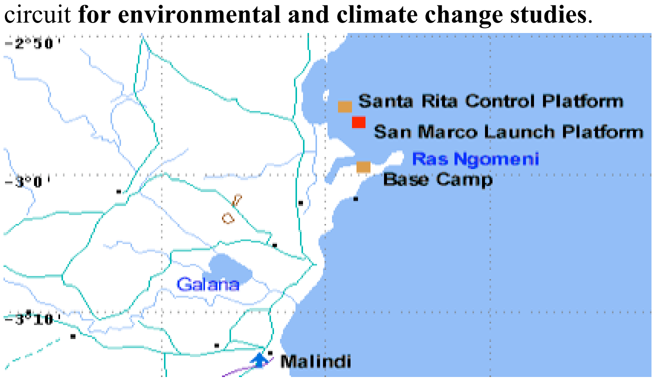


The **Luigi Broglio Space Centre** (BSC) is an Italian-owned spaceport near Malindi, Kenya, named after its founder and Italian space pioneer Luigi Broglio. Developed in the 1960s through a partnership between the University of Rome La Sapienza's Aerospace Research Centre and NASA, the BSC served as a spaceport for the launch of both Italian and international satellites. The centre comprises a main offshore launch site, known as the **San Marco platform**, as well as two secondary control platforms and a communications ground station on the mainland.

The first satellite specifically for X-ray astronomy, Uhuru, was launched from San Marco on a Scout B rocket on 12 December 1970. In use from March 1964 to March 1988, with a total of 27 launches, the platform has been inactive since, and fell into disrepair in the 1990s. Recently, the Italian Space Agency had conducted a feasibility study to reactivate it for the Russian launcher START-1.

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

On January 10, 2010 Italy and Kenys signed an agreement that would permit launch activity to begin anew, so that the Malindi base might take part in the international circuit **for environmental and climate change studies**.



Nigeria Keen to Partner with India in Space Programmes

http://www.brahmand.com/news/Nigeria-keen-to-partner-with-India-in-space-programmes/4760/3/13.html

"Nigeria is willing to partner with India i**n the development of critical space technologies**" – Nigerian Science and Technology Minister Mohammad Abubakar at the Bengaluru Space Expo-2010

Up until now, Nigeria has contracted with foreign firms to build its satellites, and with foreign space agencies to launch them. This most populous of all African Nations, and 4th most populous in the Commonwealth after India, Pakistan and Bangladesh, convinced of the benefits to its "scientific, social and economic development" of selected space missions, wants to get more involved.

Nigeria's space program is the business of the **National Space Research and Development Agency** (NASRDA)', under the Federal Ministry of Science and Technology. The mission of NASRDA is to vigorously pursue **the attainment of space capabilities** and the enhancement of the quality of life of its people. This NASRDA will do "through research, rigorous education, engineering development, design and manufacture of appropriate hardware and software in space technology, including transport and payloads, such as satellite, telescopes and antennas for scientific research and applications."

www.globalsecurity.org/space/world/nigeria/index.html

Prevously, Nigeria's space partners have been the United Kingdom, China, and Russia. China has both built and launched satellites for Nigeria. A British firm had built Nigeria's first satellite. At the Bengaluru Space Expo, Abubakar said that Nigeria would someday launch its own satellites, It was not clear if the country would also attempt to build its own satellites.

But for the meantime, Nigeria is impressed by India's ability to launch multiple satellites with the same launch vehicle. India's launching capacities are increasingly commanding world-wide attention, and Commonwealth nations are logical customers.

[Read Dave Dunlop's article "**A Strategic Role for India in the Commonwealth**" in M3IQ #5 pages 10-13 – you can download this and all other issues of M3IQ from this page: http://www.moonsociety.org/india/mmm-india/]

Satellites launched to date include: NigeriaSat 1 (2003), a communication satellite to be called NigcomSat-1 (2007 launched by China.) Scheduled for launch by Russia October 2010 are a high-res African Resources Management Constellation satellite, NigeriaSat-2 and NigerSat-X.

Nigeria Space Centre, Abuja (Nigerian Capital)

<u>Malaysia</u>'s Astronaut Program Gets a Tentative Renewal

http://www.themalaysianinsider.com/malaysia/article/astronaut-programme-dependent-on-funding/

The government was focusing on 12 projects under the National Key Economic Areas (NKEAs) and no specific provision was provided for the astronaut programme under the 10MP. Continuation of the 2nd Astronaut Program depends upon the allocation of funds.

This is a perennial problem for Space Programs and Space Agencies of all countries, as the pie that needs to be sliced is only so large, and there are everywhere strong political and public pressures to favor programs that affect the public more immediately.

Above Left: Datuk Dr Sheikh Muszaphar Shukor Sheikh Mustapha was the first Malaysian astronaut to make the trip into space, to the International Space Station, via Soyuz TMA-11. He was a member of Expedition 16, which launched October 12, 2007 and returned to Earth April 18, 2008. **Above Right:** Malaysia's 2nd astronaut, **Major Dr Faiz Khaleed** also received 12 months training at the Yuri Gagarin Astronaut Training Centre, Star City, Moscow, Russia.

Some 884 applicants answered the call in 2003. Of these 98% were under 40, 77 % had a bachelor's degree, and 62% worked in the private sector.
www.space.com/news/ap_050823_malaysia_astronaut.html

Trivia tidbit: The Malay term for "astronaut" is "**angkasawan**"

The Malay word for the Malaysian National Space Agency:

ANGKASA
MALAYSIA

Malaysia uses both satellites purchased abroad and developed in country by Astronautic Technology Sdn Bhd.
en.wikipedia.org/wiki/Astronautic_Technology_Sdn_Bhd
All of Malaysia's satellites are launched abroad. ###

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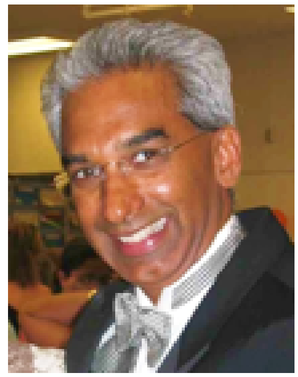
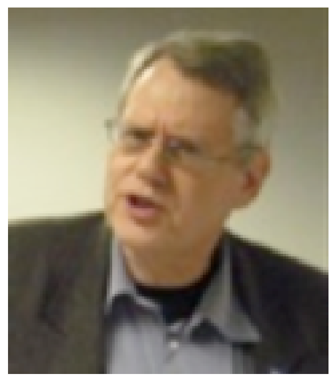


Madhu Thangavelu
thangavelu-girardey@cox.net
Mother from Kerala, father from Tamil Nadu, grew up in New Delhi. Now teaching at U. Southern California. Conductor, Graduate Space Exploration Concept Synthesis Studio USC Schools of Engineering & Architecture



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Moon Society Director of Project Development

Exec. Director of LUNAX (LUnar National Agricultural eXperiment)

University of Luna Project

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http://parallelspirals.blogspot.com/ - blog
moving to Coimbatore
Formerly President of SEDS India

Moon Rover Workshop by SEDS VIT

Report by: Komal Agrawal

A Moon Rover workshop was organized by SEDS VIT (Students for Exploration and Development of Space) as a part of its annual space fest-Antariksh'10 on 15th of August for VIT students. The main aim of the workshop was to give the students a general overview of what actually a moon rover is, its parts and construction and also the making of a manual robot.

The session was conducted by Mr. Varun Reddy and was coordinated by Rishabh, Atima, Arshi and Ankur. The workshop started with a general introduction about robotics. Simple questions regarding robotics, motors, transducers, DPDT switches and other basic concepts were asked to the students in which everyone actively participated. It aroused their interest and made the session quite interactive.

An animated video of a moon rover was screened for the participants. It showed how a moon rover lands on the surface, how it gains energy, studies the surface, collects samples and sends signals back to the earth. Knowledge about the payloads was also imparted. As different features of the moon rover were revealed in the video, it was paused, and explained simultaneously. After that detailed information of every subsystem was given which included the following subsystems: altitude determination and control (variously called ADAC, ADC or ACS), guidance, navigation and control (GNC or GN&C), communications (COMs), command and data handling (CDH or C&DH), power (EPS), thermal control (TCS), propulsion, and structures.

Following the video, construction of a manual robot was taught. Connections in a DPDT switch were explained through a power point presentation and also manually. The reasons and concepts behind the connections (diagonally opposite terminals of the switch being short circuited; the motors being connected in parallel and the need of connecting an eliminator) were explained.

The workshop was concluded by demonstrating the movements of a manual robot (made the previous day) when different switches are pressed.

No. of Participants: 118

Time-Slot of Workshop: 10AM to 12:30PM

Report on the NSS Pune/India Chapter

By Leena Sirish Bokil

[NSS = The National Space Society – www.nss.org]

We inaugurated NSS - Pune India Chapter on the 10th March 2009 at the hands of ISRO's official spokesperson - Dr S Satish, in the auspicious presence of Honorable Mayor of Pune : Mrs Rajalaxmi Bhosale.

On this occasion, Dr S Satish spoke on the topic - "**Indian Space Program - A Journey from the Church @ Thumba to Chandrayaan**". This was an illustrious presentation, portraying India's space odyssey. The event was well attended and this program had luminaries from all fields.

Shri Suresh Naik - Former Group Director of ISRO (Ahmedabad) and Founder President of the Chapter, also briefed the audience with '**Success Story of Chandrayaan**'. Sandeep Joshi, Vice President briefed about the Chapter's forthcoming activities. Secretary - Leena Bokil, Honeywell Educator, presented and hosted this particular event.

In March 2009, Space Strategist - Peter Garretson from NSS Washington DC, was on a visit to India. He gave a talk and presentation about "**Space Solar Power Satellites**" at NCRA, TIFR and MIT, Pune. Both these events were organized by NSS Pune (India).

The Offices of NSS Pune (India) Chapter were invited to attend International Space Development Conference, ISDC - 2009 at Orlando, FL. Shri Suresh Naik pgave a talk about: "Chandrayaan - I and India's Future Space Missions". This session was well attended and applauded.

NSS Pune (India) Chapter was given "The Most Promising New Chapter" award and NSS Pune (India) Chapter got upgraded to NSS - India Chapter at the same event. The relentless efforts of Shri Suresh Naik, Sandeep Joshi and Leena Bokil were appreciated at the Conference.

On 31st July 2009, an event to mark the historical "**40 years of human landing on Moon**" was held and the Speaker for this mega event was: Dr B N Suresh, Director of IIST, Trivandrum. He also interacted with aspiring space engineers/scientists/technologists and guided them about career in 'space'.

Forthcoming Activities of the NSS India Pune chapter

1. One event in the pipeline is to 'Inaugurate' and launch the National Space Society - INDIA Chapter's website.
2. Since we conduct numerous educational activities, one major activity that we've planned is an event to mark the 50th yr of Yuri Gagarin's first space voyage : 'Fifty Years of Human Spaceflight'.

Leena Sirish Bokil is the Founder Secretary of the National Space Society, India Pune chapter, a science communicator, a Honeywell Educator and Honeywell Educator.

StudSat - India’s 1st Pico-satellite

By Mamta Bharti

“Our heads are held high,
Not gazing at the sky,
But beyond it! “

-Team Studsat-1

On July 12, PSLV-C15 successfully launched CARTOSAT-2B, ALSAT-2A, NLS 6.1 & 6.2 and STUDSAT in 2010 at 9.22 am. PSLV (Polar Satellite Launch Vehicle) is the workhorse launch vehicle of ISRO(The Indian Space Research Organisation). ISRO launched the Polar Satellite Launch Vehicle PSLV-C-15 from Satish Dhawan space centre near Sriharikota spaceport that carried remote sensing Cartosat-2B along with four satellites.

One of the special features of the launch was Studsat (Student Satellite). Studsat is the first Pico-Satellite being launched by India, and more so special, as it is a project undertaken by Undergraduate students from seven different Academic Institutions, from different regions of India.

During the International Astronautical Congress, 2007, D.V.A. Raghava Murthy, Project Director, Small Satellites Projects, ISRO Satellite Centre, Bangalore, was telling a group of college students what a fascinating subject space was and why students should develop an interest in it. His speech was so inspiring that at the end of the meeting a group of students asked him *why ISRO should not help them build a satellite.* The team then approached ISRO along with the Academic institutions for a Preliminary Review of the Student Satellite project.

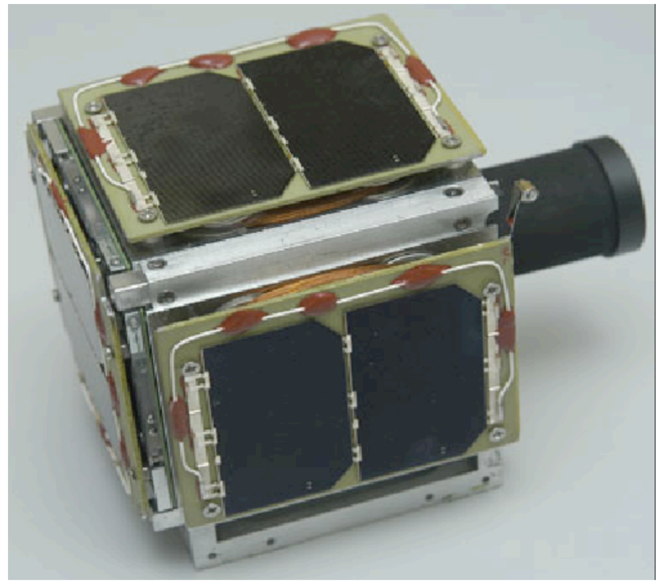
After detailed review of the project, and elaborate presentations from the team, ISRO approved their project. Subsequently, the team grew, and finally comprised of 35 students from ten different academic institutions. Of the ten participant colleges, seven formed a consortium in order to sponsor the project.

An internal MoU was signed between the colleges, selecting Nitte Meenakshi Institute of Technology, Bengluru, one of the participant institutions as their representative, to sign the official MoU with ISRO on their behalf

It took students about a year and a half to design, build and test the Studsat. On the 17th of April 2010 the country’s smallest satellite was handed over to Indian Space Research Organization at a function organized in Nitte Meenakshi Institute of Technology (NMIT).

The satellite is close to being a cube, of miniature size, when compared with the common satellites, with dimensions of 10 cm x 10 cm x 13.5 cm; it weighs just above 850 gm and has a volume of 1.1 litre, and hence falls into the category of "Pico Satellites". The satellite was launched in a 700 km solar-synchronous orbit.

The functional objective of the satellite is to perform remote sensing, and capture images of the surface of the earth using it's camera of resolution 90 m; The best resolution hitherto achieved by any Pico Satellite in the world.



