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

Moon Miners' Manifesto

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

#1		FALL 2008


Right: Chandrayaan-1 fully integrated and ready to go -- **Left:** Liftoff October 22, 2008 aboard the PSLV-C11

Chandrayaan-1 Flies!

It was a long time coming, but with few delays and some patience, those of us who long awaited this day were not disappointed. Chandrayaan-1's liftoff on October 22nd was flawless, and the several alterations of its orbit needed to get it to the Moon, and into its design operational polar orbit about the Moon, achieved on November 10th went smoothly. After a checkout of all systems, Chandrayaan's 2-year long science mission was about to begin.

About Chandrayaan-1 Turn to Page 3

India's Future in Space Turn to Pages 7-10

Complete article & feature index on last page.

Welcome to Moon Miners' Manifesto India Quarterly Edition #1

Moon Miners' Manifesto began in December 1986 as a publication of the Milwaukee Lunar Reclamation Society, a new chapter of the National Space Society. From serving space-interested people in SE Wisconsin, USA, it quickly was expanded to serve several other chapters of NSS.

In October 1995, MMM began to serve the members o Artemis Society International, and then after The Moon Society was formed in July 2000 when the ASI membership were transferred to that organization, MMM followed.

Continued on page 2

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 2008 issue will begin its 23rd year of continuous publication.

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

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

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

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

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

http://www.moonsocietyorg/publications/mmm_classics/

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About MMM-India Quarterly

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

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

Background

The Moon Society and The Planetary Society of Youth (TPSY) in India, http://www.youthplanetary.org/ in December 2003, put together a "Design a Mission to the Moon" category in TPSY's student design contest -- "A Mission to the Moon and Beyond."

The contest was designed to help students learn about various objects in the solar system as they compete in the design of a mission.
http://www.youthplanetary.org/moon_mission_contest.html

Why an MMM-India Quarterly?

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

And – *India is going to the Moon!*

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

This vision was well-expressed by the former President of India, Dr. A. P. J. Abdul Kalam in a speech at The Symposium on "The Future of Space Exploration: Solutions to Earthly Problems" to mark the occasion of the 50th Anniversary of the dawn of Space Age, Boston University, Boston, MA, April 12, 2007.

In this speech, Dr. Kalam made the point that to fully industrialize and become an equal partner in the future of our planet, India needs to access the unlimited clean undiluted solar energy available in space. We agree with his assertions and want to share that bold vision with the forward-looking people of India.

Free Access:

MMM-India Quarterly issues will be available as a free access pdf file, downloadable from the Internet. We encourage readers to share these files with others freely, and to use this publication to grow and cultivate widespread 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.

Chandrayaan-1

(Sanskrit: चंद्रयान-1, lit Moon-vehicle)

Beginnings, Mission, Instruments, Value

By Peter Kokh, Editor MMM kokhmmm@aol.com

Behind the Name "Chandrayaan"

There is no doubt that the name derives from Sanskrit, an ancient classical Indo-European language that preceded classical Latin and Greek which alao belong to the IE family. There is a dispute whether "yaan" means Journey or Vehicle. Indeed one almost implies the other. The answer is not to be found in linguistidcs but in the intention of those at ISRO who picked the name. They picked it to mean something and that consideration trumps all scholarly argument.

Chandra is the word for Moon in most languages for which Sanskrit is the mother tongue, that is, in most of the northern two thirds of India, as well as in Pakistan, Banglasesh, and Sri Lanka. Southern India is occupied by people of Dravidian descent, whose tongues are not of Sanskrit origin.: Tamil, Malayalam, Kanada, and Telugu.

Mission Prehistory

India's decision to launch a probe to the Moon was announced by then prime minister Atal Behari Vajpayee in his Independence Day address to the nation August 15, 2003.
www.space.com/missionlaunches/india_moon_030819.htm
We can assume that this venture was under dis-cussion in ISRO and by the government for some time prior.

In a report dated February 26, 2002, the ISRO said that it could "launch a probe to the moon within five years of getting a green light from the country's political leadership." To ISRO's credit, they launched Chandrayaan-1 5 years, 2 months, and one week after getting that green light.

The Beijing Declaration

http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=38863

On July 27, 2006, delegates to the ILEWG 8 (International Lunar Exploration Working Group) Confeence in Beijing, China unanimously signed the "Beijing Declaration" that called for close collaboration by four national space agencies planning to launch missions to the Moon in the next three years: Japan (Kaguya-Selene), China (Changé 1) and India (Chandrayaan-1.) This declaration called for internationally coordinated analyses to facilitate the validation of data sets produced by different instruments, enhancing the usefulness of information acquired by multiple spacecraft.

Concentrating on a small number of specific targets would facilitate the cross-calibration of different instruments. If all the orbiters monitor solar flux data, cross correlation of this data will improve calibration of all the instruments dependent on knowledge of solar fluxes. This was an opportunity to coordinate development and utilization of a common, improved Lunar Coordinates Reference Frame.

All missions should archive final mission data products in a PDS-compatible form, to implement international standards for access.

Common standards for S-band spacecraft communication, with potential for common tracking operations and backup support to other missions, if necessary. A coordinated campaign to provide data cross-check and validation for modern-era missions that have overlap in coverage, with data and experience from Past missions

The conferees seem to have realized that the final impact of orbiters on the Moon's surface is not the end of the mission but the final mission experiment. "Information about the five impact events and subsequent impacts of probes should be coordinated with other ... missions."

Standardized telecommunications, navigation, and VLBI [Very Long Baseline Interferometer] support for future orbiter, lander and rover missions. We are given "the opportunity to embark some payload technologies for navigation and guidance on orbiters and landers as part of a Global Lunar Navigation & Positioning System."

The Declaration went on to cover future lander and rover missions, covering all proposed activity over the coming "Lunar Decade."

The collaboration and collaboration that ensued guaranteed that the various science missions would not replicate one another, but rather complement one another. This coordination has been lost on many a critic.

Criticism of the Mission

"Why do we need to do something that has already been done 30 years ago and many times over?" This a criticism that was voiced at the outset and that one hears even today, after the successful launch. The complaint may be understandable, but only out of ignorance of just what Chandrayaan-1 is expected to achieve: much, much more in terms of scientific results than all past and current probes put together. India should be able to boast that it has greatly increased our knowledge of the distribution of resources on the Moon. It is one thing to know that there is iron within a hundred kilometers of a specified location, another to increase the resolution down to a kilometer or "me too" probe. But then most complaints about anything others are doing are based on ignorance. *Without ignorance, we couldn't have politics!* And what kind of world would that be?

[The following is from ISRO's Chandrayaan-1 Brochure
http://www.isro.org/pslv-c11/brochure/

The Moon: Many Still Unanswered Questions

Despite dozens of orbiter and landed probes, "there are many secrets which the Moon is yet to reveal. For example, there is no unanimous agreement in the scientific community about the origin and evolution of the Moon. Additionally, mineralogy of the Moon is yet to be understood in much finer detail. Similarly, the presence of Helium-3, said to be a relatively clean fuel for the future nuclear fusion reactors, is yet to be quantified on the Moon. And, the debate over the presence of water in the permanently shadowed regions of the Moon's polar areas is not yet settled."

"Thus, from the point of view of human intellectual quest as well as in the context of the future of humanity, exploration of the Moon is very important.

In the past few years, there has been a renaissance with regard to lunar exploration. Many countries and international space agencies, including the European Space

Agency (ESA), Japan, China, the US and Russia have undertaken or in the process of undertaking unmanned exploratory missions to the Moon. These missions intend to seek answers to some of the fundamental questions that concern the Moon. India's Chandrayaan-1 is an integral part of that renewed interest of the international scientific community about the Moon."

Chandrayaan-1: The Goals

1. To expand scientific knowledge about the Moon
2. To upgrade India's technological capability
3. To provide challenging opportunities for planetary research to the younger generation of Indian scientists

Chandrayaan-1: The Payloads

http://www.isro.org/pslv-c11/brochure/page7.htm

There are 11 scientific instrument payloads through which Chandrayaan-1 intends to achieve its objectives. The instruments were carefully chosen on the basis of many scientific and technical considerations as well as their complementary /supplementary nature.

They include five instruments entirely designed and developed in India, three instruments from European Space Agency (one of which is developed jointly with India and the other with Indian contribution), one from Bulgaria and two from the United States. Chandrayaan-1 is a classic example of international cooperation that has characterised the global space exploration programmes of the post cold war era.

Indian payloads aboard Chandrayaan-1

1. Terrain Mapping Camera (TMC): The aim of this instrument is to completely map the topography of the Moon. The camera works in the visible region of the electromagnetic spectrum and captures black and white stereo images. It can image a strip of lunar surface which is 20 km wide and resolution of this CCD camera is 5 m. Such high-resolution imaging helps in better understanding of the lunar evolution process as well as in the detailed study of the regions of scientific interest. When used in conjunction with data from Lunar Laser Ranging Instrument (LLRI), it can help in better understanding of the lunar gravitational field as well. TMC is built by ISRO's Space Applications Centre (SAC) of Ahmedabad.

2. Hyperspectral Imager (HySI): This CCD camera is designed to obtain the spectroscopic data for mapping of minerals on the surface of the Moon as well as for understanding the mineralogical composition of the Moon's interior. Operating in the visible and near infrared region of the electromagnetic spectrum, it will image a strip of lunar surface which is 20 km wide with a resolution of 80 m. It will split the incident radiation into 64 contiguous bands of 15 nanometer (nm) width. HySI will help in improving the already available information on mineral composition of the lunar surface. HySI is also built by SAC.

3. Lunar Laser Ranging Instrument (LLRI): This instrument aims to provide necessary data for determining the accurate altitude of Chandrayaan-1 spacecraft above the lunar surface. It also helps in determining the global topographical field of the Moon as well as in generating an improved model for the lunar gravity field. Data from LLRI will enable understan-ding of the internal structure of the Moon and the way large surface features of the Moon have changed with time. The infrared laser source used for LLRI is Nd-YAG laser wherein Neodimium atoms are doped into a Yittrium Aluminium Garnet crystal. The wavelength of the light emitted by LLRI is 1064 nm. LLRI is built by ISRO's Laboratory for Electro Optic Systems (LEOS) of Bangalore.

4. High Energy X-ray Spectrometer (HEX): This is the first planetary experiment to carry out spectral studies at 'hard' X-ray energies using good energy resolution detectors. HEX is designed to help explore the possibility of identifying polar regions covered by thick water-ice deposits as well as in identifying regions of high Uranium and Thorium concentrations. Knowledge of the chemical composition of the various solar system objects such as planets, satellites and asteroids provides important clues towards understanding their origin and evolution. HEX uses Cadmium Zinc Telluride (CZT) detectors and is designed to detect hard X-rays in the energy range of 20 kilo electron Volts (keV) to about 250 keV. HEX is built jointly by Physical Research Laboratory (PRL) of Ahmedabad and ISRO Satellite Centre of Bangalore.

5. Moon Impact Probe (MIP): The primary objective of MIP is to demonstrate the technologies required for landing a probe at the desired location on the Moon. Through this probe, it is also intended to qualify some of the technologies related to future soft landing missions. This apart, scientific exploration of the Moon at close distance is also intended using MIP.

The 29 kg Moon Impact Probe consists of a C-band Radar Altimeter for continuous measurement of altitude of the Probe above lunar surface and to qualify technologies for future landing missions, a Video Imaging System for acquiring images of the surface of moon from the descending probe and a Mass Spectrometer for measuring the constituents of extremely thin lunar atmosphere during its 20 minute descent to the lunar surface. MIP is developed by Vikram Sarabhai Space Centre of Thiruvananthapuram.

Payloads from outside India

http://www.isro.org/pslv-c11/brochure/page7a.htm

Of the six Chandrayaan-1payloads from abroad, three are from the European Space Agency (ESA):

1. Chandrayaan-1 Imaging X-ray Spectrometer (C1XS): This instrument intends to carry out high quality mapping of the Moon using X-ray fluorescence technique for measuring elemental abundance of Magnesium, Aluminium, Silicon, Iron and Titanium distributed over the surface of the Moon. This will help in finding answers to key questions about the origin and evolution of the Moon. The instrument is sensitive to X-rays in the energy range of 0.5—10 keV. C1XS is jointly developed by Rutherford Appleton Laboratory of England and ISRO Satellite Centre, Bangalore.