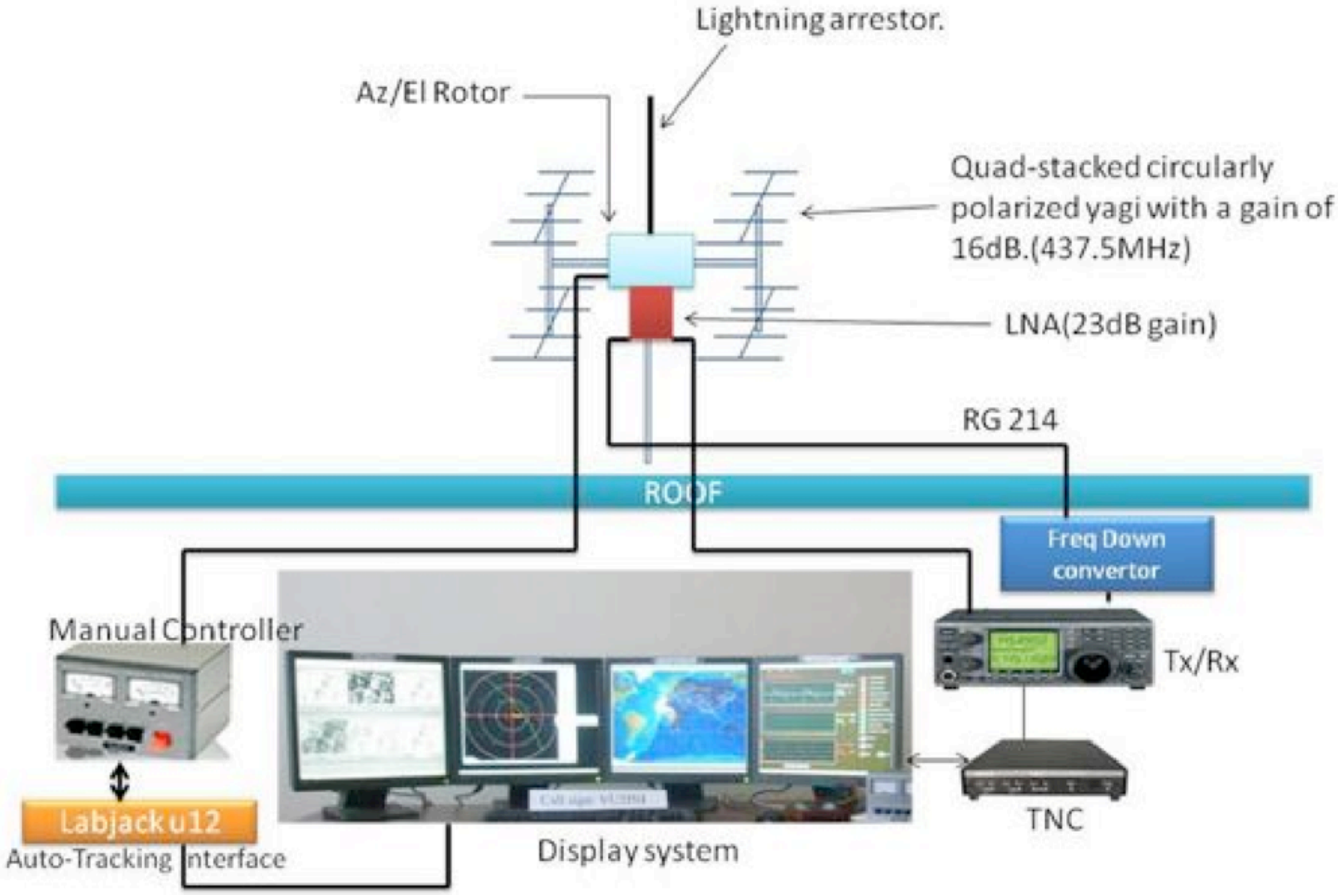
The various subsystems of the satellite are:

* Communication sub-system.
* Power generation and distribution sub-system.
* Attitude Determination and Control sub-system.
* On-board computer.
* Payload(Camera).
* Mechanical Structure.

All of the satellite subsystems have been indigenously designed by the students. Apart from these constituent subsystems of the satellite, a fully operational amateur frequency Ground Station has been designed in order to communicate with the satellite. The Ground Station – NASTRAC (Nitte Amateur Satellite Tracking Centre) has been established in Nitte Meenakshi Institute of Technology, Bengaluru.

The first signal from StudSat was received at 11.02 a.m., about 70 minutes after the launch, at the ground station the students have set up in the NMIT campus. Since then, they are getting the beacon signal all the time that indicates that the satellite's health parameters are normal.

The ground station NASTRAC (Nitte Amateur Satellite Tracking Centre), the students’ team is able to receive telemetry data sent by other satellites also .It was also heard by HAMs all over Bangalore. On 15 July 2010 NASTRAC received the Telemetry Data with packets separated and confirmed the satellite is in mission mode. The satellite has thus completed the beacon mode of communication and has entered the mission mode, where in it will transmit encrypted data at 437.505 MHz. The ground station is also capable of communicating with more than 250 amateur satellites across the globe. Further NASTRAC may also track and communicate with International Space Station (ISS), according to the students involved in the project.



The diagram shows the architecture of the ground system. The gain of the antenna, gain and NF of the LNA, the affordable losses in cable and the EIRP were all calculated based on the link budget analysis. The received data undergoes various processes such as amplification, down conversion and demodulation before bifurcating into image data and telemetry tracking data.

The image data is further processed based on the end user application and the telemetry data is used to study the health of the satellite. The up-command to be transmitted to the satellite is modulated, amplified and finally directed towards antenna systems for transmission. The down link operating frequency is 437.5MHz. The link is initiated by the ground station.

After the satellite receives the Link Establishment Frame (LEF), the satellite starts dumping telemetry data. The communication protocol used is AX.25 (using UI frame). The satellite then waits for a command from the ground station and on receiving the command it will start transmitting the image. The up-link operating frequency is 437.5 MHz. It is a simplex mode of communication between the satellite and ground station. The satellite uplinks the LEF, Keplerian elements(for on-board orbit prediction algorithm) and up-commands.

The Payoff

This initiative by the undergraduate students will surely benefit India and future generations in firing their minds towards the excitements of space and technology in ways listed below:

- This project would play a great role in encouraging and facilitating greater research and development among the student community. This is evident from the fact that ISRO received 25 proposals requesting it to guide, support and launch the satellites made by the students. Some of them have already begun working on the proposals as reported by ISRO. ISRO is not willing to up any newer launches anytime soon as it has to launch the four more student satellites which are already in the making. They are expected to be completed by the end of 2011.The four satellites are being made by students of Indian Institutes of Technology Kanpur and Bombay (one each) and Tamil Nadu-based Satyabhama University and SRM University (two jointly). The IIT-K satellite, called Jugnu, weighs three kg and carries a camera to study the near infrared region while IIT-B students have named their 3.5 kg product Pratham to measure the total electron content in the ionosphere. The Satyabhama and SRM students are building two satellites weighing up to seven kilograms each to measure the carbon dioxide content in the atmosphere of the lower earth orbit.

- Building a satellite is getting real hands on knowledge about space technology. It is an inter-disciplinary study of physics, mechanics, control engineering, communications, computer science. The project has helped students with various backgrounds to students to apply their theoretical knowledge they learned in classrooms.

- The pico-satellite is an advantage due to it's lower cost of production, 55 lakhs as opposed to other bigger satellites, quicker turn-around-period and easy launch. The launch of the satellite was free for the students further supporting the cause taken up by the students. A team from ISRO has been identified to help students in building satellites and reviewing their work. ISRO provides guidance, consultancy, support, and training to the students. Small satellites are perfect platforms for students willing to train in this technology and also helps for multiple satellite launches through a single vehicle
- Small satellites had the potential to transform the space business as they are not complex in nature, more reliable and also ideal for production.
- Apart from giving exposure to students in rocket science, the project has also helped ISRO to develop a better understanding about the operations of pico-satellites. It has been envisaged by many scientists that the future of satellite technology lies in small satellites. With regard to pico-satellites, it is expected that in future such satellites would work not in 'solo' mode but operate jointly as a cluster of few satellites. This is called as 'swarm' - a group of satellites working together. They would interact with each other and perform various tasks collectively. Such swarms have utility in many fields including defense.
- Projects of this magnitude helped to increase the student-industry link by allowing students to directly participate in an industrial venture right from the beginning till the end since the project seeks technical and material aid from the industry. The team requested the companies related to space technologies to provide them help in procuring equipment and on-board electronics. This further helped the students to enhance their presentation and marketing skill while interacting with the industrial and corporate world.
- The initiative helped to understand the various limitations and constraints in real engineering processes and students learned to provide them with suitable solutions. The pico-satellite tested the limits of their knowledge and skill. Since it was so small, it has no thrusters to orient the camera. To turn the camera to face the earth, team had to perform algorithms that could take days .The optics were bought from the market but integration had to be meticulous since a minute difference could result in blurred images. The first images had a resolution of 93 meters per pixel, the challenge was to maintain an accuracy of 0.01 mm

Left: Anusat-1
The legacy of student satellites started with the 40-kg Anusat readied by the students of Anna University in Chennai, was the first student satellite and was launched in April 2009. It carried an amateur radio store and advanced communications system.

Since then the student community of India has opened its horizons for further improvements in cost and weight of the satellites produced. Pico satellite or small satellites is the call of the day. Small satellites can help India in several ways :

A student with a completed Studsat

Smaller satellites could also play an important role in space biology and study of weather and climate. Its utility was evident in telemedicine, example of Healthnet in Africa. Snall, low cost satellites with data acquisition capabilities could help in taking preventive measures against seasonal disease like malaria. This along with helping in curbing the menace of such diseases will also help in saving the amount of money the government is spending in treatment of patients who suffer from them.

- With the advancement of technology from bigger satellites to small affordable ones has paved the way for each country to have it's own satellite that could effectively be used to serve the purpose of benefiting the country within its budget.
- Its potential could be also be utilized optimally during disaster management and rehabilitation as well. In earth observation, small satellites could be used to increase the revisit capabilities and ensuring mapping of the same area with more details.
- It could also play an effective role in military surveillance by ensuring secured communication and quick launches.

With many nations finding it difficult to invest and get involved in space explorations, ISRO's novel venture of fully supporting student satellite projects shows it's inclination towards investing in long term space dreams of India. India's future in space is undoubtedly bright, with the young brigade getting involved. **Mamta Bharti**

The author writes: I am currently pursuing my Bachelor of Technology degree at Netaji Subhas Institute of Technology in New Delhi. I am a team member of Bullethawk Racing team of NSIT which is responsible for making the first FSAE car of our college. We take immense pleasure in passing that tradition to our juniors now. I have participated in a lot of dramatics plays and have a keen interest in travelling and exploring new places.

A Lunar Space Elevator Demonstrator

By: Pradeep Mohandas

Note: This article is a first mission draft. I would like to make it as real as possible. Criticism and feedback with suggestions are welcome

ISRO does not have any publicly stated Chandrayaan III mission on the cards. But, rather than seeing it as a negative, we see it as a positive. This enables us to create room for thinking on what ISRO should do next. Maybe a sample return mission, perhaps a second bigger lunar rover, perhaps an orbital rendezvous mission etc. Our imagination would throw ideas like lunar elevators or building lunar research stations like the one we see on Antarctica.

At Moon Society, India, we were impressed by some of the research that has gone into the field of space elevators. What tingled our lunar buds more was a claim that currently available material could be sufficient to build a lunar space elevator - this is mostly because of reduced gravity and lack of atmosphere posing lesser constraints on a lunar space elevator. In the world of engineering, all claims must be demonstrable.

Step By Step

Let's say that we push to demonstrate this claim using the orbiter and lander/rover system of Chandrayaan-II. To make this test possible, we say that ISRO agrees to sign an agreement with Space Ribbons LLC, a mythical company which produces the ribbon tether for the elevator and Moonstalk LLC, another mythical entity which builds the elevator system.

ISRO develops another lunar craft, Chandrayaan-IIA. The spacecraft carries the tether, an impactor, an expandable landing system, and a model lunar elevator developed by Moonstalk and Space Tether. The system is developed by 2014. After several rounds of testing, ISRO launches Chandrayaan-IIA using the PSLV configuration -used for Chandrayaan-I - in 2015.

Chandrayaan-II's rover is now parked near the lander and has been in OFF mode to conserve power in the South Pole Aitkin Basin. The orbiter is now in position at L1 to act as the core of the counterweight. In its lifetime, the rover has studied the lunar regolith extensively to understand its properties and a penetrator on the lander has already drilled and made a regolith profile of the surrounding area. This enables scientists on Earth to design the impactor-penetrator system on Chandrayaan-IIA's impactor (let's call it Moon Impact Probe 2 – MIP2).

Chandrayaan-IIA reaches L1 and docks with Chandrayaan-II's orbiter at the point where the lander/rover system was attached at launch. With precision, Chandrayaan-IIA docks with Chandrayaan-II. This would help ISRO demonstrate rendezvous technology needed for lunar sample return and human missions to the Moon. Chandrayaan-IIA uses its thrusters to become the Moon facing spacecraft. It then deploys MIP2 attached with a camera, a spectrometer and an anchor system to anchor the tether to the lunar soil. This in a way replays the landing of MIP on the Moon.

The camera on the Chandrayaan-II lander will now be turned on to spot and lock the anchor point. Perhaps for the first time, a lander/rover will capture on camera the arrival of another spacecraft on the Moon and ground operators in Byalalu will have the benefit of precisely targeting MIP2 to the desired location.

After the MIP2 impacts and anchors on the lunar surface, the rover will rove to the impact location and study the impact debris and also check that the anchor is well grounded. This will provide a good idea of what lunar accidents look like and estimate the durability of a human rated spacecraft so that it can undertake impact landings in emergency scenarios.

Chandrayaan-IIA will then release an expandable platform towards the lunar surface. This has been attached with various sensors which check for tether damage and strength as it slides down the tether. About 20 metres above the end of the tether, the platform is expanded to full length and screws itself into the lunar surface.

Again the lunar rover checks the screwing and ensures that a tight fix has been achieved. A model lunar elevator now turns on, is checked by the rover after it climbs about 0.5 metres. From Byalalu, scientists give the signal for the elevator to carry a 10 kg mass up the elevator to Chandrayaan-IIA.

As the mass reaches Chandrayaan-IIA, a camera begins to study it to look for wear and tear and also check for stability. When the mass reaches Chandrayaan-IIA, a signal is sent back to Byalalu. As the mission control room erupts with joy, lunar scientists begin working on the design of Chandrayaan-III, a system to develop and deliver to the Moon, a working model of a Lunar Space Elevator.

Possible post-Lunar Elevator establishment scenario for Chandrayaan-II

1. Allowing the lunar rover to ride up the elevator so that it always stays in sun-lit region to recharge itself and stay warm.
2. Allowing sample return missions. Samples can be ferried up the lunar elevator where a modified form the SRE vehicles can be used to collect the sample and return back to Earth. The SRE can be carried by the PSLV and can travel piggyback.
3. It could enable the establishment of radio beacons on the lunar surface, which would enable precision landing of various spacecrafts and materials on the lunar surface.
4. Enabling Human Rescue Missions. Currently, there is no back-up system available that can be in time to reach the Moon and get back vyomanauts stranded on the Moon. The elevator could be used to ferry up vyomanauts up to a modified SRE vehicle and ferry them back to Earth.
5. A lunar elevator with a scientific payload can be used to do in-depth study of the surrounding topography.
6. Launch satellites in follow-up to Aditya-1 into heliocentric orbits

[Some of the points in the post lunar elevator establishment phase have been derived out of talks with David Dunlop. The possibility that this system could in the future be used in various parts of the Indian Space Programme just adds to the do-ability of this mission PM]

GREAT BROWSING

Soyuz complex finished in Kourou
http://www.russianspaceweb.com/kourou_els.html#2010

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http://www.africanews.com/site/Africa_AU_to_establish_African_space_agency/list_messages/33962

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Russian suggests India, China become ISS partners
http://www.brahmand.com/news/India-China-will-be-useful-partners-in-ISS-programme/4723/1/10.html

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Japan Could Put Human(oid) on the Moon by 2015
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Need to understand how humans can live in space
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http://davidszondy.com/future/futurepast.htm

6 private companies could launch humans into space
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Moon's polar craters may be electrically charged
http://www.NASA.gov/multimedia/videogallery/index.html?media_id=14044418

Model helps search for lunar dust fountains
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Designing Rolling Rovers for Mars
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Russia's successor to the venerable Soyuz Capsule
http://www.russianspaceweb.com/ppts.html

Top 10 Fantasy Spaceships Headed for Reality
http://www.space.com/missionlaunches/top10-fantasy-spaceships.html

Unfinished Soviet Buran Shuttle Found rusting
http://english.pravda.ru/history/30-09-2010/115158-russia_space_power-0/

Russian firms unveil space hotel plans
www.reuters.com/article/idUSLNE69002J20101001

Chinese target Moon landers for Bay of Rainbows
http://www.moondaily.com/reports/China_Scouts_Moon_Landing_Sites_999.html

Space Station Partners' International Docking Standard
http://www.internationaldockingstandard.com

Mars Seasonal Atmosphere Changes: Biological Causes?
http://www.popsci.com/science/article/2010-09/mars-methane-changes-seasons-and-scientists-wonder-why

Darwin's Experiment Transforming lifeless places
www.popsci.com/science/article/2010-09/future-mars-colonists-could-learn-terraform-studying-darwins-methods

The 100-Year Starship Concept to spread humanity
http://www.popsci.com/science/article/2010-10/'hundred-year-starship'-could-bring-humans-other-worlds-and-leave-them-there-forever

NASA Thruster Test Aids Future Robotic Lander's Ability To Land Safely
http://www.space-travel.com/reports/NASA_Thruster_Test_Aids_Future_Robotic_Lander_Ability_To_Land_Safely_999.html

NASA Awards Contracts for Innovative Lunar Demonstrations Data
http://www.space-travel.com/reports/NASA_Awards_Contracts_For_Innovative_Lunar_Demonstrations_Data_999.html

Contents of LCROSS impact splash-out at South Pole
http://news.yahoo.com/s/ap/20101021/ap_on_sc/us_sci_shoot_the_moon

NASA to buy private Moon data
http://www.space-travel.com/reports/NASA_to_buy_private_moon_data_999.html

Bigelow Aerospace Testing Crew Life Support Systems
http://www.spaceref.com/news/viewpr.html?pid=31881

Bigelow Aerospace Soars - Private Space Station Deals
http://www.space.com/businesstechnology/private-space-station-first-clients-101019.html

Iran aims to put man in space by 2019: Ahmadinejad
http://uk.reuters.com/article/idUKTRE66M3UU20100723

Malaysian Astronaut Program dependant on funding
http://www.themalaysianinsider.com/malaysia/article/astronaut-programme-dependent-on-funding/

List of Lunar Lava Tube Skylights Discovered to date
http://the-moon.wikispaces.com/Skylights

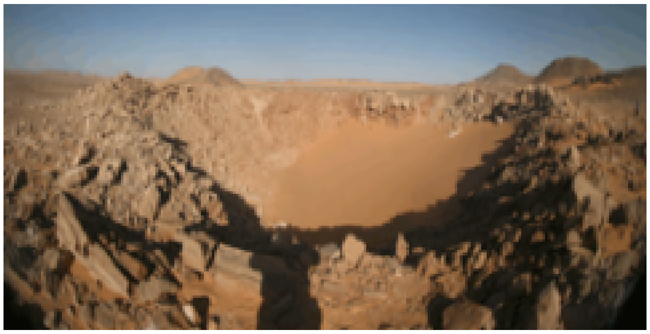
4 Lunar Reconnaissance Orbiter Lavatube Pit articles
http://lroc.sese.asu.edu/news/index.php?/archives/184-Marius-Hills-Pit-Lava-Tube-Skylight.html
http://lroc.sese.asu.edu/news/index.php?/archives/246-Depths-of-Mare-Ingenii.html
http://lroc.sese.asu.edu/news/?archives/253-How-Common-are-Mare-Pit-Craters.html (10 more possible pits)
http://lroc.sese.asu.edu/news/index.php?/archives/281-New-Views-of-Lunar-Pits.html

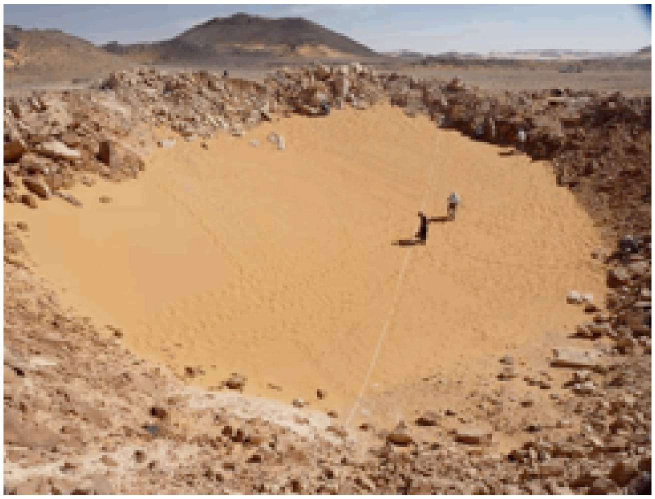
The Moon is full of useful stuff – Let's go use it!
http://www.onorbit.com/node/2594

U-Arizona Engineers Build Lunar Vegetable Garden
http://www.scitech-news.com/2010/09/ua-engineers-build-lunar-vegetable.html

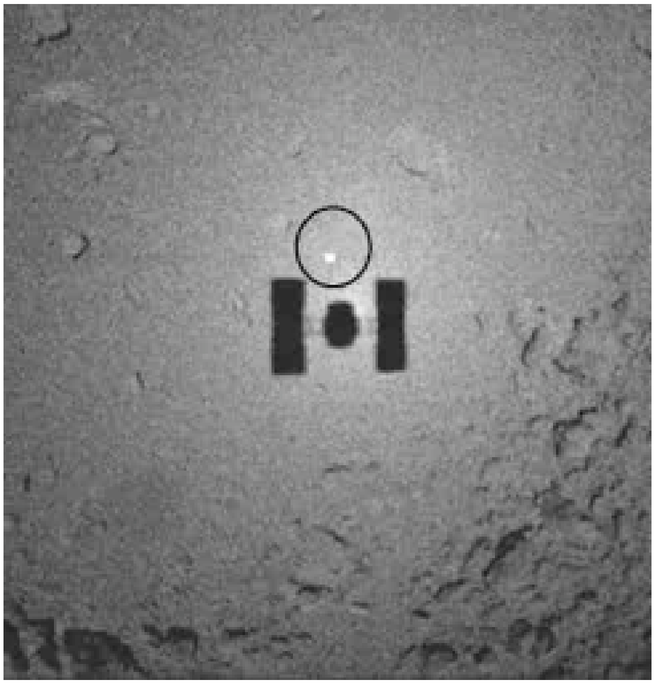
Making Mars Exploration "Relevant" to the Public
http://www.thespacereview.com/article/1705/1

M3IQ PHOTO GALLERY

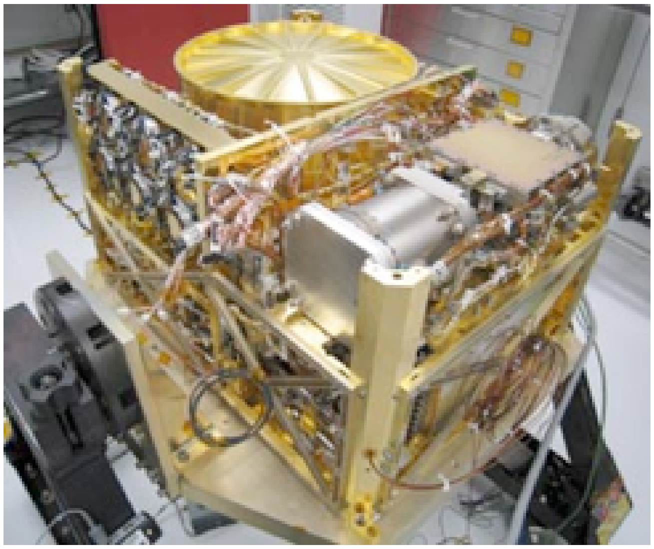




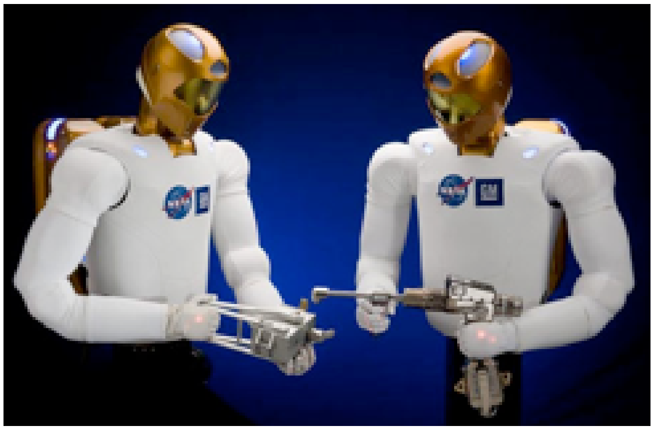
Above: two views of newly discovered and recently formed **Kamil Crater in Egypt**. 45 m wide, this crater was first spotted in Google Earth satellite photo-graphs. Based on the size and characteristics of the crater, researchers think it was caused by the impact of an iron meteorite about 4.3 feet (1.3 meters) in diameter traveling at 7,920 mph (11,732 kph).



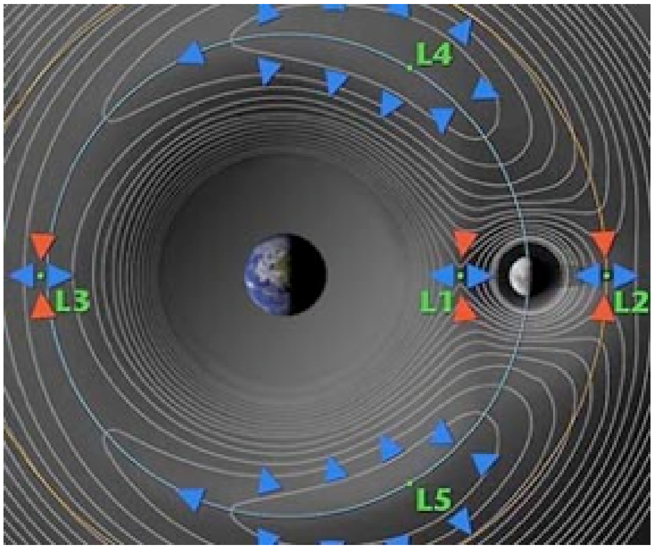
Hayabusa's shadow beside a circled **reflective target** it dropped as a guide for its sample recovery approach. Credit: JAXA – ***Did it hit the target? We don't know yet.***



The Sample Analysis at Mars (SAM) instrument suite to be installed on the Mars Science Laboratory rover "Curiosity"



Above: Robonaut 2 is the first permanent crew member and first highly dexterous anthropomorphic robot on ISS Robonaut 2 is scheduled to ride to ISS on Discovery Nov. 1 'Attached to the remote manipulator aram, 'he" will take over many risky EVA duties from human crew members.



With plenty of fuel onboard Chang'e 2, one option for an extended mission would be to explore the Lagrange points in the Earth-Moon system, before heading out even further

Chile's Atacama Analog Program

Moon Mars Atacama Research Station - MMARS

By Dave Dunlop - October 19, 2010

The Moon Society has few resources available to develop its own program of analog research, but over the last 18 months has been involved in collaborative planning with the two educators who started this proposal and planning process, Maria Catalina of San Diego CA, and Dr. Carmen Jimenez of Antafagosta, Chile. This article about the planning for a Moon Mars analog program in Chile is an overview of a very ambitious comprehensive plan for research. It stresses the practical spinoffs and applications that can come from the future space project.

The aftermath of the great Chilean Earthquake stopped forward progress for quite a number of months, but Dr. Jimenez, who was personally affected by the quake in Concepcion, was later hired by the University of Antofagasta to develop this proposal, which would nicely build on their asset of the Yungay field station, and on a strong collabor-ation with NASA's astrobiology team from AMES Research Center. We look forward to a program development initiative supported by a variety of their government agencies and universities.

The succinct overview of the multi-dimension potential of the proposed program and of the range of university and governmental interests involved in planning discussions shows the variety and ambitions in developing this research. A similar network of universities with interests that are served by analog research might also be a starting point in India in conjunction with the Indian Antarctic Program as an organizing focal point since that currently exists and has robust support. Developing a similar analog initiative in India, building on the existing foundations of ISRO's work on environmental and social and economic development would seem the most logical way of building interest and support for a manned space-flight and exploration program, and which shares opportu-nities and costs and develops long term partnerships with other countries. The educational proposals in Chile are one aspect of the proposal, which make this a highly visible and potentially politically popular effort. A similar strategy adapted to India needs and interests might well be successful in India.

Of Mines and Analog Stations

Chile's Two Tragedies and Two Triumphs

By David Dunlop - October 16, 2010
Director of Project Development - Moon Society

Today the world is celebrating with Chile on the heroic rescue of its trapped miners under the Atacama. But for their tragedy and triumph most of us would not have had the peek we did of the capabilities of the mining industry or realized how technology could reverse what was otherwise a death sentence delivered by a subterranean collapse of their mine. Now another story of tragedy and triumph is unfolding in the Atacama, one stemming from the aftermath of the great Earthquake that struck Chile and devastated the cities of Concepcion and Talcahuano and tsurrounding area.

Before the Earthquake, two educators, one American, Maria Catalina of San Diego California, and one Chilean, Dr. Carmen Jimenez (then at the University of Concepcion now at the University of Antofagasta), had proposed a Moon Mars educational and research initiative in the Atacama region of Chile in time for the 200th Anni-versary of the country and the announcement of the new Chilean Space Agency. They had engaged many both inside and outside of Chile in discussion of this multidimensional initiative. Maria and Carmen's dream reaches from the schools of Chile to the Moon and Mars via the Atacama.

Dr. Jimenez also created a "Science Castle" in a family property in her hometown of Talcahuano, thus enriching educational resources for the students. Then last January Chile was dealt a terrible blow by the Earthquake, which devastated the cities of Concepcion, Talcahuano and the surrounding region. Dr. Jimenez has bravely started again in the aftermath of both personal losses and the destruction of her "science castle." She and Maria are moving forward to turn the tragedy of last January into an even stronger program. Like the mine collapse, in the after-math of the earthquake, it seemed at first as if their goal was impossible. But that perception did not properly account for Chilean determination or the force of imagination applied to the worst of circumstances. Nor did it account for the two educators who believe that MMARS looks to the future exploration and settlement the Moon and of Mars through research, science education, and public outreach.

Maria and Carmen first met in 2007 at the Honeywell Educator Scholars Program at the US Space and Rocket Center in Huntsville, AB where they completed simulated astronaut training. Maria, Carmen and those of us supporting their vision invite those around the world looking at Chile's responses to disaster to join us in thinking about some of the advantages this project will bring to Chile. As the Director for Project Development of Moon Society in the US, I have had the enjoyable responsibility with our President Peter Kokh to have been involved in the evolution of this new project over the last 18 months. The planned activities will address many practical needs as researchers from around the world bring cutting edge technologies to Chile.

In the short term, MMARS will yield improved education, build an even stronger economy, and make advances in environmental protection with entrepreneurial innovations. In the long term, through investments in infra-structure, MMARS will move Chileans to the forefront as world leaders in the studies of astrobiology, contribute to the industrialization of space, and help open the way for humans to take that step toward a space faring civilization.

The Unique Atacama Regional Environment

Chile's unique climate and topography gives it certain advantages over almost anywhere else on Earth from the standpoint of scientists who study space. Its extremely dry air and high mountains make it a great resource for world astronomy. From the mountaintops, however, one can also move to the desert floor and find terrains such as Atacama's Valley of the Moon and locations that mimic Mars. Astrobiologists have found certain areas of the

Atacama to be so dry that even microbes have a tough time surviving conditions in the unique soil conditions that may mirror the Red Planet. (1)

1 Chile's strengths in Astronomy

So in fitting together the pieces of the Moon Mars Atacama Analog facility, the first element we might explore is that this project builds on Chile's strengths in Astronomy where it is already a world leader. Astronomy is a jewel in Chile's crown of science resources. It's connection to the sky and the stars and its exceptional view of the universe is Chile's national heritage and its participation in the advance of human expansion in space is an extension of this consciousness. Astronomy is also part of the scientific agenda for the utilization of the Moon. The special location of the lunar farside as a unique protected area from radio signals generated on Earth and therefore a prime location for radio astronomy.

A lunar analog research station in the Atacama could provide insights on the engineering and deployment of such systems on the Moon. The strengths of Chile in the field of Astronomy also provide opportunities for *an expanded educational program of astronomy education through participation in a variety of observation programs to ensure that Chilean schools reinforce this heritage of leadership*.

2 The foundation for a world class Institute of Astrobiology

A second element of the Atacama research program is to lay the foundation for a world class Institute of Astrobiology, which will bring additional international scientific participation to Chile, as has been the case in Astronomy. Astrobiology looks at issues such as the development life in extreme environments on the early Earth, in the Earth today, and on other locations in our solar systems such as Mars or other Moons such as Jupiter's Moon Europa or Saturn's Moon Titan.