2. Smart Near Infrared Spectrometer (SIR-2): This instrument aims to study the lunar surface to explore the Moon's mineral resources, the formation of its surface features, the way different layers of the Moon's crust lie over one another and the way materials are altered in space. It has the ability to detect and record near Infrared radiation coming from the Moon. Since this is the radiation band through which various minerals and ices reveal their existence, SIR-2 is well suited for making an inventory of various minerals on the lunar surface. It can detect the radiation in the range of

0.93-2.4 micron. SIR-2 is developed by Max Plank Institute of Germany.

3. Sub keV Atom Reflecting Analyser (SARA): The aim of this instrument is to study the surface composition of the Moon, the way in which moon's surface reacts with solar wind, the way in which surface materials on the surface of the Moon change and the magnetic anomalies associated with the surface of the Moon. SARA will be sensitive to neutral atoms that have escaped from the surface of the Moon and having energy in the range of 10 eV—2 keV (kilo-electron-Volt). The instrument has been developed by the Swedish Institute of Space Physics and by the Space Physics Laboratory (SPL) of ISRO's Vikram Sarabhai Space Centre built its processing electronics.

The Bulgarian Payload onboard Chandrayaan-1:

4. Radiation Dose Monitor (RADOM): This instrument aims to qualitatively and quantitatively characterise the radiation environment in space around the Moon's vicinity. It will help study the radiation dose map of space near the Moon at various latitudes and altitudes. Besides, the instrument helps in investigating whether the space near the Moon shields it from cosmic rays coming from distant cosmic sources as well as those from the sun. Such studies and investigations will be helpful in the important task of finding out the shielding requirements of future manned missions to the Moon. RADOM is developed by the Bulgarian Academy of Sciences.

US/NASA instruments carried by Chandrayaan-1

5. **Mini Syntheic Aperture Radar** (MiniSAR): This is one of the two scientific instruments of the United States flown in Chandrayaan-1 mission. MiniSAR is from Johns Hopkins University's Applied Physics Laboratory and Naval Air Warfare Centre, USA through NASA. Working in S-band, MiniSAR is mainly intended for the important task of detecting water ice in the permanently shadowed regions of the Lunar poles up to a depth of a few meters. It can optimally distinguish water ice from the dry lunar surface. MiniSAR has a spatial resolution of about 75 metres.

6. **Moon Mineralogy Mapper (M3)**: This is an imaging spectrometer which is intended to assess and map lunar mineral resources at high spatial and spectral resolution to support planning for future targeted missions. It will help in characterising and mapping lunar minerals in the context of the Moon's early geological evolution. M3 is from Brown University and Jet Propulsion Laboratory through NASA. M3 may also help in identifying water ice in the lunar polar areas. Its operating range is 0.7 to 3 micrometre. The instrument has a spatial resolution of 70 m.

Chandrayaan-1: The Journey

Subsequently, LAM is fired again to W **WCQg** Chandrayaan-1 spacecraft to an extremely high elliptical orbit whose apogee lies at about 387,000 km.

In this orbit, the spacecraft makes one complete revolution around the Earth in about 11 days. During its second revolution around the Earth in this orbit, the space0-craft will approach the Moon's North pole at a safe distance of about a few hundred kilometers since the Moon would have arrived there in its journey round the Earth.

Once the Chandrayaan-1 reaches the vicinity of the Moon, the spacecraft is oriented in a particular way and its LAM is again fired. This slows down the spacecraft sufficiently to enable the gravity of the Moon to capture it into an elliptical orbit.

Following this, the height of the spacecraft's orbit around the Moon is reduced in steps. After a careful and detailed observation of perturbations in its intermediate orbits around the Moon, the height of Chandrayaan-1 spacecraft's orbit will be finally lowered to its intended 100 km height from the lunar surface.

The Moon Impact Probe

Later, the Moon Impact Probe will be ejected from Chandrayaan-1 spacecraft at the earliest opportunity to hit the lunar surface in a chosen area. Following this, cameras and other scientific instruments are turned ON and thoroughly tested. This leads to the operational phase of the mission. This phase lasts about two years during which Chandrayaan-1 spacecraft explores the lunar surface with its array of instruments that includes cameras, spectrometers and SAR.

The 3.2 metre diameter metallic bulbous payload fairing protects the satellites and it is discarded after the vehicle has cleared dense atmosphere.

PSLV-C11: The Launcher

http://www.isro.org/pslv-c11/brochure/page10.htm

PSLV-C11, chosen to launch Chandrayaan-1 space-craft, is an uprated version of ISRO's Polar Satellite Launch Vehicle standard configuration. Weighing 316 tonnes at lift-off, the vehicle uses larger strap-on motors (PSOM-XL) to achieve higher payload capability.

PSLV is the trusted workhorse launch Vehicle of ISRO. During 1993-2008 period, PSLV had twelve consecu-tively successful launches carrying satellites to Sun Synchronous, Low Earth and Geosynchronous Transfer Orbits. Now, its fourteenth flight is being used for launching Chandrayaan-1 to moon.

The Ground Segment

The Ground Segment of Chandrayaan-1 performs the crucial task of receiving the radio signals sent by spacecraft. It also transmits the radio commands to be sent to the spacecraft during different phases of its mission. Besides, it processes and safe keeps the scientific information sent by Chandrayaan-1 spacecraft.

ISRO Telemetry, Tracking and Command Network

(ISTRAC) had a lead role in establishing the Ground Segment facility of Chandrayaan-1 along with ISRO Satellite Centre (ISAC) and Space Applications Centre (SAC). The Ground Segment of Chandrayaan-1 consists of:

1. Indian Deep Space Network (IDSN)

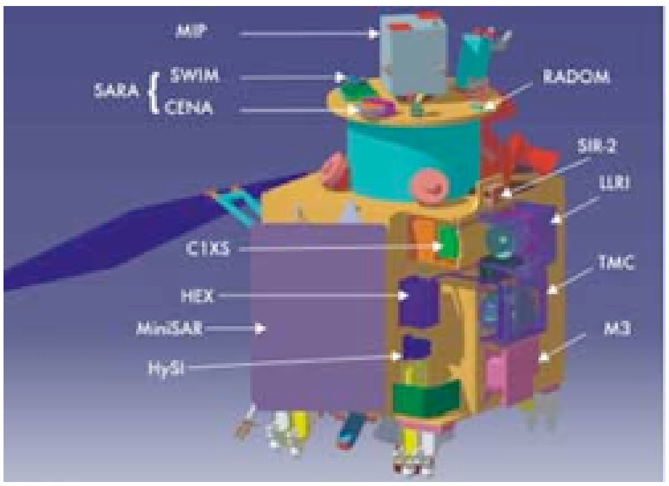
The Indian Deep Space Network consists of two large parabolic antennas, one with 18 m and the other 32 m diameter at Byalalu, situated at a distance of about 35 km from Bangalore. During the initial phase of the mission, besides these two antennas, other ground stations of ISTRAC Network at Lucknow, , Bangalore, Thiruvananthapuram, Port Blair, Bangalore, Mauritius, Brunei, Biak (Indonesia) and Bearslake (Russia) as well as external network stations at Goldstone, Applied Physics Laboratory in Maryland, Hawaii (all three in USA), Brazil and Russia support the mission.

2. Spacecraft Control Centre (SCC)
3. Indian Space Science Data Centre (ISSDC)

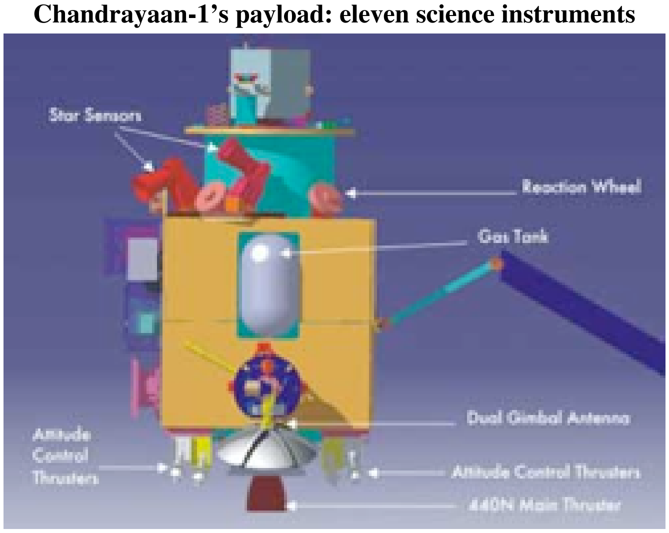
The Future

Chandrayaan-1 is the first spacecraft mission of ISRO beyond Earth orbit. Chandrayaan-1 will be followed by Chandrayaan-2 which features a lander and a rover. India and Russia will jointly participate in this project. However, there may be a provision to accommodate payloads from other space agencies as happened in Chandrayaan-1. This apart, studies are being conducted by ISRO on sending unmanned spacecraft to planet Mars as well as to asteroids and comets. Through such programmes, ISRO intends to undertake the exploration of space besides its primary mission of developing and utilising space technology for the overall development of the country.

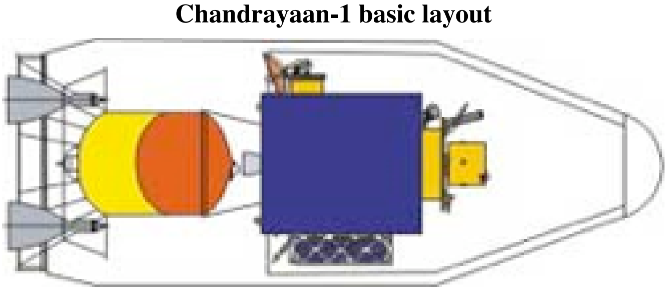
MMM - INDIA GALLERY



Chandrayaan-1's payload: eleven science instruments



Chandrayaan-1 basic layout


Chandrayaan-1 inside the rocket-top faring


Moon Impact Probe to be released early in the mission in an attempt to splash out water vapor from a S. Pole crash site.


Impact Probe released & impacted S Polar area 11|14|08
http://www.space.com/news/081117-india-moon-flag.html


Salyut-7 visited by Rakeesh Sharma

Address through multi-media tele-conference to The Symposium on "The Future of Space Exploration: Solutions to Earthly Problems"
Boston University, USA 12 April 2007

By **Dr. A. P. J. Abdul Kalam**

Space Exploration and Human Life

I am delighted to participate in the Symposium on "The Future of Space Exploration: Solutions to Earthly Problems" organised by (a) the Centre for Space Physics, (b) the Pardee Centre for the Study of Longer Range Future and (c) the Secure World Foundation of Boston University to mark the occasion of the Fiftieth Anniversary of the dawn of Space Age. My greetings to this distinguished gathering of space scientists, technologists, academicians, futurologists, industrialists, social scientists and students. May I address you, as a fellow scientist, who has been part of the growth process of space science and technology in India. This field of human endeavour has, in the last fifty years, made an unprecedented impact on the life of human race. As the first citizen of India, I am aware of the aspirations and pain of our people and the great expectations they have for further improving their quality of life using technology including space. I am glad to know that you will be discussing how space technology can enhance further, the quality of life of world citizens while examining many innovative ideas for space exploration, exciting aspects like space colonies, search for extra terrestrial intelligence and planetary exploration. We have to understand our planet more completely, evolve and adapt our life to its environment and ecology. Hence, I have chosen the topic, "**Space Exploration and Human Life"**.

Indian Space Visionary

As you know, fifty years ago, space initiatives started with only two major space-faring nations. Now, there are many. I am happy to say that India is one among them with space science and technology accelerating the social and economic advancement of the nation. When I think of space accomplishments of the last fifty years and the vision for the future, I recall Dr. Vikram Sarabhai, who pioneered India's space programme, which in the last four decades has been touching the lives of many among the billion people of India in several ways.

The Indian Space Programme

Prof. Vikram Sarabhai unfurled the socio-economic application oriented space mission for India in 1970. Today, India with her 14,000 scientific, technological and support staff in multiple space research centers, supported by about 500 industries and academic institutions, has the capability to build any type of satellite launch vehicle to place remote sensing, communication and meteorology satellites in different orbits and space application has become part of our daily life. India has today a constellation of six remote sensing and ten communication satellites serving applications like natural resource survey, communication, disaster management support, meteorology, tele-education (10,000 class rooms) and tele-medicine (200 hospitals). Our country is in the process of establishing 100,000 Common Service Centres (CSC's) across the country through public-private partnership model for providing knowledge input to rural citizens.

Recently, India has launched into orbit and recovered a space capsule after performing micro gravity experiments. This is a major technological milestone is an important step towards reusable launch vehicle and manned space missions. India is now working on its second space vision. I foresee that an important contribution for future of exploration by India would be, space missions to the Moon and Mars founded on space industrialization.

Space Research as a Technology Generator

Space research is truly inter-disciplinary and has enabled true innovations at the intersection of multiple areas of science and engineering. It has been consistently aiming at the "impossible" and the "incredible", every time moving the frontiers of our knowledge forward. Space research has had as its major focus, on making things work and bringing the dreams of mankind to fruition through technologies that the mankind can be proud of. It is almost a "Green Technology". Its greatest asset is that in many cases what is perfected as a space technology becomes a technology that enhances the quality of human life on the Earth. Some examples are - the revolution in communication, tele-presence, infotainment, and an integrated picture of Earth and its resources. Besides direct contributions, the fruits of space research have also resulted in designing innovative products such as cardiac stent and heart pacemaker for healthcare.

World Population in the 21st Century & Its Relation to Future of Space Exploration

The world population today is 6.6 billion which is projected to be over 9 billion by 2050. The critical issues arising from this population growth are shortage of energy, shortage of water and increasing damage to the natural environment and ecology.

Planetary Energy Supply & Demand: Role of Space Technology

Civilization on Earth will run out of fossil fuels in this Century. Oil reserves are on the verge of depletion, followed by gas and finally coal. However, Solar energy is clean and inexhaustible. For example, even if 1 % of India's land area were harvested of solar energy, the yield would be nearly 1000 Gigawatts, or 10 times more than the current consumption. However solar flux on Earth is available for just 6-8 hours every day whereas incident radiation on space solar power station would be 24 hrs every day. What better vision can there be for the future of space exploration, than participating in a global mission for perennial supply of renewable energy from space?

Water for future generations

More than 70% of Earths' surface is water; but only one percent is available as fresh water for drinking purposes. By 2050 when the world population will exceed 9 billion, over 6 billion may be living under conditions of moderate, high and extreme water scarcity. There is a four-fold method towards providing safe and fresh drinking water for large population. The first is to re-distribute water supply; the second is to save and reduce demand for water; the third is to recycle used water supplies and the fourth is to find new sources of fresh water.

Space technologies for new sources of fresh water

In India Earth observation satellites having unique resolution are being deployed for the survey of water bodies, their continuous activation so that water storage during rainy season is maximized. Establishing new water supply sources using advanced reverse osmosis technologies for sea-water desalination on large scales is a cost effective method of providing a new source of safe and fresh drinking water. However, desalination is an energy intensive process. Hence, the use of renewable energy through space solar satellites can bring down the cost of fresh water substantially. Space based solar power stations have six to fifteen times greater capital utilization than equivalent sized ground solar stations. Linking Space solar power to reverse osmosis technology for large-scale drinking water supplies could be yet another major contribution of Space.

Integrated Atmospheric Research

In the last four decades, space observations through balloons, rocket experiments, satellites, recordings through sophisticated ground installations, experimental techniques and instrumentation have provided valuable integrated information on atmospheric processes. I asked myself what have we learnt from atmosphere during the last four decades. What information enriched us? How our atmosphere is dynamically changing in 20th century to now in the 21st century? As you all are aware, Earth is experiencing both stratospheric cooling (due to ozone hole) and tropospheric warming (due to increased green house gases).

While the twentieth century has witnessed CO2 content in atmosphere going upto three parts per 10,000, in the early part of 21st century we are already experiencing 6 to 10 parts per 10,000. This is equivalent to nearly 30 billion tones of carbon dioxide injection to the atmosphere every year. The solution for preventing further damage to the atmosphere would be immediate adoption of energy independence through use of clean renewable sources of energy.

Disaster Management

In many places in our planet, we experience severe disasters like Earthquakes, tsunami, cyclone resulting in loss of life, loss of wealth and in some cases it destroys the decades of progress made by countries and their valuable civilizational heritage. India has Earthquake problems periodically in certain regions. US, Japan, Turkey, Iran and many other countries also suffer due to Earthquakes.

Earthquake/tsunami is a sub terrain phenomenon and predicting this from space observations would be a great challenge. Space scientists of multiple nations should work together to use satellite deep penetration images to predict the Earthquake or shock wave propagation. Other possibilities are precise geodynamic measurement of strain accumulation by satellite to detect pre-slip, and electromagnetic phenomena prior to final rupture. The focus must be on Earth quake forecasting with adequate warning so that the people can move to safer areas. Space technology can also be used for forecasting and modeling of volcanic eruptions, land slides, avalanche, flash floods, storm surge, hurricane and tornadoes.

Potentially Dangerous Asteroids

Space community has to keep monitoring the dynamics of all potentially dangerous asteroids. Asteroid 1950DA's rendezvous with Earth is predicted to be on Mar 16, 2880. The impact probability calculations initially indicated a serious condition of 1 in 300, which has to be continuously monitored. In such a crucial condition, we should aim to deflect or destroy this asteroid with the technology available with mankind.

Space Missions (2050)

Now, I would like to discuss with you certain specific priority areas in space technology and exploration.

Geosynchronous Equatorial Orbit (GEO) is a well utilized resource. The spacecraft orbiting in GEO are very high value resources. However, the life of these spacecraft are determined by component failure, capacity of fuel, internal energy systems and space environment. While new design practices and technologies are constantly increasing the life of satellite, there is a requirement for extending the life of satellite through in-orbit maintenance such as diagnosis, replacement, recharging, powering, refueling or de-boosting after use. This calls for creation of **Space Satellite Service Stations** for all the spacecraft in the GEO as a permanent international facility. Future satellites and payloads have also to be designed with self-healing capability and midlife maintenance.

Space Industrial Revolution

Mankind's 21st. Century thrust into space would herald in the world's next industrial revolution, what might be termed as the Space Industrial Revolution. This does not mean that the revolution will take place only in Space. What it essentially means is the creation of architectural and revolutionary changes leading to new space markets, systems and technologies on a planetary scale. Such a Space Industrial Revolution will be triggered by the following missions that can address all segments of global space community. What are the possible drivers for such a Space Industrial Revolution?

The first major factor will be man's quest for perennial sources of clean energy such as solar and other renewable energies and thermonuclear fusion. Helium 3 from Moon is seen as a valuable fuel for thermonuclear reactors.

Mining in planets or asteroids would need innovative methods for exploring, processing and transporting large quantities of rare materials to Earth. Moon could become a potential transportation hub for interplanetary travel. The Moon's sky is clear to waves of all frequencies. With interplanetary communication systems located on the far side, the Moon would also shield these communication stations from the continuous radio emissions from the Earth.

Hence the Moon has potential to become a "Telecommunications Hub" for interplanetary communications also. The Moon also has other advantages as a source of construction materials for near Earth orbit. Its weak surface gravity is only one-sixth as strong as Earth's. As a result, in combination with its small diameter, it takes less than five percent as much energy to boost materials from the lunar surface into orbit compared with the launch energy needed from Earth's surface into orbit. Electromagnetic mass drivers powered by solar energy could provide low-cost transportation of lunar materials to space construction sites.

Low gravity manufacturing holds tremendous promise for mankind in new materials and medicines. Studies also have shown that the needs of 12 workers could be met by a 16-meter diameter inflatable habitat. This would contain facilities for exercise, operations control, clean up, lab work, hydroponics gardening, a wardroom, private crew quarters, dust-removing devices for lunar surface work, an airlock, and lunar rover and lander vehicles.

Habitat at MARS:

As my friend Prof UR Rao, former Chairman of ISRO says, space scientists are habituated to protecting systems against single point failures; so, in the longer term, creation of extra terrestrial habitat in MARS should be studied as fail safe mechanism for our problems on Earth. How would we create livable conditions on Mars?

Moon-Based Solar Power Stations

Space solar power stations have been studied extensively during the past 30 to 40 years. However, non-availability of low cost, fully reusable space transportation has denied mankind the benefit of space solar power stations in geo-stationary and other orbits.

Moon is the ideal environment for large-area solar converters. The solar flux to the lunar surface is predicable and dependable. There is no air or water to degrade large-area thin film devices. The Moon is extremely quiet mechanically. It is devoid of weather, significant seismic activity, and biological processes that degrade terrestrial equipment. Solar collectors can be made that are unaffected by decades of exposure to solar cosmic rays and the solar wind. Sensitive circuitry and wiring can be buried under a few- to tens- of centimeters of lunar soil and completely protected against solar radiation, temperature extremes, and micrometeorites. Studies have also shown that it is technically and economically feasible to provide about 100,000 GWe of solar electric energy from facilities on the Moon.

If we have to achieve these along with the full potential of space benefits with current applications, there is one major problem we have to solve. That is, how are we going to make the cost of access to space affordable?. The question hinges on creating space markets and developing cutting edge technologies to make low cost of access to space a reality. The future of the space industrial revolution created by a space exploration initiative would hinge greatly on new means of safe, affordable access to near Earth space, as the platform for deep space exploration.

Cost of access to Space

It is becoming clear that present level of markets for communication, are getting saturated. Optical fiber technologies are providing large band width for terrestrial communications. The life of satellites in orbit having increased to 12-15 years, along with advanced technology with higher bandwidth for transponders have further reduced the demand for telecommunication satellites. The current cost of access to space for information missions such as telecommunication, remote sensing and navigation varies from US $ 10000 to US $ 20000 per kg in low Earth orbit. As mentioned, this market is saturated. Hence the future of space exploration requires that space industry moves out of the present era of information collection missions, into an era of mass missions. There is a need to reduce the cost of access by two to three orders of magnitude. It is only by such reduction in cost of access to space that mankind can hope to harvest the benefits of space exploration by 2050.

Affordable, Low Cost Space Transportation for Space Exploration Missions

The payload fraction of current generation expendable launch vehicles in the world does not exceed 1 or 2% of the launch weight. Thus to put one or two tonnes in space requires more than one hundred tonnes of launch mass most of which-nearly 70% - is oxygen.

Such gigantic rocket based space transportation systems, with marginal payload fractions, are wholly uneconomical for carrying out mass missions and to carry freight and men to and from the Moon.

Studies in India have shown that the greatest economy through the highest payload fractions are obtained when fully reusable space transportation systems are designed which carry no oxidizer at launch, but gather liquid oxygen while the spacecraft ascends directly from Earth to orbit in a single stage. These studies in India suggest that a “aerobic” space transportation vehicle can indeed have a 15% payload fraction for a launch weight of 270 tonnes. This type of space plane has the potential to increase the payload fraction to 30% for higher take off weight. For such heavy lift space planes, with 10 times the payload fraction and 100 times reuse, the cost of payload in orbit can be reduced dramatically by several orders of magnitude lower than the cost of access to space with expandable launch vehicles.

While space industrialization and space exploration will expand initially using the current generation launch vehicles, the real value of space exploration for human advancement will occur only when mankind builds fully reusable space transportation systems with very high payload efficiencies. This will become available when the technology of oxygen liquefaction in high-speed flight in Earth’s atmosphere is mastered. This technology will also be useful for mass collection from the atmosphere of other planets at a later stage in space exploration.

Maintaining Peace in Space

We must recognize the necessity for the world’s Space community to avoid terrestrial geo-political conflict to be drawn into outer space, thus threatening the space assets belonging to all mankind. This leads on to the need for **an International Space Force** made up of all nations wishing to participate and contribute to protect world space assets in a manner which will enable peaceful exploitation of space on a global cooperative basis.

Challenges before the Space Research Community

Space research has many challenges that can stimulate intellectually alert and young minds. But the attraction for the youth of today to take up science or technology as a career option has many lucrative diversions. The future of space research cannot be as green as it was in the last fifty years, if we the space scientists do not ensure a steady stream of youngsters embracing the discipline. For this to happen, the scientists of today must come up with a steady fountain of ideas that would attract the students. This is a great challenge. I would be happy if the great minds gathered here, articulate to the young, the space vision for the next fifty years and challenges presented and discussed in the Symposium. Space does not have geographic borders and why should those who pursue space research have any borders?