The Atacama region has already been identified as an area with strong resemblance to Mars. It also contains topography, which would be useful as an analog to the Moon. The University of Antofagasta has already collaborated with NASA AMES Research Center in astrobiology field work at the Yingay research station in the north of Atacama, so adding yet another scientific jewel in Chile's crown is a worthwhile goal. A consortium of Chilean Universities held their first Astrobiology Conference in Chile in January 2010. And this research effort can also add a significant educational impact on Chile's schools where advances microbiology, and genomics are creating a revolution in biology and medicine.

3. Planetary Protection

As a global community we now recognize social and environmental concerns and varied aspects of the MMARS program in the Atacama will address the standards for Planetary Protection. The efforts to visit and learn about other environments in space must not unnecessarily disturb or unalterably change the environments we explore. The lack of such consciousness on Earth has lead to extensive environmental damage and we now have the task of creating new technology applications and growing a new economy more in harmony with the environmental constraints on Earth.

New efforts to utilize techniques such as bio-mining of low grade ores and of mine tailings have direct implications for the processing of in situ resources on the Moon or Mars as well as applications for remediating the damage of current mining strategies here on Earth.

So what seems "far-out" when looking at the challenges we will face on the Moon and Mars in the future, are really down to Earth issues we face now. The MMARS projects will be instrumental in addressing problems that challenge us today resulting from a historical lack of understanding our environment and the risks we have taken with detrimental results. Such mining associated problems are world wide therefore in addressing the environmental of consequences mining Chilean research and remediation experience can also make it a global trendsetter.

4. **A focus for international participation**

Chile's Space Agency can utilize the unique environment of the Atacama *to create a program, which can be a focus for international participation and partner-ships in the human exploration of space in anticipation of the human return to the Moon and the advance to Mars*.

A diverse portfolio including commercial participation can create a flexible model of both exploration and economic utilization of space resources. There are diverse challenges in confronting the environments of the Moon and Mars, which will involve some elements that can be developed and proven in the lunar environment and then assets in the advance toward Mars. These efforts will take decades and will involve a web of international collaborations but will enrich the capabilities of Chilean science and engineering in the process.

5. Training of Planetary Scientists

An important aspect of space exploration is the *training of planetary scientists in geological settings, which mirror the geology of exploration targets on the Moon and Mars*. The Atacama provides a wealth of opportunities for such fieldwork and training in planetary geology and this proposed program can provide another resource for other cooperating countries. Chile has extensive connections in the mining industry so this project builds on another area where Chile is an international leader with a strong foundation for further success.

Both the Moon and Mars offer the exploration and utilization of lava tube environments in providing pre-existing sheltered volume from radiation hazards and small meteorite impacts. Yet remote engineering systems that can explore these potential natural assets have yet to be proven. Subsurface environments in the Atacama created by prior mining activities offer engineering development design and testing opportunities that can advance the ability to explore and utilize lava tubes on Earth's neighbors.

The challenge of rescuing Chilean miners has brought the world's attention to Chile's valiant effort to use such engineering resources to save human lives and increase the safety of those working in underground environments.

Mine safety is not only a Chilean issue but a global issue so *developing engineering for the safe use of lava tubes space is also immediately relevant to improving engineering capabilities and safety for the global mining industry.*

7. Test ground for robotic systems

Another important aspect of Moon and Mars exploration is *the use and testing of robotic systems in varied terrains by both telerobotic and human teams.* Engineering development and testing programs can also make use of analog environments for the development of reliable and effective systems. Chilean engineering can therefore benefit from the challenges of learning to live and work on other planets.

Smart design and reliable performance in the face of extreme conditions are benchmarks of advanced engineering. Chilean universities and companies can advance their international reputation through testing and demonstration in the unique and extreme environments found in Chile's Atacama and also in the Antarctic, which is another analog for the extreme environment on Mars. Chile's experience in operating permanent Antarctic Stations gives it additional depth in planning a MMARS program. These bases include:

- **Captain Arturo Prat** on the Antarctic Peninsula, established in1947 by the Navy
- **Bernardo O' Higgins Station** on Greenwich Island, in 1948 by the Army
- **President Eduardo Frei Montalvo Base** on King George Island, in 1969 by the Air Force
- **Professor Julio Escudero Base**, on King George Island established 1994 by the Chilean Antarctic Institute.

8. **Analog Research Lessons for the host area**

The Moon with its exceptional low temperature environments and newly discovered sources of water challenges the current state of exploration engineering. Mars offers a much richer store of water than the Moon yet extracting it from the Martian environment will require engineering innovations suited to the Mars environment. For Chile's Space Agency, the Atacama Desert environment provides a "precursor environment" for learning to live and work in the desert of the Moon and the Martian desert. Chile's experience in operating in the extreme low temperature Antarctic environments is also an asset in building international partnerships in learning to live and work on other planets such as the Moon and Mars but also learning to live and work better within the environmental constraints of extreme Chilean environments.

What must be done on the deserts of the Moon and Mars can inform our understanding of how to better design for constrained water resources in the Chilean desert.

India's former President Dr. A.P.J. Abdul Kalam, a scientist in his own right, has called for the evolution toward "carbon neutral cities" as a measure of the need to move off dependence off fossils fuels. A space analog research base, if it is to aspire to a real lunar environment must also design for the recycle of scarce water, carbon, hydrogen, and nitrogen and of the diverse biomass created by those co-dependent organisms necessary for the survival of *homo sapiens*. While Mars has a much richer inventory of the necessities for life, it also has many challenges of its own.

The effort to meet this standard of stringency in space must also drive us to improve the standards of sustainability in Chile and also therefore to a standard of scientific and technical leadership around the world.

The scarcity of clean water resources is one constraint that is also a point of growing conflict around the world. Space environments such as the Moon and Mars demand the careful recycling of resources such as water and the maintenance of standards of purity in such reutilization. The world's dusty towns are also the best immediate customers for those who design and consider the supply chain and water management in Moon or Mars Research Stations. These Chilean solutions can also be a model for people around the world who face the water constraints of desert living.

9. Lesson's for Chile's own poor soil areas

The design of food production and bio-regenerative processing of human bio-products in a Moon base of Mars base can also provide models of adaptation for Chilean communities located at high altitude that live in environments with "poor" soils, a short growing seasons, and unpredictable weather. This perspective of course is broader than just the benefit to those Chilean communities, which face the challenges of Earthly extreme environments. This aspect of space analog work is one than can also apply such designs and transform much of the world's environmentally disadvantaged communities. Therefore Chile has an opportunity to be a global leader in adaptation strategies in the face of climate change and the challenges of its own social and economic development.

10. Architectural and Systems innovation

Architectural design is another field where the MMARS program demands innovation. On the Moon and Mars there will be needs for a variety of systems such as:

- Modular habitation systems,
- Mobile exploration systems,
- Laboratory systems for in situ analysis
- Engineering labs focused on in situ resource utilization.
- Closed environment food production and bio-regenerative life support systems that create sustainable systems for both humans and essential co-dependent species.
- Portable energy systems that can reliably sustain many demands for energy in the challenging radiation and broad temperature ranges experienced on the Moon and Mars

These systems are at the frontiers of interdisciplinary development. A central purpose of space analogs is to move the engineering along the Technology Readiness Level continuum from concept development, to small scale prototypes, to early model demonstrations for human occupants, through systems integration, and finally to flight hardware development readiness for spaceflight.

Along the way are many opportunities for "spin off" applications of the work in both science and commercial contexts. The global space community can benefit from a Chilean MMARS program and Chile can benefit by being part of the leading edge in architecture and engineering systems design. This is a sound mission for the Chilean Space Agency, for sustaining world-class university systems, and for commercial innovation.

A group of those interested in the advance of MMARS program share the common background of extensive operational experience in analog environments and reflect international participation in the goal of simulated activities to explore protocols for off planet activities as well as human factors.

This group includes:

Maria Catalina, The Astronaut Teacher Alliance
Peter Kokh, Moon Society President
Paul Graham, OpenLuna Foundation Project

Others such as the Mars Foundation's Bruce MacKenzie see developing a Mars analog as an opportunity to model "arriving, surviving and thriving" on Mars, i.e. they are looking beyond initial exploration base needs.

This hand-on experience living and working in analog operations is a solid foundation for creating a generation 2.0 MMARS, which advances the engineering continuum.

The Chilean Air Force has also been an early and strong supporter of the development of a Moon Mars analogue initiative in the Atacama Desert and has expressed a sincere interest in the development of a research station that has elements of educational outreach to pre-college students.

11 Creating an Educational Infrastructure.

The central point to the research applications above is the opportunity to create an educational infrastructure, which provides for participatory exploration for Chile's students. Chile can be a global model for science education, which engages students and creates opportunities for "constructivist" learning by direct involvement on the part of both educators and their students.

Chile's student scientists and their science teachers must accompany those scientists studying the heavens above, or the microbial environments in Chile, in their journey of discovery. The chance "to go along and participate in these explorations" will provide many opportunities to create a new paradigm for the world's systems of education.

One psychological result of a space directed education MMARS program is to create an "Overview Effect" in, which our *student astronauts gain a space perspective in looking at the Earth and other planetary locations as places they can explore with tools they are acquiring*. (2)

The Atacama is a vast region that invites explorers to use modern tools in remote sensing, navigation, mapping, sampling, data analysis, and direct observation to create geographic information systems. Learning how science is done, and how people work collaboratively in unique, extreme and remote environments also creates practical benefits. These tools and skill sets are also widely used in the modern economy so what works in space is useful on Earth and those with these skills can contribute to the modern economy. This educational initiative in the Atacama will be a test-bed for the acquisition and utilization of these skills by Chile's students and their use in Chile's economy. It will also provide a learning and training environment for Chile's teachers so that this research participation in the Atacama can be linked to classrooms throughout the country and around the world.

12. Benefits for local tourism

Chile's development of these innovative programs will also benefit in the promotion of "specialized" tourism in Chile. This Atacama research program initiative will increase Chile's strength in science and technology innovation and therefore strengthen Chile's appeal to eco-tourism and science tourism. Showcasing such research can create jobs in both educational and the hospitality industries.

Summary

Two educators, California's Maria Catalina and Chile's Carmen Jimenez have proposed a multifaceted project that makes use of Chile's unique Atacama region as analogues of both the Moon and Mars. While an Earthquake may have struck Chile, it did not shake the confidence and aspiration of those who share an interest in the development of the MMARS program.

These include the Chilean Air Force, Chile's Space Agency, several Chilean Universities, as well as researchers in Astronomy, Astrobiology, Mining, and Aerospace Systems Engineering. Chilean communities in the Atacama have welcomed this plan and participants in planning include individuals and organizations from other countries such as, Argentina, Australia, Canada, India, Holland, Spain, and the US.

MMARS is a robust initiative that builds on Chile's strengths by providing access to the unique environment of the Atacama to refine the protocols set forth by the first individuals who built such structures as biodomes, and analogue habitats in extreme environments to simulate human survival on the Moon and Mars. Chile will take a "place at the table" of a global community that shares the vision of exploring outer space and provide a wide range of opportunities for Principal Investigators to engage in "proof of concept" activities at the MMARS analogue test-bed.

Deliverables include innovations that will facilitate human settlement of space with multiple "spin-off" benefits that will also address the unprecedented environmental challenges facing our world. The survival needs of *all* human individuals include the responsible use of resources so we meet such needs as adequate access to food, water, housing, and medicine. These educators have their feet on the ground with a passion for the practical application of science and other human activities on the international level.

For more information

and/or how to support this collaboration, visit the MMARS website:

http://moonmars.org

And the Google Group site repository of design concepts

http://groups.google.com/group/moonmars

NOTES

(1) Chris McKay article about Atacama astrobiology work: http://quest.nasa.gov/projects/spacewardbound/docs/McKay2002AtacamaAdAstra1.pdf

(2) "The Overview Effect" is a termed coined by Frank White, Author of the 1976 book of the same title to describe "the euphoric feeling of universal connection" experienced by astronauts observing the Earth from orbit. In this same sense we intend to give students a broad view of their connection to the entire solar system and the interconnections of understanding the Moon, Mars and the Earth.

What is an "Analogue" Site or Location?

"Analogue sites are places on Earth that present **some geological, environmental or biological conditions that are estimated to exist on some celestial bodies, today or in the past.**

"The so-called "analogue" studies are necessary because they allow us to understand how some processes work on Earth and thus to interpret and to validate the data that are received from orbiters or from roving exploration robots.

"Analogue sites are also important places to work on the optimisation of scientific and technological requirements as well as working on the exploration stategies for manned or robotic exploration missons to the Moon or to Mars."

- Richard Léveillé, of the Canadian Space Agency
Validation d'instrumentation spatiale dans les sites analogues - Richard Léveillé – 2007
www.ubordeaux1. fr/exobio07/fichiers_cours/Leveille.pdf

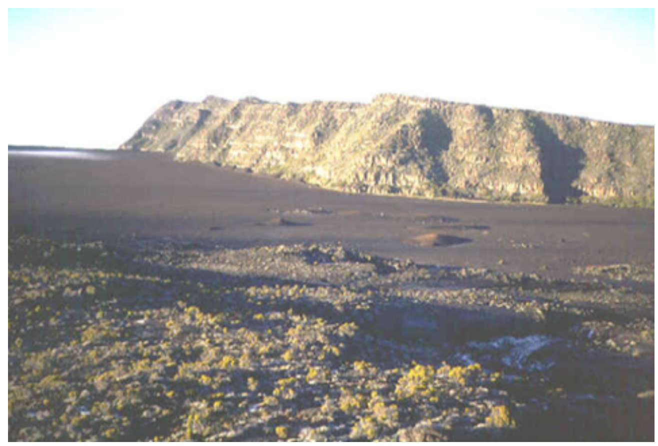
France's Analog Research Station on the Indian Ocean Island of La Reunion

Report by Peter Kokh

Sources: http://www.science-sainte-rose.net/salm/Abstract%20IAF%206322.pdf
http://www.science-sainte-rose.net/salm/Flyer%20Ste%20Rose%20for%20Gluc.pdf

Reunion lies east of Madagascar in the Indian Ocean

Piton de La Fournaise in many respects resembles Mars' great shield volcanoes such as Olympus Mons, Pavonis Mons, etc. With the "Plain of Sands", and many volcanic hills and large lava tubes, Commune Sainte-Rose offers several analogue sites for future Moon and Mars simulation exercises. **Below:** The "Plain of Sands"



Above: the opening of a lavatube in Piton de La Fournaise
Lava tubes are found on both Moon and Mars, making this site especially appropriate for joint Moon Mars simulations

Sainte-Rose Space Connections

The commune of Sainte-Rose is no stranger to "space." It was one of the sponsors of "Sputnik-40-Years", in 1997. In 2002, a TV documentary was made on this site, with participation of several scientific experts, to present in a vivid manner what future human exploration of Olympus Mons might be like. In 2006 NASA installed in Sainte-Rose a temporary tracking station for the launch of the New Horizons Pluto probe. Today, the commune of Sainte-Rose offers to Moon and Mars researchers a permanent support base for an operational Moon Mars Analogue program.

The University of La Reunion

The University of La Reunion was among the first to demonstrate a system of wireless power transportation (WPT) by microwaves, a technology that will be essential for future space power systems. In support of the Sainte-Rose Moon Mars Analog project, ULR offers teams in the fields of volcanology, energies and technology, especially in the domain of robotics. Together with the National Park of La Reunion, it offers environmental outreach services.

The buildings of a former police station, half-engulfed in lava during the 1977 eruption, are available as a permanent base for the Moon Mars Analogue Site in Sainte-Rose.

Why India Might Want to Consider Cosponsoring a Moon Mars Analog Program on Reunion Island

India already has a tracking station on nearby Mauritius.

There is a ban on ethnic censuses in France so it is unknown what the exact percent of the population is of Indian origin. However, people of **Tamil** and **Gujarati** origin make up the majority of the Indo-Réunionnais people; **Bihari** and other origins form the remainder of the population.

Source: http://en.wikipedia.org/wiki/Réunion

Disadvantages: There are no non-stop flights between Mumbai and St. Denis, Reunion. Air France offers several one-stop flights, but these may be via Dubhai, with long durations between flights.