Space Missions 2050

I would like to suggest the following space missions for the consideration by the space community assembled here to be fully accomplished before the year 2050.

1. Evolving a **Global Strategic Plan** for space industrialization so as to create large scale markets and advanced space systems and technologies, for clean energy, drinking water, tele-education, tele-medicine, communications, resource management and science; and for undertaking planetary exploration mission.
2. Implementing a **Global Partnership Mission** in advanced space transportation, charged with the goal of reducing the cost of access to space by two orders of magnitude to US $ 200 per kg. using identified core competencies, responsibilities and equitable funding by partners, encouraging innovation and new concepts through two parallel international teams
3. Developing and deploying in-orbit Space Satellite Service Stations for enhancing the life of spacecraft in GEO as a permanent international facility.

Conclusion

Since the dawn of space era in 1957, space science and technology has enhanced man's knowledge of Earth, atmosphere and outer space. It has improved the quality of life of human race. Our space vision to the next fifty years has to consolidate these benefits and expand them further to address crucial issues faced by humanity in energy, environment, water and minerals. Above all, we have to keep upper most in our mind the need for an alternate habitat for the human race in our solar system. The crucial mission for the global space community is to realize a dramatic reduction in the cost of access to space.

To meet this challenge the scientific community can draw the inspiration from the saying of Maharishi Patanjali, about 2,500 years ago "When you are inspired by some great purpose, some extraordinary project, all your thoughts break their bounds. Your mind transcends limitations, your consciousness expands in every direction, and you find yourself in a new, great and wonderful world. Dormant forces, faculties and talents come alive, and you discover yourself to be a greater person by far than you ever dreamt yourself to be."

I wish you all success for this Symposium on "The Future of Space Exploration: Solutions to Earthly Problems"

May God bless you. ###

A video of Dr. Kalam's Speech is Available at:

http://www.bu.edu/pardee/multimedia/Space-Abdul−Kalam/

Full Text (pdf format)

www.bu.edu/csp/Conferences/Space_Exploration/Day1/Presentations/Kalam_Space Exploration and Human Life.pdf

India's Two Astronauts

Rakesh Sharma - Cosmonaut #138

http://www.geocities.com/siafdu/ac2.html

In 1984 he became the first citizen of India to go into space when he flew aboard the Russian rocket Soyuz T-11. April 2, 1984 and docked and transferred the three member Soviet-Indian international crew which also included the Ship's Commander Y.V. Malyshev and Flight Engineer G.M. Strekalov (USSR) to the SALYUT-7 Orbital Station. The crew spent seven days aboard the Salyut space station during which they conducted scientific and technical studies which included 43 experimental sessions. Sharma used Yoga techniques to combat the debilitating effects of weightlessness. His work was mainly in the fields of bio-medicine and remote sensing. With Sharma's flight, India become the 14th nation to send a man to outer space.

Kalpana Chawla (March 17, 1962 – Feb. 1, 2003) was an Indian-American astronaut / space shuttle mission specialist. One of seven killed in the Space Shuttle Columbia disaster.

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

http://www.space.com/missionlaunches/bio_chawla.html

http://www.jsc.nasa.gov/Bios/htmlbios/chawla.html

Kalpana flying free in Zero-G then, and now.

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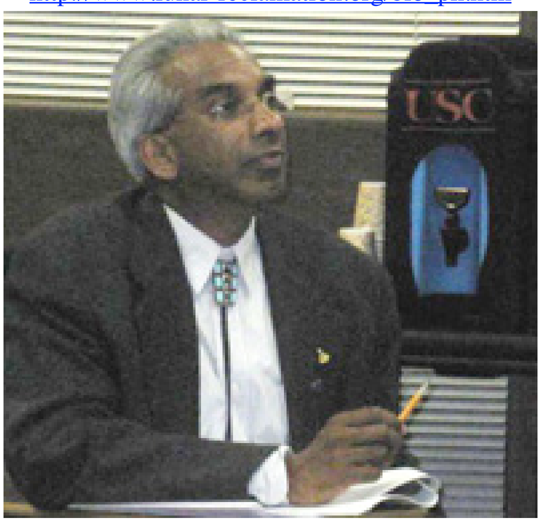
Peter Kokh kokhmmm@aol.com
http://www.lunar-reclamation.org/bio_pk.htm



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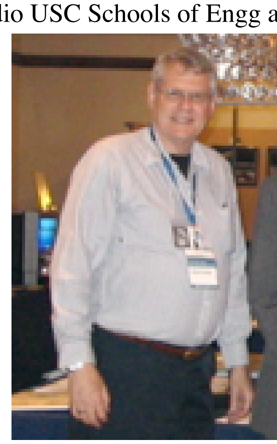

David A. Dunlop dunlop712@yahoo.com
Moon Society Board, Director of Project Development

Help Wanted !

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

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

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

mmm-india@moonsociety.org

[This email address goes to the whole editorial team]

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

Guidelines for Submissions

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

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

Submissions should be short, no more than a few thousand words.

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

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

ESA Video about Chandrayaan-1

http://www.youtube.com/watch?v=043KLT0zoHY

Help Circulate *MMM-India Quarterly*

Readers are encouraged to share and to distribute this first edition widely, either as an email attachment, or via the direct download address:

http://www.moonsociety.org/publications/mmm-india/m3india1_fall08.pdf

MMM-India Quarterly will remain a free publication. We will set up an online subscription service so that each issue is emailed to your email box directly, if you wish.

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

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

Student Space Organizations in India

The Planetary Society of Youth (TPSY)

http://www.youthplanetary.org/

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SEDS-India

(Students for the Exploration & Development of Space)

http://india.seds.org/

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Anmol Sharma
(Director, Chapter Affairs)

The Chapters Under SEDS INDIA:

1. SEDS VIT - Vellore Institute Of Technology University (Vellore)
   http://www.vit.ac.in/seds_vit/index.html
2. National Institute Of Technology (Suratkal)
3. National Institute Of Technology (Trichy)
4. Jawahar Lal Nehru Technical University (Hyderabad)
5. Kumaraguru College Of Technology (Coimbatore)

Pro-Space Organizations in India

Astronautical Society of India

http://www.asindia.org/default.aspx

IndianSpaceTalk@groups.indianspace.in

National Space Society Kolkata chapter

http://chapters.nss.org/a/lists/International/ChapList_IN.shtml

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Planetary Society of India

[Organisation for promotion of astronomy]

http://planetarysocietyindia.blogspot.com/2008/08/space-camp-india-astrounaut-training.html

http://planetarysocietyindia.blogspot.com/

http://planetarysocietyindia.org/

Space India - ISRO Newsletter - twice a year

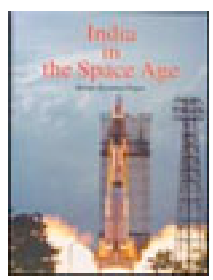
http://isro.gov.in/newsletters/newsletters.htm

Aeronautics & Aerospace Journals & Magazines Published in India

(Stress on AEROspace)

International Aerospace Magazine India
http://www.internationalaerospaceindia.com/default.htm

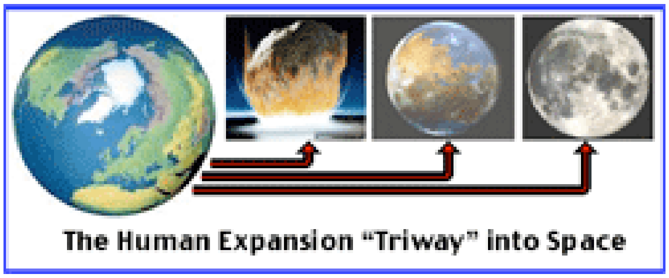
Vayu Aerospace Review – India
http://www.vayuaerospace.in/



India In the Space Age

Author	:	Mohan Sundara Rajan
Subject	:	New Arrivals
Language	:	English
Paper Binding		Rs. 235.00

The book narrates the exciting journey of India's emergence as a leading Space power. The focus is on the challenges faced in making and launching world-class rockets and satellites which are being used for an amazing variety of applications including telecommunications, television and data links, weather monitoring and forecasting, education, health, and disaster relief as well as remote sensing of natural resources besides exploration of the Moon and outer space.



Moon, Mars, or Asteroids: Which path to pick?

By Peter Kokh

There are three principal human space expansion pathways, each focused on one of three principal imperatives in which space is the key to the ultimate challenge facing humanity. ***Survival!***

1. Planetary Defense of our home world from potential impactors (Near Earth ASTEROIDS)

2. Establishing a viable exclave of human civilization on another world (MARS) to guarantee human survival should civilization on Earth be wiped out by an impact or other natural disaster, or implode through human-caused environmental degradation.

3. Using Space Resources to halt, and ultimately reverse environmental degradation on Earth through overuse of fossil fuels, and to create a more equitable global economy **(THE MOON)**

Path #1 The Danger of Asteroid Impacts

Before we can design a suite of astrochunck orbit adjustment method, we need to

1. Identify all the possible impactors out there, and then

2. Tag them with transponders so that we can keep ultra-accurate track of them and

3. Characterize each as to internal cohesiveness and structure, then

4. On the basis of which population group poses the greatest threat, **prioritize development and testing of methods of deflection**

Given the relative likelihood of different size impacts over time, the **first things first, one step at a time** plan sketched at right offers the best cost-benefit ratio. We have to keep in mind that the **odds of disaster from impact are less than the odds of a super-volcano eruption, or of a super-tsunami event, or of a next ice age,** any of which could devastate Earth on a continental scale. Asteroids are not the only natural threat we face. But they are the threat that we can do the most about.

I**. Changing Orbits of Threatening Astrochunks**

We are learning that asteroids come not only in many sizes and with serveral kinds of mineralogy, but that they have several kinds of complex rotations and several degrees of internal cohesiveness.

- Punch a bean bag, and it doesn't fly away from you, it just rearranges itself around the impact point
- Giving an asteroid with a complex wobble a push in the desired direction can be very tricky.
- No one strategy fits every case

2. Other benefits of Asteroid identification & tracking

Near Earth Asteroids & Comets are not only possible threats, they **are reserves of raw materials** that may be essential to our growing material needs:

√ iron, nickel, and other "engineering **metals**

√ **precious metals:** gold, silver, platinum - Platinum is now involved in over 25% of all modern industrial processes. It is most needed for the fuel cells that could usher in the "Hydrogen Economy

√ **volatiles:** water-ice, hydrocarbons, carbon and nitrogen ices - these may be vital imports for a lunar economy. Water-ice rich comets, comet hulks, and carbonaceous chondrite asteroids may be of use in the terraforming (or rejuvenation) of Mars

Path #2. A Viable Human Colony on Mars

Mars is in many ways the most "Earth-like" planet in our solar system.

1. Total land surface of Mars is equal to total land surface of Earth

2. Mars day is just a bit longer than ours. Mars has four seasons.

3. Mars has **a thin atmosphere** and apparently **a lot of water** locked up in underground aquifers

4. A Mars colony **could someday survive cutoff** of support from Earth

5. We may be able to **restore the warmer, wetter climate of early Mars**

Stephen Hawking warned, "the survival of the human race is at risk as long as it is confined to a single planet. Sooner or later, disasters such as an asteroid collision or nuclear war could wipe us all out."

Synergies between Highways 1 & 2

- Mars could provide a valuable **vantage point for identifying and tracking Earth approaching astrochunks** that also approach MarsSome of these asteroids are sure to contain **resources that will be of value on Mars** and contribute to faster and more diversified industrialization
- Early civilization on **Mars could also be threatened** by asteroid impacts
- Some of the **techniques developed to redirct Earth-approaching asteroids** might also be used to direct comets into collision course with Mars if this would prove useful in adding to Mars water reserves

Path # 3. Using the Moon to Save Earth from Ourselves:

Consequences of Greenhouse Gas Overproduction

OPTION 1. SOLAR POWER SATELLITES made from Lunar Materials

- Solar Power Satellites **receive more intense sunlight "24/7"** and can beam the power to rectennas on Earth by microwaves or lasers
- A lot of material will be needed to build them, and it will cost **1/20th of the fuel to source the needed materials from the Moon as from Earth** because of the Moon's lighter gravity

• A solar satellite can be **built of 92% lunar materials at only an 8% weight penalty**

• Solar Power Satellites are an **ideal solution for** coal-burning China and India and other quickly industrializing **Nations**

OPTION 2. SOLAR POWER ARRAYS on the Moon

• **Extensive farms of solar panels along the east and west limbs of the Moon** would beam power direct to Earth or via orbiting relays

• **When one limb is in darkness, the other will be in sunlight**, guaranteeing around the month coverage

• **Solar arrays would be far cheaper to build on the Moon itself**, but the challenge for beaming power over a distance 10 times as great may be a problem.

OPTION 3, LUNAR HELIUM-3 is the ideal Fusion Fuel

• Had we the fusion plants to burn it, **one Shuttle External Tank full of liquid Helium-3 would be enough to power the United States for a year.**

• There is **enough helium -3 in the upper 2 meters of the moondust to bring the whole world up to the US standard of living** and keep it there for a thousand years

• And then? There's **a lot, lot more in the atmosphere of Uranus**

• It's a great recipe, but first **we have to catch that rabbit - *fusion!***

The Moon has the resources to support an industrial economy

Living Comfortably on the Moon

• We will cover ourselves with a 5 meter thick **blanket of moon dust** that will provide protection from the cosmic elements and thermal equilibrium

• Heliostats will funnel **sunshine** inside; periscopic picture windows will connect us visually to the outdoors

• Graywater system toilets will fill the home with **greenery, flowers, and sweet fresh air**

• Each home will enter on a pressurized street for **shirtsleeve travel anywhere** in town

• Lunar materials will provide art and personal decor

Synergies with Planetary Defense from Asteroids

• **Remote control telescopes on the Moon** will identify more and smaller astrochunks and do a better job of tracking them.

• **Lunar industries will be a market** for materials mined from asteroids in the process of being shepherded into safer orbits

• **A Catch-22 of Orbital Mechanics** is that the closer two bodies are in orbital period, the less frequent the launch windows between them. For the main asteroid belt between Mars and Jupiter, the Moon will be the preferred staging point and outfitting point for asteroid belt bound missions, rather than Mars.

• **The Moon itself holds the shattered relics** of hundreds of thousands of asteroid impacts

Synergies between Highways to Moon and Mars

• **The Moon Society can support this long range goal by prioritizing development of technologies useful on both worlds:**

√ Modular architectures including modular life support biosphere systems;

√ Life support technologies

√ Space suit development

√ Mining, processing, and construction technologies

√ Modular factory systems √small pocket hospitals

√ Agricultural and food production systems.

• **Identify trade products** between Mars and the Moon to support each other's economy

• **This is but the start of a potentially very long list.**

Postscript: Lifeboat/Ark/Archives Survival Projects

Establishing a survivable Human Settlement on **Mars,** if it includes a Bio-bank of Earth's diverse plant and animal species with representative breeding stock, and an exhau-tive archive of human culture and technology is helpful. But there risks being a settlement bias to pick and choose.

An all inclusive Grand Archives of all Humanity and of Earth in a lava tube on **The Moon** that has already remained intact for 3.5 billion years or more is the best bet.

CONCLUSIONS

In the United States, there has been strong debate, sometimes acrimonious and personal, between those who would concentrate entirely on one of these three Highways to Space to the exclusion of the other two. This constant debate, with none of the parties willing to listen to the others, has had a negative effect on both the Media and politicians.

"You guys certainly do not have your act together!"

But in fact, we most certainly do!

We are all united behind the one overriding imperative: ensuring the survival of our species and of our homeworld.

All that is missing is the recognition of this fact, upon which not only can mutual respect be fostered, but productive collaboration as well.

We included this essay in this very first edition of MMM-India Quaarterly in the hopes that pro-space Indians will not fall into the same unproductive debate trap.

There are in fact three, equally important, and mutually reinforcing Highways to Space.

We hope that India will see the importance of supporting all three, even if, for budgetary reasons, it may be expedient to concentrate on just one for now, or to support one or two of the others at a more modest level.

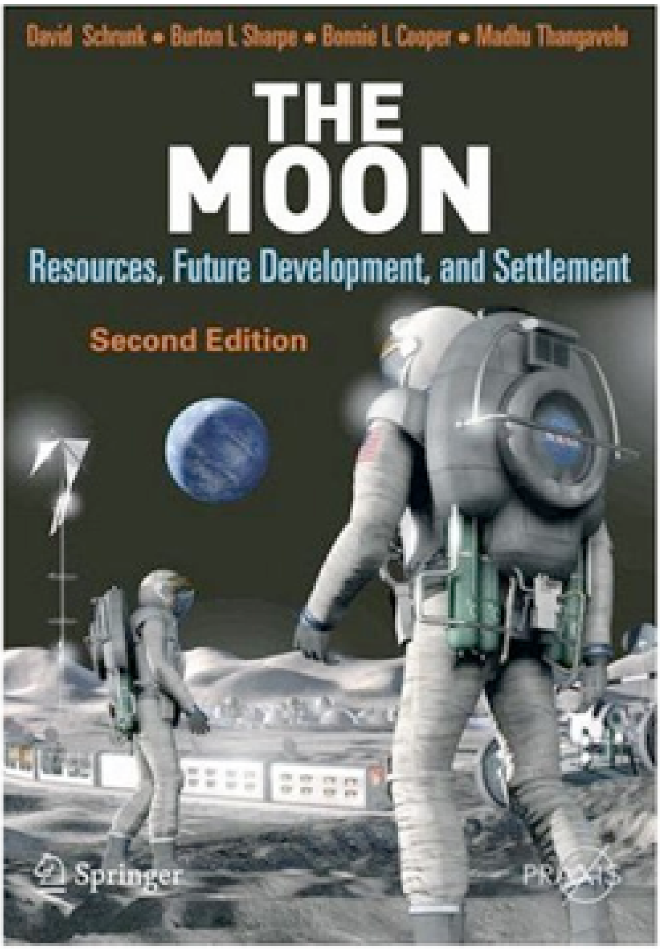
The above essay is a text version of a presentation that is available in either a pdf slide shoe version or as a PowerPoint Presentation.

http://www.moonsocietyorg/spreadtheword/pdf/Triway1.pdf

http://www.moonsocietyorg/spreadtheword/ppt/Triway1.ppt

These presentation files may be freely distributed and used. **<PK>**

THE **book** WORM



David Schrunk*, Burton Sharpe, Bonnie Cooper, and Madhu Thangavelu

(Springer Praxis Books / Space Exploration) (Paperback)

Reviewed by Peter Kokh for Moon Miners' Manifesto

Take your pick of "must buy" or "immediate classic" or "ambitious Primer with Vision and Scope".

Not a few people have taken a hard in depth look at what it will take to establish a permanent outpost on the Moon - as if that was an end all and be all goal in and of itself. In this new volume, Schrunk and his team are clearly out to do more. Seeing the Moon in the much wider light as a world with considerable mineral resources and its strategic location on the shoulder of Earth's gravity well, they outline a feasible, realistic scenario for the coming century.

Their goal is not "a" moon base. It is a global integration of the Moon into Earth's economy. Looking at the Moon's resources, where they are located, and at which parts of the Moon have special advantages, they take us from a first south polar outpost step by step into a future when humans will be busy all over the Moon, and making money doing so.

Their vision is grounded on established technologies, never depending on developments or breakthroughs that may or may not ever happen. On the airless Moon, good old fashion electric railroads (eventually MagLev) will be the principal way of moving goods and materials from one part of the globe to another. Relying solely on solar power, they manage the long lunar nights by setting up grids that loop both poles at approximately 85° N and S latitudes, depending on the terrain, of course.

The Moon will produce power for Earth, and become the principal spaceport by which we open the rest of the Solar System and beyond. By the turn of the next century, hundreds of thousands of people, and maybe more, will live and work on the Moon.

Profusely illustrated with B/W sketches, the authors take us through every well-reasoned and grounded step. More material and additional appendices added in the second edition, in which the last word of the title was changed from "Colonization" to "Settlement." For all of us interested in the Moon, this book is a must read. Do buy it! PK

1. Lunar Origins and Physical Features: Origin; Physical Features: Exploration of the Moon

2. Science Opportunities - Engineering Challenges: Geoscience; Astronomy from the Moon; other science opportunities; Engineering challenges

3. Lunar Resources: Elements; Lunar regolith; Water; Sunlight; Vacuum; Temperature profile; Physical mass of the Moon; Topography; Sterile environment; low gravity; Orbital mechanics

4. Lunar Logistics: Getting to the Moon; Staying on the Moon; Design concept

5. Mining and Manufacturing: Mining; Transportation of raw materials; Beneficiation; Processing of crude ores; Lunar manufacturing

6. Circumferential Lunar Utilities: Lunar electric power; The lunar power system; Circumferential lunar utilities; The south pole station; railroad operations; the 'breakout'

7. Governance: Government structure; Space law; Outer space treaties; Creation of a new lunar government; Port authorities; LEDA

8. The Mission to the South Pole: Global Survey; Robotic survey and sample return; Lunar base site selection criteria; Initial robotic operations at the lunar base; The lunar 'seed'; The seleno-lab; mission concept; Embryonic circumferential infrastructure

9. Settlement of the Moon: The first lunar base; Growth of the first base; Return of humans; Controlled ecological life support system; A cis-lunar transport and logistics system; The second lunar base; Infrastructure development in the south polar region; Global development

10. Exploration of Space From the Moon: 'Spaceport' Moon; Solar sails; Energy transmission in space; Solar power satellites; Exploration of the solar system from the Moon; Exploration of the stars

Appendices: More than two dozen appendices going into depth on relevant issues complete this book.

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Beyond Our First Moonbase:
The Future of Human Presence on the Moon

by Peter Kokh, Editor: Moon Miners' Manifesto,
President: The Moon Society – kokhmmm@aol.com

[Reprinted with permission, from **The Moon: Resources, Future Development and Settlement** by David Schrunk, Burton Sharpe, Connie Cooper and Madhu Thangavelu, [Review previous page] in which book it appeared as Appendix T. This essay also appeared in Moon Miners' Manifesto 20th Anniversary issue, #201. December 2006]

Beginnings

If all goes as planned, U.S. budget crises notwithstanding, mankind's first outpost on the Moon will start to become real around 2020, a historic event, that were it not for politics, might have happened decades earlier.

The vision outlined in **The Moon: Resources, Future Development and Settlement** (see above) is a bold one, showing how we could set up our first outpost so that it would become the nucleus from which human presence would spread across the face of the Moon.

NASA itself has such a vision, but the agency can only do what it is authorized to do. If the history of the International Space Station offers clues, NASA's official goal, which only includes setting up a first limited outpost as a training ground for manned Mars exploration and nothing more, will be under increasing budgetary pressures to slim down into something with no potential for growth at all. The intended crew size, the planned physical plant, and the capabilities that are supported, will all be tempting "fat" for budget cutters who cannot see, or appreciate, the possibilities beyond. This is the risk of publicly supported endeavors in space. It is difficult to get political leaders, and the public itself, to look beyond very near future goals. The chances that our first outpost will be born sterile cannot be dismissed.

But if private enterprise is involved and ready to take over when and where NASA's hands are tied, there could be a bright future for us on the Moon. Much of that promise may involve finding practical ways to leverage lunar resources to alleviate Earth's two most stubborn and intertwined problems: generating abundant clean power, and reversing the destructive pressures of human civilization on Earth's environmental heritage

Cradlebreak: early lunar building materials

The Moon has enormous resources on which to build a technological civilization. But first things first. How can we break out of a first limited-vision outpost? A humble start can be made by demonstrating the easier, simpler ways to start lessening the outpost's heavy dependence on Earth. Oxygen production comes first. Close behind is hydrogen harvesting, whether from lunar polar ice deposits or from solar wind gas particles found in the loose regolith blanket everywhere on the Moon.