Thanks to Pradeep Mohandas for finding this story. **PK**

An ISRO-Run Moon/Mars Analog Research Facility at Maitri?

By Dave Dunlop and Peter Kokh

Foreward: India's Antarctic outpost at Maitri is located on the ice-free and rocky **Schirmacher Oasis** (brown area on map below), shared with Russia's Novolazarevskaya 3km ESE along with the ALCI airstrip to the south.

Pros and Cons

- The ice-free rocky terrain makes the **Schirmacher Oasis** a superior site to NASA's at McMurdo Sound (**PRO**)
- Its use as a space analog especially for operations in the Mars temperature range, and for modeling operations at the end of a long supply chain is significant. (**PRO**)
- The time to deploy people and equipment to Antarctic for simulations is not unlike planning a Moon Mission, with lots of lead time, training, and issues of equipment function and tending at a great distance. This is on the one hand an excellent parallel to operations for the Moon or Mars (**PRO**) but much more cumbersome and costly than doing the same kinds of things in India itself (or on closer Reunion) (**CON**)
- That India's Antarctic station is an up and running and budgeted program, means that from a budget, it would be a matter of incremental cost to ISRO to collaborate.(**PRO**)
- ISRO would be playing on the bureaucratic turf of another department. This is a potential negative of conflicting program priorities. That NASA is doing its analog exercises at McMurdo creates a precedent of inter-departmental cooperation, however.(**CON**? **PRO**?)
- Using India's Maitri station for a space analog is a win/win for both ISRO and the Antarctic Program as far as overall budget impact on the one hand and favorable press about working and learning in extreme environments. (**PRO**)
- An initial analog exercise could be done from the existing Matri complex (below) with a top goal to locate a nearby, but out-of-sight area for a new analog structure. (**PRO**)

See M3IQ #4, pp. 4-5 for more on Maitri Station. **DD**

One Editor's View of the New “Moon Race” or, perhaps better, a New “Moon Rush”

By David A. Dunlop

A Definition of The New Moon Race

Now I also want to say that I don't believe for a single minute that there is not a new Moon Race no matter what the ISRO team officially says but let me define my terms and explain my definition of "a race". The Chinese say exactly the same thing. It is strictly true that no third party ever said “There is now a new race to the Moon.” Mike Griffin set a target date for the US Constellation Program of a US human return to the Moon first by 2018 with a little wiggle room to 2020. No third party ever said to US and the Soviets that "you two get into a race to be the first with humans to the Moon.

John Kennedy just made the statement that "we go to the Moon because that task will best serve to organize our talents and efforts" and and "do the other things" and "not because it is easy but because it is hard". He never said we go to the Moon to beat the Soviets just to show the world that our technology is superior and that our will is superior to attain what was held to be almost an impossible feat at the time.

Of course everyone in the US took it to heart that we "had to" beat the Russians especially because they had so many space firsts that it in essence was taken as humiliation for the US. When the Soviets saw the US taking up Kennedy's lunar challenge they also made intense efforts toward the same ends. People of that generation (like Peter Kokh and I) consider it to be *a humiliation that 40 years later the US has still not been back and many of the old guard NASA also feel that.*

The former NASA administrator, Mike Griffin went to China during his term to talk with them and was shown many of their facilities. When he came back and testified to Congress about the Constellation Program he said it might well be that by the time the US returned to the Moon in 2020 there might well be a Chinese flag there. Now this was a very transparent attempt to get the US Congress to put more money into the Constellation Program by fanning the flames of the old Moon race and substituting China for the Soviets.

Now, I do not think the Russians will settle for becoming a second rate space power even for all their economic difficulties after the collapse of he Soviet Union as their economy expands again they are now spending $1B per year with ambition to spend triple the amount they were spending in 2007 or 2008 by 2015. So I see the Russians racing to remain a major space power carefully leveraging their resources collaboratively where they can.

There is no Moon Race to be "first" because that race was won more than forty years ago. There is however the issue of being first to get back and the additional issue of "first to stay". The former is trivial; the later is a very significant advance in capabilities and ambition.

Scientific Collaboration and Geopolitical Competition

I think that the truth about "The new Moon Race" is that while there is in fact a considerable amount of multinational discussion and scientific collaboration that goes on via a number of informal as well as formal channels that

all of the National Space Agencies also have their appropriate national pride going hand in hand with their national ambitions to be excellent and world class.

I also think that India, Russia, Japan, China, ESA, and the US and all have expressed interest in going to the Moon with humans. So the Apollo program of a human lunar landing has become an international benchmark because only the US could do it as an early post WWII superpower.

The US gave up its Apollo program because we beat the Soviets and then stupidly lost interest. Fortunately however we were able peacefully with the resolve of the cold war, and with the NATO partners and Japan and Russia, change raw competition into the International Space Station collaboration.

I think many in China look to see China as rapidly becoming "the newly ascendant world superpower" and I have heard this directly expressed by young Chinese who see this as “the Chinese century.” In the political arena the Chinese have pushed for the creation of the Asia Pacific Space Cooperation Council, which I believe is their strategy to pull a group of space "client nations" around their space program, which by the way includes Pakistan, Indonesia, Malaya, Mongolia, Peru, and some others.

Now that perception naturally invites a national push back from all the other nations, which have no interest in becoming either military, economic or political vassals of a new Chinese imperialism. In the lunar programs of all these nations there is a real need to be seen as genuine technological competitors even as they now all really share the scientific information they are gaining. For example Dr. Gopalswami told me at the March Annual Science Conference that he thought Indian would join the Lunar Science Institute network within 18 months.

Of course any nation that takes on this Lunar Challenge will have national pride in their team and its capabilities and achievement. I think therefore that the Russian "pride" in the Apollo era Moon race is still there in the desire to come back to achieve that human landing feat. Roscosmos Administrator Permakov has previously stated that they hoped to put a man on the Moon by 2026.

The Europeans are proposing a development program of their ATV vehicle to achieve manned capacity about 2020 with also a lunar cargo delivery vehicle to be ready about the same time. Japan also has its HTV vehicle, which I believe has the size and similar potential to be upgraded for human crews. So India's target of human space flight to LEO by 2015 is in fact on a much faster track than ESA or JAXA at the moment. The new private US human capabilities such as Space X and Orbital Sciences will probably not come on line until about 2014 and NASA not even that soon.

Dr. APJ Abdul Kalam addressed the US International Space Development Conference in May of this year and I believe correctly stated that the various national space programs were not well coordinated and that more constructive things could be done than are at present. I find it hard to disagree with his opinion as a rational criticism and conclusion of international space efforts. I hope that the Moon Rush mentality can be replaced by a better and faster collaboration to use the Moon's position and resources to address many of the most important problems on Earth.

More Players in the Space Arena

In that time I also think that some new players such as **Korea** will have manned space by 2025 and perhaps we will see a South American Space Agency pooling the efforts of their countries following the example of the Europeans. At the moment **Brazil** is the clear leader with a $2 Trillion economy about half the size of India and a sophisticated aerospace industrial infrastructure. They seem not much interested in combining efforts with other Latin American nations in part because now they are well ahead of the others and perhaps in part because of the language difference between Portuguese and Spanish.

But **Argentina** now has announced an effort to create a launch site along its southern coast, and **Mexico** also just legally established a new space agency and is working out administrative details. The South Americans and the Mexicans also share an increased resistance to traditional US economic and political dominance. I think that the result of the South American Common market with an economy the size of India (if Mexico is added, for space cooperation) could be a formidable South American Space Agency even if Brazil remains on its own.

In Africa the African Union in August just approved a study of the potential of creating an **African Space Agency** with 53 countries contributing. July 1 of this year the **East African Common Market** was established by Kenya, Rwanda, Burundi, Tanzania, and Uganda with a total of 130 million people and the goals of creating a common currency by 2012 and some political union by 2015. Four of the five are commonwealth countries.

A Strong Opportunity for Commonwealth Cooperation

That is why I have promoted the notion of India becoming the space leader of the many commonwealth nations because they are the only one with real launcher and launch facility capacities. (British nuclear submarines with Polaris missiles excepted) India also has the common legal, financial, and intergovernmental ties of the long standing commonwealth framework and the largest economy. With a little work I think India and its advanced potential Commonwealth partners (UK, Canada, and Australia) can be directly competitive with China's growing space capabilities. The overall size of the Commonwealth economy would be competitively ranked as a global superpower with a space agency, with India as its largest component.

Because both India and China have a long political and economic history of exploitation by the Western nations I think neither nation will settle for less than complete independence and a broad demonstration of technological competence in their own space infrastructure and appropriately so.

So these G-20 nations will increasing add to the space picture and hopefully the Moon picture as they develop their individual capacity for space activities and operations. I hope that in fact a collaboration of all six current major space-faring powers can agree to a joint human lunar program in order to build on the success of the ISS. *That partnership really needs to extend to all the G-20 nations. It is not just the big six space faring nations now that is important to this vision.*

As their economies expand and their technology advances all can contribute to this vastly expensive ambition, justly share national pride of achievement, and also share national benefits in the advancement of technology, education, employment, and many spin off benefits.

So I in fact don't see the international community to be ready to go to the Moon together with highly redundant supply chain capacity until sometime between 2020 and 2025. If the big six work together then they could easily have a supply chain for a lunar program that could quickly establish very capable international base(s) and R & D, global lunar exploration, and a large science project like a far side radio telescope.

With a frequent and highly redundant lunar supply chain there can quickly be a number of sites and activities on the lunar surface:

- North Polar location with access to indigenous water
- South Polar location with access to indigenous water
- Farside radio astronomy
- Pyroclastic regions in mid-latitudes (where lava tubes offer great advantages and where pyroclastic deposits also offer indigenous water.

If I live to be 84(I just turned 64) I hope much of this Moon Rush turned to become rapid and effective lunar programs cooperation and that this is something I will see in another 20 years. **DAD**

The Pitfalls of a “Space Race” Mentality

Comment by Peter Kokh

While I do not question the sincerity and conviction of ISRO statements that “India is not in a ‘Space Race’ with China” or anyone else, it remains that the Russians have drawn the opposite conclusion from India’s insistence that the Chandrayaan-2 lander mission be timed for the same year as China’s first Moon landing mission.

But I do not want to talk about evidence one way or the other. Rather, I want to point out the risks of getting drawn into a race. Why? Because no one can deny that the public and the media, *and the politicians as well,* love the idea of a race. It gets the adrenalin up. *It becomes a matter of national pride.*

So whatever ISRO’s sincere intentions, the danger of being drawn into a “race” mentality is very strong.

ISRO needs to be on its guard. Why?

Getting drawn into such an atmosphere of national bravado will impose high risk of

- **Downward redefinition of goals**
- **Inappropriate choice of equipment**, and
- **Failure to build foundations** upon which a robust future “beyond the race finish line” can be pursued.

US President John F. Kennedy's May 25, 1961 Speech before a Joint Session of Congress

Prior to this historic announcement (I was 23) there had already been much discussion of going to the Moon and establishing a Moon base. Wernher von Braun had well-developed plans already published in the early 1950s well before Sputnik-1 launched the Space Age.

Von Braun's plan envisioned a station in space at which a fleet of moon ships (three in most illustrations of the period) would be assembled. But once the race was on and we were engaged "winner take all" with the Soviets, those plans were brushed aside. Why? *Because "doing it right" would take time, and in a race, we could not afford to take time.*

So America built the mighty Saturn V, to be able to launch a minimum moon lander to the Moon in one mission Instead of three bigger ships and a sizable contingent of astronauts landing on the Moon to set up shop, we got one much smaller ship, barely big enough for two over a short period. By the 4th successful mission (skipping Apollo 13), Apollo 15, we had boosted the lander's deliverable payload to land a unpressurized manned "moon buggy."

The race was won with the Apollo 11 landing. But we sent five more missions. Why?

a) to **grind in the fact that we won**

b) to **pretend that we were there for science alone**

Of course, the official line was we were there to do science. But science was always in the position of "frosting" and not "the cake." [I am not sure if this figure of speech is common in India.] By taking one step at a time, as was proper, however, the public became bored. The goals of pure science are not enough to captivate the public. The pubic wanted a moonbase, a permanent human foothold on the Moon, another Antarctica.

But the launch system chosen *to win the race,* was too expensive for frequent and sustained launches

Meanwhile, American politicians, while happy to be able to show the Soviets that "the American way of life was superior," had other priorities. Money spent on the Apollo Race diminished the slices of the budget pie available to the programmes in which they were more interested. I have long said that

Nothing rational – in so far as space is concerned – can be accomplished by the political process.

Of course, those who know no other way to get anything done, will deny this. In the long run, we can only establish ourselves in space permanently, if that effort becomes a part of economic expansion: for example, to get access to resources that can help solve otherwise intransigent terrestrial problems such as environmental degradation and providing sufficient clean energy.

The foundations we chose *not to use* for the Moon Race with the Soviets, would not have been laid by the Bush Return to the Moon Program either. Mike Griffin choose the brute force path of the Constellation program, again choosing to ignore building up an industrial and service capacity in low Earth orbit.

Currently, all of the nations now considering manned landings on the Moon, are looking at these as science missions, to satisfy the curiosity of scientists who could care less if mankind ever expanded its econosphere and settled presence to frontiers beyond Earth.

But fortunately, we now have a growing number of industrialists and entrepreneurs who see space as a theatre in which to make money, and a means to add to the foundations and health of the overall world economy. It is these people who will at last take the "The" out of "Space Station" by erecting others, both more spacious and far less costly. *Nothing is cheap if you do it but once!*

Already Earth's economy has expanded to include not only satellites in low Earth orbit but in Geosynchronous orbit which is 7 times the diameter of Earth itself. We already have an "Econosphere" foothold in space in which more than $200 Billion worth of annual activity is anchored: Global Positioning Satellites, Television-to-home satellites, other communications, weather, navigation, and Earth-sensing satellites.

GEO is already crowded, and positions are already regulated – there are currently only 180 slots, 2° apart. If we continue the absurdity of launching individual satellites into GEO, capacity will soon be reached. We need to think in terms of giant platforms that can host dozens, hundreds, or more satellite systems with the platform supplying energy and station keeping, and possibly replacement and repair.

Building such platforms as well as building solar power satellites, also very large constructs, will require a very large supply of materials. While it may take some investment to begin to produce suitable materials on the Moon, it may pay off economically to do so, *as the volume needed rises*. Why? Because it takes only 1/20th the fuel to bring a mass of given size from the Moon down to GEO as it takes to bring the same mass up the much shorter distance from Earth. It's a "gravity well" fact of life.

We cannot, however, return to the Moon to stay, much less set up industrial operations, by continuing to launch directly from Earth to the Moon. No, instead we need to build assembly and refueling stations in low Earth orbit. We need to build similar facilities at the Earth-Moon Lagrange point 1. Refueling in LEO is estimated to allow shipping to the Moon for a third of the fuel cost, or, shipping to the Moon three times as much for the same investment.

Beyond that, we need to shed the V2 mentality that was born at Peenemunde in northern Germany during the NAZI period. What mentality? That only what is in the nose cone is the payload. After all everything else is destroyed.

But what is so in war, is not necessarily so in space. We currently value only the payload in the nose faring, and write off everything else as useless. But with proper design and choice of materials, everything that is not fuel could be resused for other purposes at stations along the way, in LEO, in GEO, at L1, and on the Moon.

We need to shift from the Space Transportation 1.0 mentality ("everything but the contents of the nose faring of the final stage is tossed aside") to Space Transportation 2.0 ("If it isn't fuel, its payload!)

Back to National Space Agency Moon Missions

It would seem that we have gone far astray from our topic. But we need to put current Moon mission plans in context. We need to do these missions in a way that will not lead to another dead end, and worse, to another retreat from the Moon, this time an international one.

One way to bridge the gap is the concept of an "International Lunar Research Park" in which things needed in common (spaceport, site preparation, warehousing, waste treatment, etc.) are shared, and probably provided by an involved industrial consortium. The individual national space agencies could then deploy their outpost structure, "plug in" and start operations, their astronaut-personnel free to do what they came to do.