If we have access to basalt soils in the frozen lava floods of the maria, we can cast this material into many useful products. Not the least of those are pipes, sluices, and other components of regolith handling systems: cast basalt is abrasion-resistant. If we expand the outpost with inflatable modules shipped from Earth at significant savings in weight per usable volume over hard-hull modules, we can use cast basalt products, including floor tiles and tabletops to help outfit these elbowroom spaces. We can learn from a thriving cast basalt industry on Earth.

Experiments done on Earth with lunar simulant, of similar chemical and physical composition to lunar regolith, then repeated with precious Apollo moondust samples, give us confidence that concrete and glass composites will be very important in any future construction and manufacturing activity on the Moon. We could make additional pressurizable modules from fiberglass reinforced concrete or glass composites. We can make spars for space frames and many other products out of these composites as well. The Moon's abundant silicon will allow us to make inexpensive solar panels for generating power. Production of usable metal alloys will come later. The Moon is rich in the four "engineering metals:" iron (steel), aluminum, titanium, and magnesium

An Industrial Diversification Strategy with maximum potential for cutting dependence on Earth imports

The name of the game is Industrial "**MUS/CLE**." .

- **MUS:** If we concentrate on producing on the Moon things that are **M**assive, yet **S**imple, or small but needed in great numbers (**U**nitary) so as to provide the major combined tonnage of our domestic needs, we will make significant progress towards lessening the total tonnage of items needed from Earth to support the expansion effort.
- **CLE:** Until we can learn to make them ourselves, we continue to import the **C**omplex, **L**ightweight, and **E**lectronic items we also need, but which together mass to much less. It would be very helpful to the success of such a strategy, to design everything needed on the Moon as a pair of subassemblies, the MUS assembly to be manufactured locally, and the CLE assembly to be manufactured and shipped from Earth, both being mated on the Moon.

Simple examples are a TV set: works manufactured on Earth, cabinet on the Moon; a metal lathe built on Earth, its heavy table mount manufactured on the Moon; steel pipe and conduit on the Moon, all the fittings and connectors from Earth. You get the idea.

As the population of pioneers and settlers grows, and our industrial capacity becomes more sophisticated and diversified, we can assume self-manufacturing of many of those items as well. Making clear and steady progress in assuming an every greater share of self-manufacturing physical needs is essential if we are going to encourage both continued governmental support and attract every greater participation by private enterprise

Paying for the things we must import

Seeing that Earth seems rather self-sufficient, and products from the Moon would be expensive, many writers have concentrated on trying to identify "zero mass products" such as energy, to provide the lunar settlements with export earnings. The need for exports is indeed vital. As long as the settlement effort must still be subsidized from Earth, there will always be the risk of unrelated budgetary pressures on

Earth fueling support for those who would pull the plug on lunar operations.

Thus it is vital that settlers develop products for export to help them pay for what they must still import. Only when we reach import-export parity, will the lunar settlement have earned "permanence." Permanence can't be simply declared. Tagging NASA's first moonbase as "a permanent presence on the Moon" is in itself just so much empty bravado. If we do not begin developing and using lunar resources seriously and aggressively, the effort will fail of its own costly weight.

Now here is the point where many will balk. Yes, there are grandiose plans to use lunar resources to build giant solar power satellites in geosynchronous orbit about the Earth, or to build giant solar farms on both the east and west limbs of the Moon to beam power directly to Earth, and/or to harvest precious Helium-3 from the lunar topsoil or regolith blanket, a gift of the solar wind buffeting the Moon incessantly for billions of years, the ideal fuel for nuclear fusion plants. But none of these schemes will materialize right away. Meanwhile what do we do? Cannot anything the Moon might manufacture to ship to Earth be made less expensively here at home? No!

But that does not matter. Earth itself is not the market. Developing alongside of an upstart settlement on the Moon will be tourist facilities in Earth orbit. And that is something the lunar settlement effort can support. Anything future Lunan pioneers can make for themselves, no matter how unsophisticated in comparison with the vast variety of terrestrially produced alternatives, can ge shipped to low Earth orbit at a fraction of the cost that functionally similar products made on Earth can be shipped up to orbit. It is not the distance that matters, but the depth of the gravity well that must be climbed. It will take one twentieth of the fuel cost to ship a set of table and chairs, a bed frame, interior wall components, floor tiles, even water and food, from the Moon, 240,000 miles away, than from Earth's surface, 150 miles below.

Thus, in the near term, the future of Lunar Settlement will be closely tied to the development of tourist facilities, hotels, casinos, gyms, etc. in orbit. This sort of development will start to bloom about the same time as a lunar settlement effort starts to break out of an initial limited moonbase egg. But the linkage will become visible much earlier: it is very likely, that the first space tourist will loop-the-Moon, without landing, before the first astronaut since Apollo 17 in 1972 sets foot on the Moon.

The Russians say that they can provide such a tourist experience, skimming low over the Moon's mysterious farside, in just two years after someone plunks down $100 million. That will indeed happen, and it will create a benchmark that others will want to follow, inevitably brining the price down for a ride to an orbiting resort.

The Moon from a Settler's Point of View

Magnificent Desolation? Yes. Harsh and unforgiving? That too. Alien and hostile? Of course! It has always been so from the time our ancestors on the plains of East Africa started pushing ever further into unfamiliar lands: the lush, dense jungles, the hot dry deserts, waters too wide to swim, high mountain ranges, and eventually, the arctic tundra. Judged by the pool of past experience, each new frontier was hostile, unforgiving, and fraught with mortal dangers .. until we settled it anyway.

Once we learned how to use unfamiliar resources in place of those left behind, once we learned how to cope with any new dangers, as if by "second nature," then the new frontier becomes as much home as places we left behind. Anyone raised in a tropical rain forest, suddenly transported to Alaska's north slopes, might soon perish, unable to cope. The Eskimo never gives it a second thought. How to cope with ice, cold, the arctic wildlife, the absence of lush plant life, has become second nature.

And future Lunans will reach that point as well. Yes there is sure suffocation outside the airlock. Yes the sun shines hot and relentlessly with no relief from clouds for two weeks on end. Yes the Sun stays "set" for two weeks at a time while surface temperatures plunge. Yes the moon dust insinuates itself everywhere. The litany goes on and on. Lunans will learn to take it all in stride. How to take due precautions for each of these potential fatal conditions will have become culturally ingrained 2nd nature. The Moon will become a promised land to Lunans.

Making ourselves at Home

Even in the first lunar outpost, crew members could bring rock inside the habitat as adornment in itself, or perhaps carve one into an artifact. An early cast basalt industry, early metal alloys industries, early lunar farming, will all supply materials out of which to create things to personalize private and common spaces alike. Learning to do arts and crafts on the Moon may seem useless and irrelevant to some, but it will be the first humble start of learning to make the Moon "home." And so it has been on every frontier humans have settled.

We will also learn to schedule our activities and recreation in tune with the Moon's own rhythms. We'll do the more energy-intensive things during dayspan, the more energy-light, manpower-intensive things saved for nightspan. With no real seasons, the monthly dayspan-nightspan rhythm will dominate. The pioneers may bring some holidays with them, but will originate other festivities and both monthly and annual celebrations.

Getting used to lunar gravity will also help the pioneers settle in. They will quickly abandon trying to adapt familiar terrestrial sports, which can only be caricatures of the games of Earth. Instead, they will invent new sports that play to the 1/6th gravity and traction, while momentum and impact remain universally standard. Alongside the development of lunar sports will be forms of dance. Can you imagine how ethereal a performance of Swan Lake would be on the Moon? How many loops could an ice-skater do before finally landing on the ice?

But they have to live underground!

On Earth, our atmosphere serves as a blanket which protects us from the vagaries of cosmic weather: cosmic rays, solar flares, micrometeorite storms. If our atmosphere were to "freeze out" it would cover the Earth with a blanket of nitrogen and oxygen snow about 15 feet thick, and still provide the same protections.

On the Moon, eons of micrometeorite bombardment have pulverized the surface and continue to garden it into a blanket of dust and rock bits 10-50 feet thick. Tucking our pressurized outpost under such a blanket, will provide the same protection, along with insulation from the thermal extremes of dayspan and nightspan.

Will our outposts look like somewhat orderly mazes of molehills? To some extent, perhaps; but the important thing is that we do not have to live as moles. We have ways to bring the sunshine and the views down under the blanket with us. In the spring of 1985, I had the opportunity to tour a very unique Earth-sheltered home 20-some miles northwest of Milwaukee where I live. Unlike typical earth-sheltered homes of the period, TerraLux (EarthLight) did not have a glass wall southern exposure. Instead, large mirror faceted cowls followed the sun across the sky and poured sunlight inside via mirror-tiled yard wide tubes through an eight-foot thick soil overburden. Periscopic picture windows provided beautiful views of the Kettle Moraine countryside all around. I had never been in a house so open to the outdoors, so filled with sunlight, as this underground one. At once I thought of lunar pioneers, and how they could make themselves quite cozy amidst their forbidding, unforgiving magnificent desolation. The point: yes, the Moon is a place very alien to our everyday experience. Nonetheless, human ingenuity will find a way to make it "home."

What about us outdoorsmen?

While Lunans will find plenty do do within their pressurized homes, workplaces, and commons areas, many will miss the pleasures of outdoors life on Earth. Fishing, swimming, hunting, boating, flying, hiking and mountain climbing and caving. The list goes on and on.

Yet some of these pleasures we may be able to recreate indoors,fishing in trout streams, for example. We will want an abundant supply of water, and waste water in the process of being purified can provide small waterfalls and fountains, even trout streams for fishing and boating. In large high ceiling enclosures, humans may finally be able to fly with artificial wings, as Icarus tried to do.

Out-vac, out on the vacuum washed surface, it will be more of a challenge. Present space suits are too cumbersome, too clumsy. We need suits that offer more freedom of motion, that tire us less easily. Then out-vac hiking, motor-biking, mountain climbing, and caving in lavatubes will become practical. Out-vac sporting events, rallies, races, and games will follow. As we learn to take the Moon's conditions for granted, and to "play to them," we'll invent sporting activities that suit the environment.

Agriculture and mini-biospheres

The idea of going to the Moon with sterile tin cans and a life-support system tucked in a closet with a few token house plants thrown in for good luck is absurd. As it happens, NASA has abandoned "Advanced Life Support." Instead we have to approach creation of living space on the Moon as a mating of modular architecture with "modular biospherics." Every pressurized module should have a biosphere component, so the two, living space, and life in that space, grow a pace, hand in hand. The clues are not in the organic chemistry labs but in the many down to earth "back to earth" experiments thriving on Earth as we speak. Earth life must host us on the Moon even as it does on Earth, not vice versa. Lunar settlements will be "green" to the core. And we will feel at home.

One settlement, a world "doth not make"

The Moon's resources are not homogeneously situated. A site handy to polar ice reserves will not be near mare basalts, nor iron and titanium rich ilmenite, nor vast underground caves formed long ago bu running lava. As the lunar economy expands, we will need to establish settlements in a number of differently advantaged areas. And that will make the Moon a real "world." Lunans will be able to travel elsewhere, get away from it all, experience cultural, artistic, archeological, and climate variations. Even as an outpost cannot be "declared" permanent, neither can a solitary settlement. No matter where we choose to set up shop first, we need a global vision. The authors have this vision, and their brilliant concept of a lunar railroad network illustrates that well.

Getting through the Nightspan

To many people spoiled by abundant energy "on demand," the need to store up enough energy during the two week long dayspan to allow the outpost to not just survive the nightspan, but to remain productive is daunting. Yet all of human progress is built on utilizing various forms of power storage, starting with firewood. Even in nature, the spread and survival of species has turned on this point, from bear fat to squirreling away nuts. The problem is one of attitude. Those with the right attitude will find a way, many ways in fact. The same goes for managing the thermal differences between lunar high noon and predawn. Since we first began to move out of our African homeworld to settle the planets of Eurasia and the Americas, we have tackled harder problems. Those not intimidated by the challenge will lead the way.

The pattern emerges

Lunan pioneers will make progress in all these areas together: providing the bulk of their material needs by mastering lunar resources; becoming ever more at home through lunar-appropriate arts, crafts, sports, and hobbies; creating a uniquely Lunan culture. This process must start immediately. The first outpost should be designed to encourage, not discourage experimentation by those with the urge to create and fabricate with local materials. Things shipped from Earth should be designed and manufactured in MUS/CLE fashion, so that their simpler and more massive components, made on Earth can be replaced with parts made on the Moon, freeing up the original parts for reuse. Parts made here of elements hard to produce on the Moon, like copper or thermoplastics, will help spur infant lunar industry at a quicker pace.

The Necessary Gamble

It is predictable that NASA, however free the life styles of its individual employees, will continue to take a conservative stance on fraternization between outpost personnel. It is predictable that there will be an absolute ban on pregnancies. Yet, this is something that cannot be conveniently postponed. The only way to know for sure if infants born on the Moon will turn out to be healthy, is to see how the second native born generation turns out. Will they be fertile? Experiments with animals with much shorter life cycles will give us debatable clues. There is but one way to find out for sure. Do it! Take the plunge.

Official policy may be quite strict and allow no exceptions. But then individuals will take matters into their own hands. Confidence in this outcome will grow, if there are for-profit commercial outposts on the Moon.

As long as we play the "outpost game," and that is what it is, of rotating crews with short tours of duty, as long as we avoid allowing people to choose to live out their lives on the Moon, raising families, as nature dictates, we will not see the rise of a lunar civilization, nor real use of lunar resources to help solve Earth's stubborn energy and environmental needs in sustainable fashion. Human choices must be taken out of the hands of politicians and administrators afraid of conservative opinion. Nations may build outposts, but only people pursuing personal and economic goals can give us settlement. If history is any guide, that is exactly what will happen.

Antarctic outposts are a dead-end paradigms no real use of local resources, no economic activity, no real society. For the Moon, we see instead, a real human frontier in which an initial small outpost will seed a self-supporting frontier of hundreds of thousands of pioneers in a number of settlements. Many of these Lunans will be native born, others fresh recruits from Earth seeking the promise of starting over, starting fresh, getting in on the bottom floor. Throughout history, those doing well stayed put. Frontiers have always been pioneered by the talented but "second best" seeking a more open future.

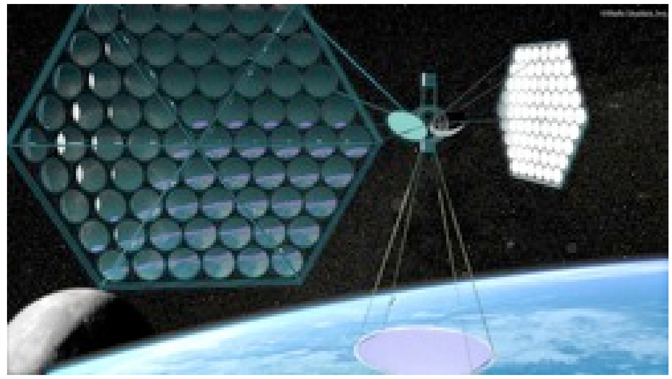
The Moon will become a human world. **<PK>**

Chandrayaan-1 Impact Probe Successful!

November 14, 2008, the probe separated on schedule and impacted the Moon near the South Pole 25 minutes later,. The photo below was snapped moments before impact.

For more about this event and the historic placing of the Indian flag on the Moon in the process, see:

http://www.isro.org/pressrelease/Nov14_2008.htm



Space-Based Solar Power – "SBSP" & Solar Power Satellites – "SPS"

A Decades old Idea Receiving Fresh Attention

By Peter Kokh

The idea of Peter Glazer in the 1960s to use the abundant "full-strength" 24-hour sunshine in space to provide Earth with virtually limitless clean energy was ahead of its time. The Space Age had just begun. In the following decade Gerard O'Neill, a physics professor at Princeton University in New Jersey, USA, developed a scenario by which we would mine the Moon for materials to build hundreds, if not thousasnds, of these huge structures to create a power belt orbiting Earth in Geosynchronous orbit. Gigantic "space colonies" would house the workers needed.

In 1977 NASA put together an in depth 185 page report. "Space Settlements: A Design Study" for the US Congress on three options for Spaced Based Power, It was not too long after the Apollo Program had been cancelled along with the last three planned Moon missions: Apollo's 18, 19, and 20. Congress made it abundantly clear that they did not want to hear the word "Moon."

These ideas were decades ahead of then current technology. NASA dutifully dropped the idea and went on to other things.

Three decades of development of more areas of technology later, technologies than we had yet to dream about back then, and, in the midst of the twin crises of environmental degradation and dwindling energy reserves, and it became clear to people in the US Air Force that it was time to dust off these premature studies and designs and reinvent them accordingly.

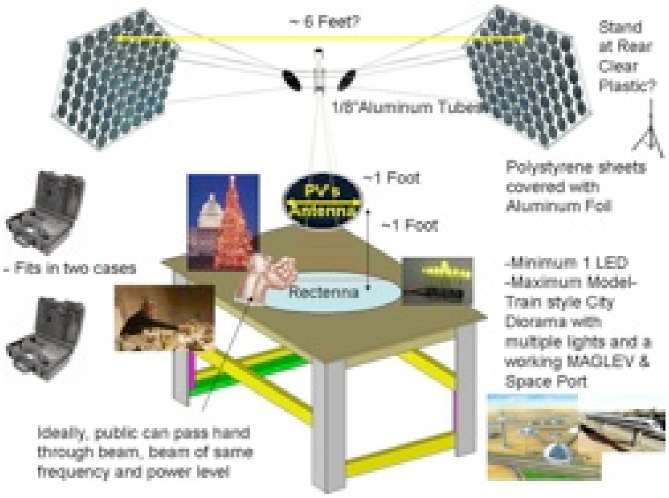
The US Defense Department's National Security Space Office (**NSSO**) had led a study group to investigate space-based solar power (SBSP) and has found SBSP to be an especially promising way to reduce US dependence on foreign-oil and as a way to reduce global warming. At a National Press Club event, October 10, 2007, sponsored by NSS (the National Space Society), the NSSO released its findings. Buzz Aldrin was one of many notables on hand.

http://www.nss.org/settlement/ssp/library/nsso.htm

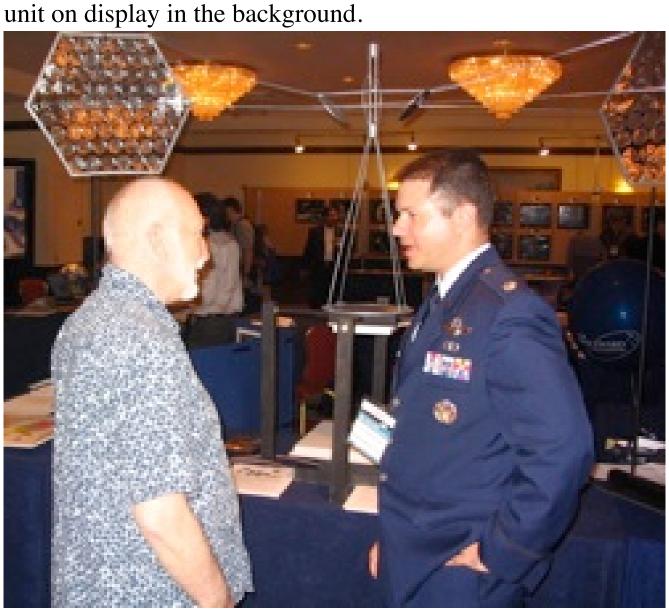
The National Space Society, in anticipation of the announcement, had put together a Thirteen Member "Space Solar Alliance for Future Energy" (SSAFE), of which, The Moon Society was one, to promote these concepts among the public, as well as to acquaint Congress with the scheme.

For its part, NSS put together a comprehensive online library of everything that has been published about these concepts to date: **The Space Solar Power Library**.

The Moon Society jumped in and undertook to design and built a working "table top" model of a current lead design for a solar power satellite.



This effort was successful and the working "demo" unit made it's debut at the 2008 International Space Development Conference in Washington, DC, May 28-June1, 2008. Three Moon Society members and one Society Advisor had been part of the 100-person plus panel that had created the NSSO Study and Report. Shown below left to right are Society President Peter Kokh and USAF Lt. Col. Peter Garretson of the NSSO office, whose design we had used, the unit on display in the background.

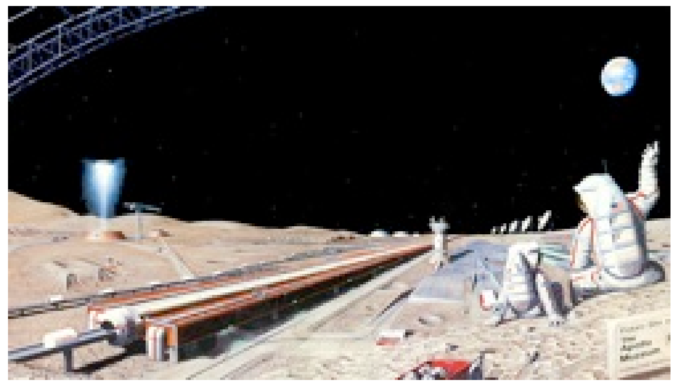


Our project had cost under US$ 1,000. The Moon Society is following up on this project, putting together an **online kit** including parts list, parts sources, diagrams, blueprints, and instructions, including the procedure to be followed to get FCC approval to demonstrate this microwave device in public. Our purpose is to allow other groups to put together their own unit and use it in public outreach. The more citizens see how space based solar power would work, the more support there will be in the US Congress for a major program to build and deploy SBSP.

This online kit is not yet ready, and we will announce it when it is available.

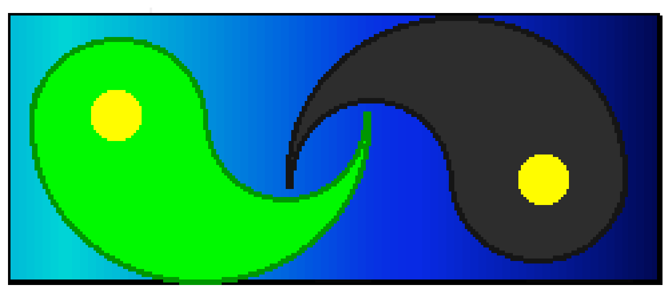
Meanwhile, The Moon Society is pursuing a "Game Plan" to identify and tackle the many technology and other issues that must be successfully addressed to make such an ambitious scheme start to become a reality.

What's in it for the Moon Society? Our interest is in being able to demonstrate that it will be both less expensive and less environment-intrusive to manufacture components for Solar Power Satellites from lunar materials, than to build them with components made on Earth and shipped up to orbit by thousands and thousands of rocket launches. Tonne for tonne, the same payload can be shipped from the Moon to GEO for a twentieth the fuel cost of shipment up from Earth's surface. Lunar sourcing would involve establishment of lunar frontier settlements, and the creation of a vigorous "Earth-Moon Economy."



Above: a **mass driver** launches unit-size payloads form the Moon to a holding area in space with maximum economy. Artwork by Pat Rawlings

One thing we are looking at is putting together the a series of **"Mother Earth – Father Sky" conferences** to begin a serious conversation between environmentalists who favor small local alternate energy projects and space solar power supporters who see that in the long run, while local alternative energy projects will slow the pace of environmental degradation, only space-based macro-solutions can solve the problem long-term.



Another thing we are looking at is launching s series of **Solar Power Beaming Contests**. But we'll leave that for Society Director of Project Development, whose contest proposal is just below. **<PK>**

NOTE: Dr. A. P. J. Abdul Kalam had spoken about India's need to deploy Solar Power Satellites in his speech at the Massachusetts Institute of Technology (MIT), reprinted in full above, pages 7-10, specifically pages 7 and 9.

A Power Beaming Competition Proposal

Second Draft November 18, 2008 David A. Dunlop,
Director Project Development, Moon Society

Goals: Develop a competition funded by either NASA under the New Centennial Competition Program or DOD under their competition authority or a combined initiative that will:

1 Advance the state of power beaming technology along the space solar power technology road map being developed by the AFRL,

2 Provide a practical demonstration of the utility of this technology that is informative, appealing to the public, and policy makers, 3 Attract the participation of student engineering teams sponsored by leading universities.

Background:

The NSSO report on Space Based Solar power generated a broad response from the space advocacy community. A coalition of 14 organizations was formed to focus attention and efforts to advance a program to provide energy beamed from space-based sources such as solar power satellites.