Now the South Polar site has been the darling of most observers for some time. The cryo-ice is too hard to harvest by current means. The peaks of "eternal sunshine" are in very uneven "unbuildable" terrain. It may cost more to collect needed solar power in such a situation than to store power produced in dayspan for use in nightspan – a system that would allow us to set up *anywhere* on the Moon – including *where the resources are*. And unless we are going to rule out certain otherwise needed resources, we are going to have to deploy a number of sites in different areas.

This implies a plurality of International Lunar Research Parks. Many nations now collaborate in Antarctica and there are several shared stations. That pattern can translate to the Moon, up to a point. In Antarctica, use of local resources is forbidden by treaty. *On the Moon, use of local resources is the whole point.*

If there is anything that has come out from the recent round of lunar missions (Kaguya, Chang'e-1, Chandrayaan-1, Lunar Reconnaissance Orbiter) it is that the Moon is a very *non-homogeneous* place. So while collaboration is in order, for all the space faring nations to gather in one and only one spot, will necessarily be a cul de sad, a dead end.

Far more science will be done on the Moon if people live there, than if they only visit. If the Industrial Lunar Research Park, have *learning how to make and use lunar building an manufacturing materials* as a major research thrust, and industrial corporations are welcome to participate, a "morphing" transition to civilian lunar frontier settlements will be gradual and sure.

To the science purists, I say "what good is knowledge if it doesn't have practical applications? *Take off you horseblinders!*

In Antarctica, we have learned to leave the military at home (except for their logistic capacities). On the Moon, we need to go one step further, provide scientists with all the research tools they want, but go beyond that to provide "tinkerers" – those who want to see what they can make of whatever surrounds them – with the tools they need as well.

The story of our intercontinental spread out of Africa has involved settling one frontier after another, each with a different set of available materials, flora and fauna, and foodstuffs. In each case we have adapted to the frontier and *"made ourselves at home."* On the Moon we can do the same. **PK**

Space Settlements: Classic Island One (Bernal Sphere) & How to Improve it

By Peter Kokh

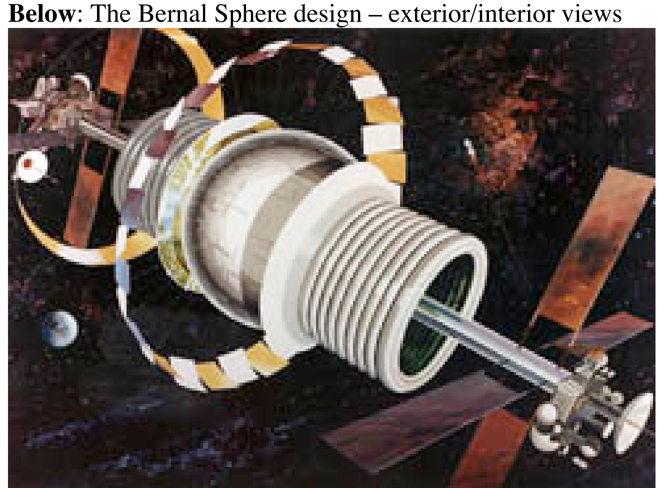
What an ideal introduction to this topic as segue! **Not all advocates of using space resources** to construct solar power satellites and other platforms in Geosynchronous Earth Orbit [GEO] **are in favor of civilian industrial settlements on the Moon.** Enthusiasts who prefer Dr. Gerard O'Neill's roadmap abound. In his vision, mass-drivers would launch same-weight payloads of *unprocessed* moondust into space, to be collected at the Earth-Moon Lagrange 2 point behind the Moon, and then be shipped to locations where giant space coloinies (settlements is now the preferred word) or oases would be built. These hollow constructs would rotate to provide Earth-normal artificial gravity against the inner surface of their hulls.

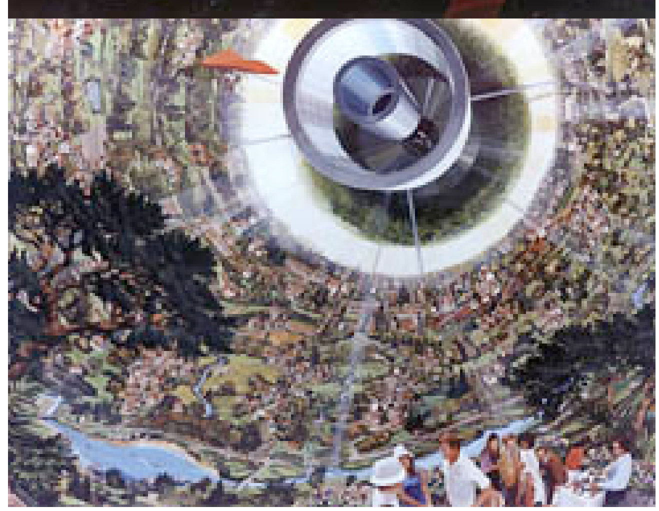
They would house workers in "Earth-reminiscent" conditions. These workers would then process the moondust into building materials with which to build and deploy solar power satellites. Moon dust ingredients not used for these building materials would be used to shield the space settlement hull against radiation, and provide thermal insulation.

Classic types of Space Settlement architectures

The sphere, torus, and cylinder are the shapes that almost all (one exception, mine – more on that later) space settlement designs follow. The population capacity varies, with the sphere at the low end, the cylinder at the high end.

Below: The Bernal Sphere design – exterior/interior views





More on the Bernal Sphere
http://www.nss.org/settlement/space/bernalsphere.htm
http://www.nss.org/settlement/space/bernalspheredetail.htm

Counter-Chauvinisms

O'Neill and his followers were quick to label any dtractors of his vision as "planetary chauvinists," who could not get used to the idea of living on an interior surface of a hollow spinning body, instead of on the exterior surface of a solid spinning body. We are used to centri*fugal* gravity, being pulled toward a center. But the experience of centri*pedal* gravity, being pushed outward from a central axis, is identical. Well, not quite! Because of the much higher rotation rate, on the order of a minute in contrast to a full day, there is the irritating matter of corriolis effects, and one can get dizzy turning too fast in artificial gravity environments.

O'Neill's ace is that thre are no planets in our solar system with Earth-like gravity except the hellish Venus. The unexamined assumption is that humans cannot successfully adapt physiologically to significantly lower gravities. The Zero-G (microgravity for purists) experience endured for long durations (months to a year or more) that produce muscle loss and other unwanted effects is cited. But there is an infinite difference between "0" and "1/6th" gravity. So the assumption that we cannot adapt to lunar or even Martian gravity is unverified. Real experience will tell.

Natural or Artificial?

But there is another reason that some of us might be uncomfortable in a space settlement, and this will apply less to those who have lived in urban environments all their lives to the exclusion of any significant countryside experience, than to those of us who love the raw manifestation of geological forces: mountains and valleys and just plain rocks. Yes, we can make fake (Zoo-type) mountains and land forms, but it's not the same. Some of will prefer raw unplanned natural settings.

And some of us enjoy seeing the stars. We can handle stars circling overhead once a day, but once a minute? Give us a break!

We need to accept each other, "Different strokes for different folks!" "Vive la difference!" The future has room for artificial gravity space settlements and for lunar and planetary surface settlements both, not to forget settlements in lunar and Martian lavatubes!

A counter-charge of chauvinism

Let's say we forget about the difference between artificial and natural for a moment. Classic space settlement designs all appear to be the work of the professional class of scientists, educators, writers, artists, and others who take "day shift" experience for granted.

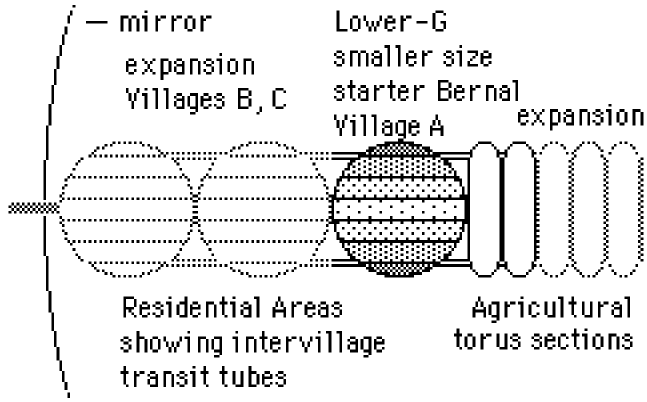
Shipping industrial equipment to Moon or Mars and to Space Settlements as well will be expensive. On Earth, the only way to make expensive equipment profitable is to operate it around the clock, "24/7" as we say. And that means some after work 2nd or 3rd shifts. I personally have spent many years working 6pm to 6am.

Now on Earth, we can't do much about this. Some of us have to stay awake all night and sleep much of the day. But in artificial environments, this is no longer necessary, *if!*

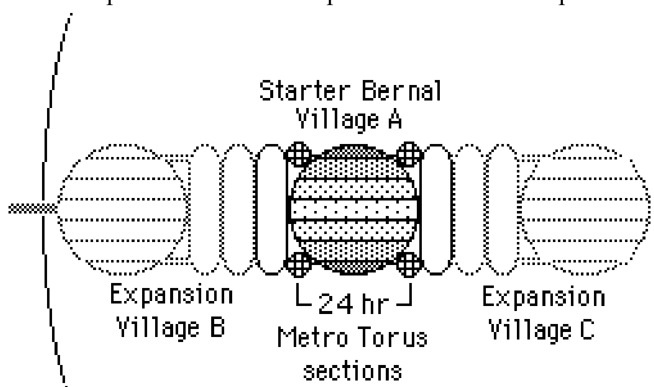
If we "triplicate" our space settlement interiors into three "valleys" with simulated daylight and night staggered 8 hours apart. In such a setup, everyone gets to sleep at night and be up during the day, but the industries and utilities can be in an area lit aroung the clock, manned in sequence by those "on their own daylight cycle."

The Bernal Sphere Reinvented

Below are two versions that would work.



One method of expansion: Mirror works full time, lighting two villages at a time; each getting sunlight 16 hrs (2/3rds day) a day on schedules staggered 8 hours apart. Transit tubes are placed 60û or 120û apart to stiffen the complex.



The "Trivale" Concept is not new

We (the Milwaukee Lunar Reclamation Society design team) came up with this idea when working on our award winning paper for the 1989 National Space Society Space Settlement Design Contest: category: "Lunar Settlement for 1-5 thousand people".

http://www.moonsociety.org/publications/mmm_papers/rille_paper1.htm

Our entry, dubbed Prinzton because it would be in a rille near the crater Prinzton, called for a 3-village system.

http://www.moonsociety.org/publications/mmm_papers/rille_paper3.htm

As the three villages would be well-shielded, it would be a simple matter to control sunlight access to simulate staggered daytime shifts.

We think that space settlements redesigned to be work shift neutral, would be a great improvement.

Postscript: Little did I think when I wrote these papers, that I would get a prestigious award of a brass Bernal Sphere!

http://www.nss.org/awards/oneill_award.html **PK**

Using Aircraft to Explore Mars

By Peter Kokh

From Rubble Piles to Hidden Valleys

Of foremost importance to me as a Moon Society leader are projects and missions that could greatly increase both student and public enthusiasm for further exploration of Moon and Mars. The public, given ample photographic evidence from orbiters and rovers alike, sees both worlds as monotonous dusty rubble piles. Yet both Moon and Mars have extensive networks of subterranean passageways – “lava tubes” much like those found on Earth in lava flows and on the flansks of great shield volcanoes like those in Hawaii and Reunion, only on a much larger scale in inverse proportion to local gravity.

In the past few years, as the resolution of orbiting cameras has improved, we have found teasing evidence, a number of lavatube skylights or “pits” on both worlds. These features are instances of ceiling collapse – probably caused by lucky strikes by small meteorites.

Now if NASA or some other national space agency would mount a mission to just one of these pits, lowering a probe into its depths to map and report back on the void below, people everywhere would become more aware of the Moon’s and Mars’ Hidden Valleys, and the implications for frontier settlement.

We can fly on Mars

For Mars, another mission, already preplanned by NASA, to demonstrate flight of a small drone aircraft over the landscapes and canyonlands of Mars could do much for public appreciation of Mars as a potential human world. Indeed, NASA had planned such a demonstration, timed for December 17, 2003 – on the 100th anniversary of the Wright Brothers first flight at Kittyhawk, North Carolina. What a stupendous way to observe a momentous century!

Visualization by NASA artist

What happened? The the Mars Polar Lander fiasco and budget problems. Yet many aviation enthusiasts feel certain that the feat can be done.

It won’t be easy. Mars’ atmosphere is thinner than we once hoped, the equivalent to air pressure on Earth at 38,000 m (12,000 ft.) The record for fixed wing propellar craft is only half as high, about 17,000 m (57,000 ft), while turbojets have made it to 28,000 m (91,000 ft.) Of course rockets have gotten much higher, but not at cruise altitude.

Actually, NASA’s Helios, an unmanned solar-electric aircraft on an August 14, 2001 flight, holds the record for non-rocket plane altitude of 29,524 m (98,863 ft) in an effort to lead up to a workable design for the proposed Mars drone aircraft NASA hoped to fly “on location” less than two years later. But that’s as far as we got.

Space enthusiasts have not forgotten

Paul Swift, formerly of Toronto, now in Calgary, is one who would personally demonstrate flight at 38 km here on Earth. I met Paul and wife Holly at the 1993 National Space Society International Space Development Conference held that year in Huntsville, Alabama (where it will be held again in 2011). Paul would chair the ISDC the following year, 1994, the first ever ISDC to be held outside the US, in Toronto, Ontario, Canada.

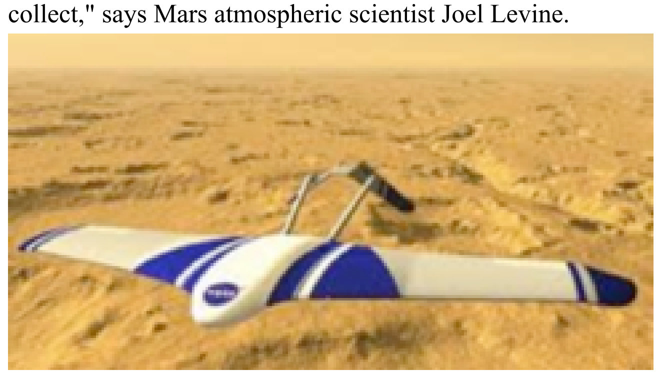
The Mars (Society) Aviation Task Force (2001)

Paul is a veteran pilot with considerable experience flying helicopters. To Paul, the proposed feat is not one of design, but of money to make it happen. Meanwhile, in 20002, Paul and I co-founded the Mars Society’s Mars Aviation Task Force. Our confidence that we would find many collaborators within the ranks of the Mars Society, met with disappointing results. Whether others doubted the feasibility of the project or were too busy doing other things or were only along as passive supporters, we did not know.

Today there is new focus on Marsplane missions

http://www.marsdaily.com/reports/Airplanes_Could_Unlock_Mars_Mysteries_999.html

"A powered airplane flying a mile above the surface can obtain measurements over inaccessible parts of Mars and collect a whole bunch of data that no rover can collect," says Mars atmospheric scientist Joel Levine.



Artist's concept of the ARES airplane flying over the surface of Mars. Credit: Langley Research Center, VA

We need to promote this technology research! **PK**

The “Farm:” An Inflatable Centrifuge Biology Research Module on ISS

M.Thangavelu[1], L. Simurda[2]

As the sole manned laboratory in Low Earth Orbit, permanently operating in microgravity and largely unprotected by the Earth's atmosphere, the International Space Station serves as an unparalleled platform for studying the effects of low or zero-gravity and the space radiation environment on biological systems as well as developing, testing and certifying sturdy and reliable systems for long duration missions such as ambitious interplanetary expeditions planned for the future. Earth-bound research, automated research aboard satellites and short missions into low-altitude orbits cannot replicate long-term ISS experiments.

Abandoning or de-orbiting the station, even in 2020, leaves the international scientific and engineering community bereft of a manned station in orbit and destroys any opportunity for conducting long-term microgravity and radiation experiments requiring human oversight in space. The United States should invest in extending the station's life by a minimum of 15 years from present by attaching an inflatable "Farm" centrifuge module to equip biologists, psychologists and engineers with the tools required to investigate these questions and more.

At a time when humankind has only begun exploring the effects of the space environment on biological systems, it is essential that we not abandon the only empirical research facility in operation today and instead begin vigorously pursuing research in this area that is of vital importance to all humanity, not only in the basic and applied sciences but also in international collaboration.

I. Introduction

In June 2010, President Barack Obama announced a novel vision for NASA and proposed extending the life of the International Space Station (ISS) until at least 2020. As a response to President Obama's call to "utilize the ISS for scientific, technological, commercial, diplomatic, and educational purposes; support activities requiring the unique attributes of humans in space; serve as a continuous human presence in Earth orbit; and support future objectives in human space exploration..." the United States should invest in extending the station's life by a minimum of 15 years from present and attaching an inflatable "Farm" centrifuge module. (see Figure 1) Installing such a module equips biologists, psycho-logists and engineers with the tools required to investigate the effects of microgravity and the space environment - research fundamental to facilitating long-duration and far-reaching manned missions beyond => Low Earth Orbit. It will also allow for the development, testing and certification of sturdy. reliable manned systems such as the Closed Ecological Life Support System(CELSS) that are essential for successful long duration missions.

According to NASA Administrator Charlie Bolden's plans for the ISS, "There's so much we need to know before we can venture safely out of low Earth orbit for the long term. We're going to address practical medical questions about astronaut bone density and the effects of radiation; how we can reach destinations sooner to mitigate the effects on space travelers of long journeys. In addition, NASA will support a broad array of biological, materials, and combustion research aboard the ISS, which will advance our spaceflight capabilities, as well as benefit those disciplines more broadly."2

Current ISS facilities need vast improvements to fully explore and settle these queries. While the ISS contains a number of centrifuges, these only allow for small, short-term experiments. The addition of the Farm module first supplies a location for short- and then long-term experimentation on a larger scale. Then, it provides the location for implementation of a greenhouse and complete biologically based life support system that will prove instrumental for future interplanetary travel. In the Farm, scientists will explore questions including whether the side effects of living in a zero-gravity environment can be overcome with simulated gravity, how to sustain living plants and animals in a space-bound greenhouse to provide nutrition for astronauts, and how to integrate these same plants and animals into a closed life support system.

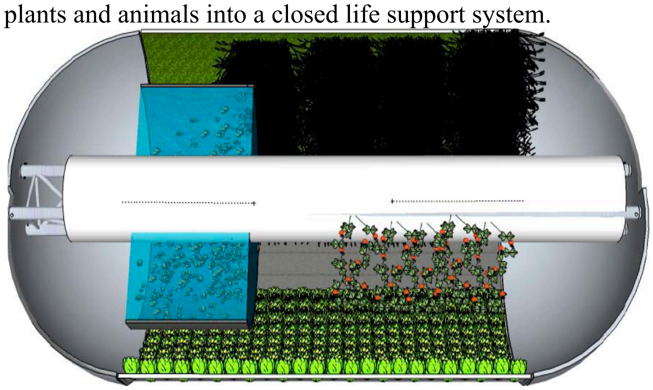
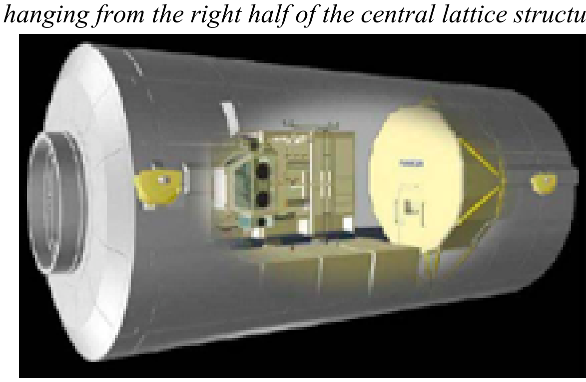


Figure 1: The Farm Module. *The Farm module evolution in its second and third stages when it serves as a greenhouse, life sciences laboratory and life support test bed. Shown above are the greenhouse sections and enclosed fish tank. The upper section of the outer growing region contains wheat, the lower contains lettuce. Tomatoes grow hanging from the right half of the central lattice structure.*



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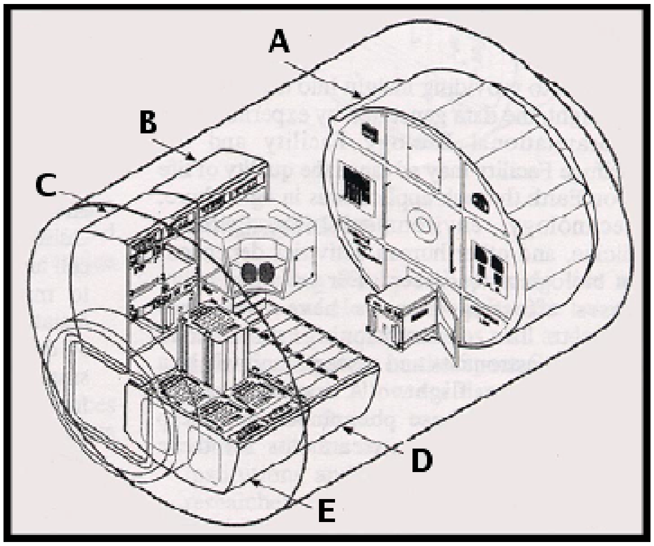

Centrifuge Accomodation Module with Centrifuge Facility:
Key: A-2.5 n diameter centrifuge, B-Life Sciences Glovebox, C-Habitat holding rack 1, D-Service system, F-Habitat holding rack 1

Figure 3: Two images of NASA's proposed Centrifuge Accommodations Module. *Seen above left is the instrumentation previously proposed to fill NASA's Centrifuge Accommodations Module (CAM), including a centrifuge, life sciences glovebox, service system and multiple habitat holding racks.1 Seen above right is a more detailed schematic of that proposed CAM.2*

1 "ISS Centrifuge Accommodations Module.jpg," http://en.wikipedia.org/wiki/File:ISS_Centrifuge_Accommodations_Module.jpg However, the vision altered to a longer-term goal of designing an inflatable module that could house astronauts on long-duration interplanetary missions, for example

2 "Centrifuge Accommodation Module with Centrifuge Facility" http://ti.arc.nasa.gov/projects/ssrl/centrifugeclose2.html

II. The Farm Module: History

The Farm combines an array of scientific and engineering components from previous NASA projects and current industry programs to fashion a cutting-edge module with the greatest usability, durability and efficiency. For example, precedent has been established for both the need for and feasibility of using centrifuge and inflatable modules on the ISS. At the beginning of the decade, NASA engineers designed and planned to launch the rigid-walled Centrifuge Accommodation Module (CAM) to the ISS to house an assortment of biological and engineering experiments (Figure 3).3 The large centrifuge module would have held dual centrifuges that could simultaneously produced gravity levels between 0.01 and 2 g. Like the Farm, CAM was intended to provide scientists with the space and basic tools required to investigate fundamental biological questions and eventually facilitate future long-duration or far-reaching space missions. With enough space to hold 8 experiments at any given time, the CAM was designed to house research on microorganisms, plants and animals as large as rats.4 In terms of engineering designs, the module overcame possible problems regarding connecting a spinning module with a stationary ISS through the use of slip-ring technology.5 But aalthough it was set to launch aboard a space shuttle in 2006, the 8.9 by 4.4 meter Module was cancelled in 2005 due to budgetary short runs and schedule issues.

Similarly, NASA thoroughly developed the foundations of an inflatable module during the 1990s in its Transition Habitat or TransHab project. NASA engineers originally strove to design an air-inflated replacement crew module for the International Space Station's current rigid-shell units to provide astronauts with more space to move about.6 However, the vision altered to a longer-term goal of designing an inflatable module that could house astronauts on long duration interplanetary missions, for example, a trip to Mars.7 According to designs, a central rigid-core structure would protect experiments and equipment during launch. Once in orbit, a multi-layered Kevlar blanket surrounding the rigid core would inflate to a predetermined pressure using compressed oxygen and nitrogen stored in preinstalled tanks.

Figure 4: NASA's Proposed TransHab Module. *Above is a conceptual drawing of the compartmentalized inflatable TransHab module that would have replaced current crew quarters onboard the International Space Station.* http://www.life.com/image/50703432

Inflatable modules proved enticing because of the advantages they hold over their conventional rigid counterparts. Most significantly, inflatable modules increase their volume in orbit beyond that possible using conventional hard-shell modules (which are limited in size because their finished volume must fit within the rocket payload fairing) and weigh less per unit volume upon launch (lowering launch cost). Furthermore, some of the materials available for use in the walls of inflatable modules prove more durable in withstanding dangers like space debris and micrometeorite impacts than current rigid-wall-module constructions. In a break-though design, the skin of the TransHab module was made up of 12 different layers, with the outer ones breaking up any debris or space objects that hit the module through a combination of the materials Nextel and open-cell foam. The inner layers, composed of Kevlar, Combitherm and Nomex, maintained the module's pressure.8 However, TransHab was abandoned in 2000 due to NASA budget constraints.

The private industry quickly continued development where NASA left off. In particular, Bigelow Aerospace bought the rights to patents developed in the TransHab project in hopes of designing an inflatable module for later use in space hotels orbiting the Earth and beyond.9 During the following years, Bigelow engineers developed two 3-meter-long by 2-meter-diameter modules, Genesis 1 and Genesis 2.10,11 These modules consist of an inflatable, flexible and air tight multilayered (including vectran, a material twice as strong as kevlar) skin surrounding a 1.6 meter diameter rigid core structure that protects vital components during launch. To increase the module's durability, the outer shell is covered with Micro Meteorite Orbital Debris (MMOD) shielding, which is seen on most spacecraft.12 Tests run by Bigelow aerospace have shown that simulated micrometeorites that rip right through the side of an ISS module only pierce about halfway through the combination of vectran and MMOD on the inflatable modules.13 Furthermore, Bigelow engineers found that even if a micrometeorite were to penetrate the walls, astronauts would have approximately 24 hours to find the hole and patch it before the structural stability of the module was compromised.14

So far, their calculations have proven correct as both modules have launched and are still demonstrating the reliability of the design. Genesis 1 launched on a Dnepr rocket on July 12, 2006 and remains in orbit today.15 Its success proves that inflatable modules can survive the stresses of launch and remain pressurized regardless of such dangers as orbital debris and radiation. Then on June 28, 2007 Genesis II launched, again proving that inflatable modules can withstand launch and the stresses of space.16 The module completed its 10,000 orbit in April 2009 and remains pressurized.

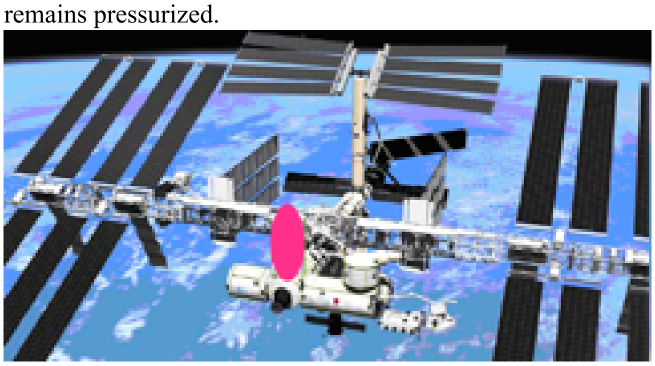

Figure 5: Layout of modules on the ISS. *The pink oval shows a currently unused port originally slated for use by the Centrifuge Accommodations Module. In this location, the "Farm" would sit next to the Japanese Kibo module and be ideally located to include additional solar panels.4*

III. Module Layout

The Farm module builds on Bigelow's next human-rated inflatable structure, the *Sundancer*, and serves as a lower-cost, larger-volume alternative to NASA's previous Centrifuge Accommodations Module. With 180 cm (greater than 6000 cu ft.) of habitable interior volume after inflation, the Farm proves large enough to concurrently accommodate both an array of experiments and astronauts.17

Like the Genesis modules, the Farm initially launches in a deflated state with its multi-layered vectran sleeve wrapped tightly around a central rigid truss containing basic experimental payloads. In orbit, astronauts connect the module to the open dock originally slotted for the Centrifuge Accommodations Module, leaving the Farm sitting adjacent to the Kibo module (Figure 5). Oxygen and nitrogen stored in onboard tanks then inflates the module to 101.3 kPa or 14.7 psi, to match the environment onboard the ISS. This means the module will contain a conglomeration of automated experiments, those requiring human oversight and those managed by the astronauts themselves.18

4 http://www.astronoo.com/images/images_du_mois/iss.jpg

Figure 6: Farm module with pole structure extended. *The image at left shows the extended pole structure, which will deploy using a spring-loaded system, Once the structure has deployed, experiment boxes will fit between the poles and lock into place.*

After pressurization, an internal pole system deploys from the central core via a spring mechanism (as seen in Figure 6). This serves as the support structure that attaches experiment boxes (most launched from Earth and ferried to the ISS at a later date) to the module core. ISS astronauts then enter the module to remove an original set of experiment boxes from the central truss and secure them to the support structure. LED systems are also attached to the outer layer of the support structure by the astronauts to provide lighting that can be tuned to the frequency maximizing growth for various plants within the module. The outer meter of the cylinder (also a meter at the end next to the airlock) contains free space left open for astronauts to maneuver while the entire central core contains experiment boxes.

Once astronauts install the first experiments, they initiate rotation with a simple computer panel controlling the module's environment (humidity, temperature, ventilation, light levels, air pressure) and angular velocity. They must now tether themselves to the central structure while working with various experiments to keep themselves rotating at the same rate as the module. The core is separated into four distinct segments, each housing motors simultaneously providing distinct gravitation levels between 0.1 g to 2 g. For larger experiments, the four core regions combine and spin at the same angular velocity.

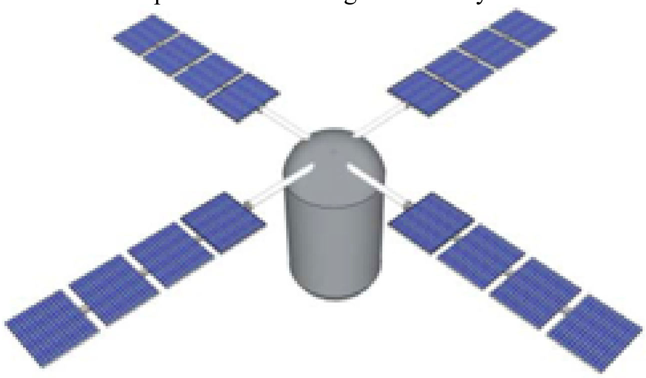

Figure 7: Solar panels on the Farm Module. *The above picture shows a possible layout for the utilization of solar panels at the far end of the "Farm" module to augment power provided from the ISS.*

IV. A Stand-Alone, Self-Sufficient, Energy-Independent Architecture

The power consumption necessary to maintain rotation and the strict environmental controls (for air and nutrient circulation and LED lighting necessary for biological experimentation) requires the Farm module incorporate its own means of power generation. With the module's location in the port originally slotted for the ACM, the options include a set of solar panels or an RTG cluster and radiator tucked at the far end of the Farm module. (figure 7) The Farm is designed to utilize auxiliary power from ISS main power system only if there is an emergency.

V. Fundamental Questions/Time Scale

A. First Five Years:

During its first five years of operation, the Farm houses an array of short- and long-term biological experiments building on results from previously completed Earth-bound and short-term space-based research. Varying rotational settings onboard the Farm allows scientists to examine the effects of assorted gravitational levels for plants and animals and determine whether rotational forces can replace the zero-g space environment without triggering adverse side effects similar to space adaptation syndrome. After establishing the lower limit of the “comfort zone,” or the lowest angular velocity negating the side effects of zero gravity for animals and plants, experimenters can establish optimum gravity levels for plant growth. Concurrent multigenerational biological studies can explore the effects of microgravity on basic biological mechanics, for example whether mammalian reproduction is possible in space and whether microgravity affects embryonic development.

Once scientists grasp the basic mechanics underpinning the growing of plants and animals in space, they can explore optimizing the limited space devoted to a "farm" in space. For example, tissue-culture techniques may be used to grow plants and scientists may be able to bioengineer new breeds of plants and animals better fit to survive in the low-g atmosphere or produce food more quickly. Some experimentation has already been conducted on these topics in microgravity. For example, experiments aboard the MEKADA space shuttle mission (STS 107) demonstrated that fish might be bioengineered to use light rather than gravity to orient themselves.19

Bioengineering has also been applied to select plants, such as a space-age wheat known as USU-Apogee. Developed at the Crop Physiology Laboratory at Utah State University, the dwarf red spring wheat produces the equivalent of nearly 600 bushels of grain per acre, three times that of normal varieties of wheat. Apogee was developed to thrive under "space farm" conditions, including constant artificial light and high carbon dioxide levels. In a mere 23 days after germination, the plant produces heads. It takes most varieties a full week longer. Furthermore, USU-Apogee is space-efficient, standing only 18 inches tall when mature. In addition, botanists have created varieties of sweet potatoes, rice, peanuts, and beans that prove more productive than their natural counterparts. 20

B. Following Ten Years

During the following ten years, the Farm module will transform into a functioning greenhouse where astronauts cultivate both plants and animals. From studies completed onboard the ISS and in various closed environments, we know that meal time plays a vital role in the social atmosphere.21 As one of the few times astronauts set aside work, relax and interact, meals help to create and reinforce the station's social hierarchy. In addition, the ability to garden or simply relax in a greenhouse module greatly improves morale during long-term missions in harsh, barren, hard technology environments. Similar effects have been seen on Earth when the inhabitants of the South Pole Station seek out comfort in the greenhouse module during the six months of darkness between March and September.22

Astronauts themselves should thus be added into the equation as an integral part of the experiment on both a psychological and biological level. Psychologically, scientists must determine the effect of eating animals the astronauts have possibly grown accustomed to see as pets, whether the psychological boost provided by familiar foods increases productivity or social interaction, and whether spending time in the Farm module increases productivity. Biologically, scientists can examine the level of comfort for humans residing in a centrifuge module, explore the side-effects that occur when space residents spend only a few hours a day in a spinning module, and determine whether working in a rotating module affects productivity and biological functions or physiological parameters such as bone and muscle mass. Based on experiments where people lived in centrifuges and slow rotation rooms on Earth, it appears that the module should provide a maximum rotation rate between 1.5 and 1.8g.23

But the most basic question will be whether astronauts respond well to having fresh fruits, vegetables and meat at each meal. Once it is up and running, the Farm module will produce a good percentage of the astronaut's diets. Just like on Earth, the dietary requirements vary from one astronaut to the next; however NASA estimates that a small female astronaut consumes approximately 1900 Calories per day while her large male counterpart consumes about 3200. However the completion of previous experimentation on Earth is not a guarantee of success in space. If spinning the Farm module leaves astronauts disoriented or otherwise incapable of completing their work, another solution must be sought regardless of how well plants and other animals acclimated to the rotating environment.24

Using Earth-bound analogues, it is possible to estimate the percentage of an astronaut's diet that can be grown in a greenhouse. McMurdo Station, which encloses 200 square meters, produces up to 140 kg of food each month and 250 heads of lettuce every 10 days. Assuming seven astronauts live onboard the station (three small women and four large men), the greenhouse would need to produce the equivalent of 18,500 Calories of food to serve as the sole source of food for all seven astronauts. 25

After proving the technology needed to grow a variety of foods needed for both nutrition and comfort, the greenhouse will be integrated into a larger program to create a closed life support system. This system will provide astronauts with everything they need to survive (air, water, food, etc.) with a minimal input of consumables. Dr. Ray Wheeler of NASA has posited that a lunar greenhouse providing 50 percent of the caloric intake of astronauts inhabiting a lunar base would provide complete air revitalization and water recycling. Considering the Farm module will enclose approximately the same volume, it can be assumed astronauts will produce approximately the same weight of food. If the greenhouse is devoted to growing one-quarter wheat (339 kCal/ 100 g), one quarter lettuce (12 Cal/ 100 g), one quarter cucumber (12 Cal/100 g) and one quarter tomato (18 Cal/ 100 g), the Farm will yield approximately 4445 Cal/day, or 24 percent of the astronaut's diet. This calculation neglects any volume devoted to rearing animals and will change based on the particular types and amounts of foods grown in the module.26

Similar methods can be employed in the Farm module to test out possible Closed Ecological Life Support Systems that(CELSS) will be integral to future interplanetary transport vehicles as well as Lunar and Martian bases. Integrating plants and animals already growing onboard into the life support system will save mass and space on long-term missions. Furthermore, replacing a complicated mechanical life support system with plants and animals negates the need to repair or replace complex electromechanical systems while beyond Earth re-supply capability. For example, using regenerating plant or algae lungs to purify air negates the need to replace and repair air filters.

To accomplish this complex task, throughout the period of experiments and evolution, the Farm will also serve as a platform for the evolutionary integration of a reliable closed ecological system(CELSS). This will be done in stages, by emprically hooking up and switching over waste management and filtration systems, CO2 scrubbers and O2 replenishment from proven physico-chemical systems used in the ISS today.

VI. Future Studies:

A number of specific questions can be answered onboard the Farm, including but not limited to:

- Window studies of plant reactions to ultra-short photoperiods (60 minutes of light to 30 minutes or darkness) to validate the use of sunlight to grow plants in earth orbit. This would lower the power dependence of the module and leave astronauts with food in the case of an emergency.
- Exploring the possibility of genetically engineering plants that would better survive short photoperiods to facilitate the use of sunlight to grow the plants.
- Discovering the gravitational "comfort zone" for humans and animals.
- Uncovering the effects of artificial gravity on biological systems.
- Determining the effects of long-term rotation on growth and life cycles.
- Exploring how plants and animals adapt to life in space over multiple generations. What are the long-term effects?
- Ascertaining how plants and animals can be bioengineered to better survive in space.

VII. Beyond the Science

The "Farm" module fulfills more than just the scientific and engineering goals set forth in the National Space Policy - it also facilitates the realization of numerous political and social goals. In particular, the Farm triggers commercial involvement, academic participation and international cooperation with NASA on a large scale.

A. Commercial Involvement

The new National Space Policy particularly emphasizes a close coupling between NASA and the commercial space industry. In the document, President Obama argues NASA must "Seek partnerships with the private sector to enable safe, reliable, and cost-effective commercial spaceflight capabilities and services for the transport of crew and cargo to and from the ISS" thus freeing NASA to focus on sending astronauts to locations beyond LEO. 27

The Farm module provides private companies with a vested interest in supporting ventures to and from the ISS by providing them with information necessary for their long-term venture plans. Burgeoning commercial space tourism corporations around the world are planning a variety of far-reaching enterprises that run the gamut from Earth-orbiting hotels to lunar vacations. For example, engineers at Bigelow Aerospace are developing the *Sundancer* inflatable module in hopes of creating a space hotel in Earth orbit. InterOrbital Systems CFO Randa Millron dreams of creating a lunar hotel where adventurers can relax in their hotel rooms while basking in the other-worldly environment. As all such enterprises involve crew members living outside the reaches of Earth's gravity and atmosphere for long periods of time or possibly even permanently, scientists and engineers must understand the long-term effects of the space and microgravity environments on the human body before their dreams can truly be realized. Furthermore, providing food in space and on colonies will be essential to making space hotels and permanent colonies feasible and cost-effective endeavors. Developing a Controlled Ecological Life Support System (CELSS) and answering the biological questions needed to successfully grow plants and animals in zero- or partial g- environments proves essential to the commercial space community, meaning NASA can use the commercial industry's need to create a better working relationship through the Farm module.

B. Academic Involvement

Closer to home, the Farm will help inspire children to become interested in science and the space program. For years, NASA has endeavored to excite children in the classroom and tap the world of higher academia for novel ideas and willing workers. Such efforts can be enhanced by the integration of plants and animals into the science education program, directly supporting Director Bolden's plans to use "the International Spaces Station as the national lab it was envisioned to be. We will make full use of its incredible potential, and enhance our use of its research and developments capabilities on-board. All kinds of educators, colleges, science institutions, and other government agencies, will be using the ISS for research."28

NASA can use the Farm module to inspire children in the classroom through a combination of visual and educational activities. Installing cameras throughout the module will allow students to monitor the growth of individual plants and animals as well as watch astronauts gardening. Combining these visual aids with worksheets on the effects of the space environment will engage students and provide them with a deeper understanding of both the science occurring on the ISS and how much there is still left to learn onboard. NASA can also engage students by periodically holding lotteries to name the plants and animals. Furthermore, long-term student projects should mimic experiments taking place onboard the ISS - for example, students can create a small hydroponics system and grow soybeans during their school year.

On another front, students in higher academia represent an under-utilized and oftentimes willing resource that NASA must utilize to the fullest extent possible. In order to integrate students' novel ideas, NASA will invite them to work with its scientists and engineers on both the front and back end of ISS experimentation. From the outset of this program, students help draft ideas and build experiments already planned for launch to the ISS. Once the experiments have been conducted, students broaden their knowledge base and gain valuable experience by analyzing data. Using students serves multiple purposes - it engages students and helps them to become excited about the future of the ISS and space research as a whole, lightens the work load on NASA scientists and engineers, and ensures data is examined in a timely manner.

C. Aiding Cultural Understanding/International Involvement

Facilitating international cooperation has been a cornerstone of the ISS since its inception and will continue to be so in the coming years -- the future of space travel does not lie with any single nation alone, but with humanity as a whole. President Obama just re-committed NASA to utilizing the ISS as a means of facilitating cultural understanding and aiding nations around the globe. "The United States hereby renews its pledge of cooperation in the belief that with strengthened international collaboration and reinvigorated U.S. leadership, all nations and peoples--space fairing and space-benefiting--will find their horizons broadened, their knowledge enhanced, and their lives greatly improved."29 Utilized correctly, the Farm module can help ease international tensions and foster friendship and cooperation. Growing foods that reflect astronaut's cultural backgrounds in the Farm module will provide each astronaut with the comfort of familiar foods. The diversity of foods will also serve as a segue for astronauts from varying cultural backgrounds to share information about their own customs and cultures. For example, soy beans can be grown alongside lettuce and wheat. But the advantages reach beyond the astronauts. When the general population identifies with some of the foods grown in the Farm as originating in their own culture and recognizes others as international cuisine from beyond their borders, they will begin to recognize that space exploration is not limited to individuals from a particular nation, but for everyone. In essence, the Farm provides the means to diminish cultural boundaries between the astronauts and to demonstrate to individuals on Earth that exploring beyond Earth will require a truly international program and partnership.

D. Public Involvement

Plants and animals can also serve as a segue to generate awareness and interest for the ISS and space program as a whole within the general population. Members of the public oftentimes doubt the significance of research conducted onboard the ISS, perceiving the operation as a waste of time and funds. It is easy to see why they have difficulty identifying with members of an astronaut corps conducting research or maintenance tasks onboard an alien and sterile-looking space station. Highlighting projects involving plants and animals onboard the Farm will give a familiar face to the ISS program. Providing live webcasts of plants and animals will allow the public to become invested in ongoing research and create an emotional tie to the space program.

Furthermore, the general population has difficulty recognizing the extent to which the technology developed for and integrated into the ISS is incorporated into their daily lives. The Farm provides the perfect platform for discussions and programs revealing these breakthroughs and how they affect the general populace. For example, highlighting how the transgenic plants modified to produce vegetables more quickly and in a smaller area can be implemented to help abate starvation in developing nations provides a perfect illustration of how products created in the space program directly affect the lives of the general populace.

VIII. Conclusion

The Farm module and the ISS as a whole provide a unique location for experimentation, international cooperation, academic involvement and public understanding and appreciation of the space program in general and human space activity in particular. The addition of the unique inflatable "Farm" module provides scientists and engineers with the tools they need to unlock the future of human spaceflight. With these tools they can begin to integrate the components of a closed ecological life support system to sustain permanent presence in space, allowing humanity to explore and eventually settle distant planets, while unravelling the mysteries of our universe.

IX. Acknowledgments

This paper results from a section in the final project completed at the University of Southern California in the ASTE 527 Space Exploration Architectures Concept Synthesis Studio during the fall semester of 2009. The course is all about creating new and innovative ideas for human space exploration. In the fall of 2009, the participants focused on the future of the International Space Station as their team project. Each participant chose to focus on one area of interest. The slides of the entire Team project entitled "The International Space Station :Investing in Humanity's Future" may be found at: http://denecs.usc.edu/hosted/ASTE/TeamProject20093/

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Upcoming Conferences & Events

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

INDIA

Jan 3-7 — Indian Space Research Organization, Chennai, India: '98th Indian Science Congress.'

ELSEWHERE – a selection by the editor

Nov 1-3 — National Space Organization of Taiwan, Intern'l Astronautical Federation, Taipei, Taiwan: '6th Workshop on Satellite Constellation and Formation Flying.'

Nov 4-7 American Soc. for Gravitational and Space Biology (ASGSB), Washington DC: '

Nov 5-7 Students for the Exploration and Development of Space, Northrop Grumman, et al, Urbana IL: SEDS SpaceVision 2010: Envision. Ignite. Achieve.'

Nov 8-10 The National Academies Space Studies Board, Irvine CA: 'SSB Fall Workshop 2010: Sharing the Adventure with the Public – The Value and Excitement of Grand Questions of Space Science and Exploration.'

Nov 14-18 Japan-US Science, Technology & Space Applications Program, Hawai`i Island HI: '2010 JUSTSAP Symposium: The Next Giant Leap – Building Sustainable Settlements Beyond Low-Earth Orbit.'

Nov 15-17 Jet Propulsion Laboratory, Glenn Research Center, US Air Force Research Laboratory, Colorado Springs CO: '18th Advanced Space Propulsion Workshop 2010,' low Technology Readiness Level (TRL = 1-3), far-term space propulsion and power concepts

Nov 17 Intern'l Academy of Astronautics, Washington DC: 'Space for Humanity: Space Agencies Summit.'

-------2011------

Jan 17-21 ESA, Noordwijk, The Netherlands: 'Landing Site Characterization; Selection Future Exploration Missions.'

Feb 10 ESA, Moscow, Russia: Mars500 mission 'arrival' on Mars to begin surface operations.

Feb 15-17 Intern'l Space University, Strasbourg, France: '15th ISU Annual Intern'l Symposium: International Space Station: Maximizing the Return from Extended Operations.'

Mar 7-11 Lunar and Planetary Institute, The Woodlands TX: 'The 42nd Lunar and Planetary Science Conference.'

Apr 11-14 American Inst. Aeronautics & Astronautics, San Francisco CA: '17th AIAA International Space Planes and Hypersonic Systems and Technologies Conference.

Apr 28-30 Space Tourism Society, Los Angeles CA: 'Space Tourism Symposium 2011

May 10-13 International Academy of Astronautics, Bucharest, Romania: '2nd IAA Planetary Defense Conf'

May 18-22 International Space Development Conf, Huntsville, Alabama, US: – National Space Soc., Moon Soc.

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– Mongolian proverb

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http://www.MoonMinersManifesto.com

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

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

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

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MMM 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.

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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.

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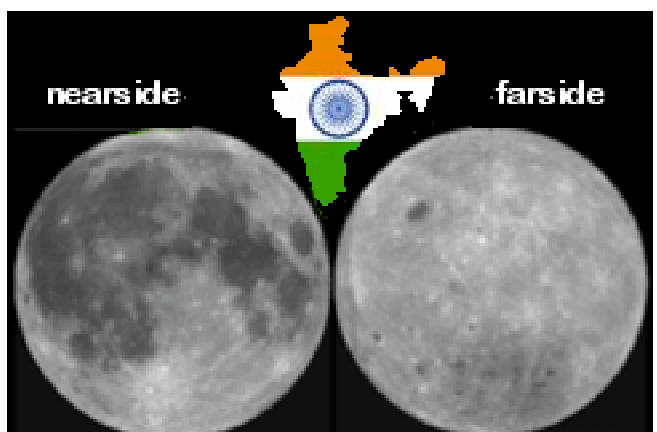

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