In October of 2008 the AFRL hosted a workshop in Orlando to assess the state of space solar power technologies, create a development road map, and define technology metrics for the short term (< 5 years), mid-term (between 5 and 10 years), and long term (> 10 years) as a means of guiding potential investments in these technologies

The Moon Society, the Spaceward Foundation, and the National Space Society as members of the Space Solar Power Coalition were represented at the AFRL workshop on the state of space solar power technology. Subsequent to the workshop I agreed to draft a competition proposal for consideration of the Moon Society, SpaceWard Foundation, and NSS and as something for presentation to both the AFRL and NASA Centennial Program that would address the above-mentioned goals as a follow on effort to the Workshop

It is the purpose of this draft to create a structure that can be critiqued and improved from those with a variety of perspectives and expertise so that this suggested competition can be funded, serve the interests of the research and development communities by providing practical demonstrations of technology, and provide a stimulus to encourage those entering academic engineering programs and the aerospace workforce

Proposal # 1 Laser Beamed Power to Ground Rover

Both military and civilian applications have been identified for a ground rover with a power supply delivered by laser. Mobile ground rovers would have military utility in monitoring the defensive perimeter of forward military bases. On the Moon both NASA and JAXA have identified rovers supplied by a laser power beam as an enabling technology that is useful in exploring the cold traps on the lunar polar regions

The Space Elevator Competition is an early demonstration of laser power beaming technology over the relatively short distances that characterize suspended tethers at present. A Short term objective (<5 years) on the solar power technology road map could be the demonstration of useful laser power delivery in the 5, 10, and 15 kilometer range to a mobile ground platform consistent with the metrics for short term research and development

We propose a competition to provide a demonstration of laser power beaming to a mobile platform in the lunar analog conditions of Antarctica. We suggest a two-stage competition

Stage One:

In stage one US university teams would compete to demonstrate laser power beaming in the US to a mobile platform beginning at the 5 km distance. The winners of this competition (The top Three Teams) would then proceed to Stage Two. As technical objectives are met then distances can be increased

Stage Two:

The finalists would be funded to demonstrate their powered rovers under the Antarctic conditions adjacent to the McMurdo base at the South Pole where there are adjacent mountains that provide an lunar analog to power beaming from a crater rim down to a rover exploring the crater interior

Additional Considerations:

The requirements for a demonstration range at both Stage One and Stage Two are an essential precondition for this proposed competition. They may be met by use of certain Federal facilities

Stage One:

A Stage One demonstration initiative is very close to the requirements of a military ground rover. Use of Federal facilities in US territory may make many of the development issues (at first blush) manageable, practical, and cost feasible. Getting the completion up and running for the first two or three years on US soil as would be a credible development path as a Stage One only competition. From an organizational perspective this would seem prudent.

It might be the case that the Space Port America site in New Mexico or another site close to the existing Space Elevator competition might be feasible involving the White Sands missile range. The Mohave Spaceport in California near Edwards Air Force Base is another consideration with close proximity to both affordable transportation and media coverage. A list of additional issues have been identified for later expansion and exploration.

Identification of potential Federal Test Range facilities: (DOD, NASA, DOE, Dept. of Interior)

Terrain and operational requirements: Elevated terrain with a down range beaming potential of 5, 10, 15 miles.

It might also be the case that a mountain top astronomical observatory campus might have both the elevation, powerful supply and isolated down range characteristics necessary for a day time operation posing no operational problems for those observing at night time. Sites in Arizona, Texas and Hawaii come to mind. Things to consider are; power supply, FCC & ITU requirements and regulation, supervision, physical security, safety & risk management, transportation costs and accessibility, logistics, budget development.

Stage Two:

Stage Two presents a considerable jump in organizational and management issues. The U.S. Antarctic

Program is overseen by the National Science Foundation. The McMurdo Base is supported by a NAVY run logistics chain. The costs of operating a Stage Two competition program in Antarctica might be an order of magnitude greater than at US territory in the lower 48 states for example based Stage One effort

The Antarctic Base is already a test bed for space robotic technologies so what is exceptional about this proposal is the cost differential from Stage One

We are convinced that the interested generated by the Antarctic demonstration will resonate with both the public as well as the student community. This initiative must generate interest, excitement, and credible institutional participation to be worthwhile in its productive impact on technology development, engineering education, and workforce development. Site characteristics include: Elevated terrain with a beaming potential of 5, 10, 15 miles proximate to McMurdo power supply FCC & ITU requirements and regulation, supervision, physical security, safety & risk management, transportation costs, accessibility, logistics Budget Development

Development Justification Considerations:

The efforts to develop such a competitions are substantial. It is also clear that such efforts are considerably greater at stage two in an Antarctic Environment. It is also clear that the relative costs of technology development via the use of a competition in analog environments are much below space based demonstration initiatives.

Alternative Arctic Analogs:

Other arctic analog options for a Stage Two might also exist such as those on Devon Island, Canada operated by the Canadian Space Agency and the Mars Society. Thule Air Force Base in Greenland might also be an optional location

Such arctic options also introduce the possibility of working cooperatively with international partners such as CSA, ESA, JAXA, or Roscosmos in broadening the competition by putting up prize money and sponsoring teams from their countries and hosting a demonstration site. Svalbard Island, Norway also comes to mind as a potential site. Potential sites might be provided by Russia.

Stage Two potential collaborations and sponsor-ship might also be facilitated by discussing them in the context of the International Lunar Exploration Working Group at the upcoming International Conference on the Exploration and Utilization of the Moon in late October 2008 in Titusville, Florida which I plan to attend

Mobile rovers are a key enabling technologies in both surface exploration and identification of lunar situ resources. The Space Resources Roundtable Organization is also a co-sponsor of the ICEUM Conference and therefore would logically have a stake in seeing this technology advance.

I am suggesting the cost barriers represented by the Arctic and Antarctic options may be lowered by sharing costs internationally. I also believe that the impact of the competition would be greatly enhanced. Laser power beaming under Arctic and Antarctic conditions can be clearly demonstrated to have relevance to the problems of lunar cold traps but also as near term tools in polar operations. They offer not only benefits to those working to develop laser power beaming but also to those that wish to advance human-robotic synergies such as the NASA's RATS program

These connections and collaborations of course multiply the complexity of developing this proposed competition but with commensurate potential for drawing financial and logistical support, public interest and education, and the participation of university engineering programs from around the world.

International Efforts & Activities

An International Challenge from the Moon Society The Moon Society proposal for a NASA or DOD funded competition for a laser-powered rover is a suggestion that should apply equally to other space faring nations. Conditions in space are cold. The need to explore the cold traps in lunar polar craters stretches the abilities of robotic technologies to sustain their function in the extreme low temperatures. It demands a robust power supply for mobility, the operation of sensors, and of associated activities such as drilling and collecting samples. A laser beamed power supply offers an approach that could provide the power.

The NASA Centennial Challenge funded Space Elevator Competition run by the Spaceward Foundation is a first step in developing laser beaming power supply equipment. All Moon-faring countries need to confront the rigors of powering rovers in the cold on the lunar surface by fostering both interest and research in this work. Similar non-US competitions and investment of research funding should be created. The challenged of powering a rover 5 or 10 or 15 kilometers away from a laser on an elevated point is the first step in this challenge. This step is not constrained by the need for cold temperature but by range safety requirements in the operation of high power lasers. Facilities such as the Mohave Spaceport/Edwards AFBASE or Spaceport America/White Sands might host the first stage competition.

As this first goal is achieved then this technology should have to demonstrate it reliability as a second step in cold lunar analog settings such as Antarctica, the Mars/Moon Analog program operated by the Canadian Space Agency on Devon Island or other settings on Greenland, Svalbard Island etc.

The Moon Society would encourage an international competition open to universities and student teams from all space faring countries contributing to the prize. Because concerns about the development of robust lasers having military or dual use applications all participants should be required to agree to fully disclose their technology as a condition of participation. This should insure that ITAR considerations do not create a situation preventing the sharing of such newly developed technology in civilian missions on the lunar surface or create a political resistance to the use of such newly developed technologies for nonmilitary purposes. Perhaps the X-Prize Foundation, with its Google Lunar X-Prize experience with international teams, might be a mechanism for developing a multinational laser power competition and also create a structure for media and commercial cosponsorship and support of this competition.

<DAD>

Lunar Missions of Recent Years

Robotic Exploration of the Moon – Wikipedia

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

Galileo Lunar Flybys – Dec 8, 1990 – Dec 8, 1992

http://www.lpi.usra.edu/meetings/lpsc2005/pdf/1219.pdf

http://www.lpi.usra.edu/expmoon/galileo/galileo.html

Clementine – 1994-95

http://nssdc.gsfc.nasa.gov/planetary/lunar/clementine1.html

http://www.cmf.nrl.navy.mil/clementine/

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

http://www.lpi.usra.edu/expmoon/clementine/clementine.html

Lunar Prospector – 1998-99

http://lunar.arc.nasa.gov/

http://nssdc.gsfc.nasa.gov/planetary/lunarprosp.html

http://www.lpi.usra.edu/expmoon/prospector/prospector.html

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

http://www.lunar-reclamation.org/papers/lp_prehistory_paper.htm

http://www.sciencemag.org/content/vol281/issue5382/

http://www.lunar-research-institute.org/lunar_prospector_book.asp

SMART-1

http://www.esa.int/esaMI/SMART-1/

http://www.esa.int/esaSC/120371_index_0_m.html

http://smart.esa.int/science-e/www/area/index.cfm?fareaid=10

http://sci.esa.int/science-e/www/object/index.cfm?fobjectid=31407

http://en.wikipedia.org/wiki/Smart_1

Other "Lunar Decade" Missions

Kaguya - Selene

http://www.jaxa.jp/projects/sat/selene/index_e.html

http://www.selene.jaxa.jp/en/index.htm

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

http://www.planetary.org/explore/topics/kaguya/

Changé-1

www.cnsa.gov.cn/n615709/n772514/n772543/93747.htm

http://en.wikipedia.org/wiki/Chang%27e_1

http://en.wikipedia.org/wiki/Chang'e_program

http://www.astronomy.com/asy/default.aspx?c=a&id=6160

Lunar Reconnaissance Orbiter

http://lunar.gsfc.nasa.gov/

http://lroc.sese.asu.edu/mission.html

LCROSS impact probe

http://lcross.arc.nasa.gov/

Lunar Libraries & Book Shelves

Apogee History of Spaceflight Books

70 + Individual Paperback Volumes - Titles

http://www.cgpublishing.com/Space_Series.html

Gallery of Apogee Book Covers

http://www.cgpublishing.com/Books/SPACE_SPLASH.html

Pocket Space Guides

www.cgpublishing.com/Books/POCKETS_SPLASH.html

Assorted DVDs

http://www.cgpublishing.com/Books/SER_SPLASH.html

Moon Society list of Books on the Moon (with covers)

http://www.moonsociety.org/info/moonbooks.html

Ken Murphy's Extensive Lunar Library

http://www.outofthecradle.net/categories/lunar-library/

Books for Children

http://www.moonsociety.org/info/moonbooks.html#childrens

Home on the Moon by Marianne Dyson

http://www.mariannedyson.com/hotmreviews.htm

Moon (National Geographic Children's Books)

http://www.educationoasis.com/ch_book_reviews/reviews2/moon.htm

Science Fiction involving the Moon – Book Lists

http://www.biblioinfo.com/moon/sf_moon.html

Lunar Study & Observing Certificates

http://www.moonsociety.org/certificate/

http://www.amlunsoc.org/lunar_certificate.htm

http://www.astroleague.org/al/obsclubs/lunar/lunar1.html

http://www.rasc.ca/williamson/index.shtml

Lunar Calendars

http://www.moonsociety.org/info/moon_calendars.html

http://www.lunar-reclamation.org/papers/mooncalendar_paper.htm

Miscelaneous

LPOD – Lunar Photo of the Day

http://www.lpod.org/

Directory of Lunar Place Names*

http://www.lunarrepublic.com/gazetteer/index.shtml

Lunar Glossary & Dictionary*

http://www.lunarrepublic.com/info/glossary.shtml

The Full Moon Atlas*

http://www.lunarrepublic.com/atlas/index.shtml

- *Our listing of these pages does not imply endorsement of the Lunar Republic's land/property sales program.*

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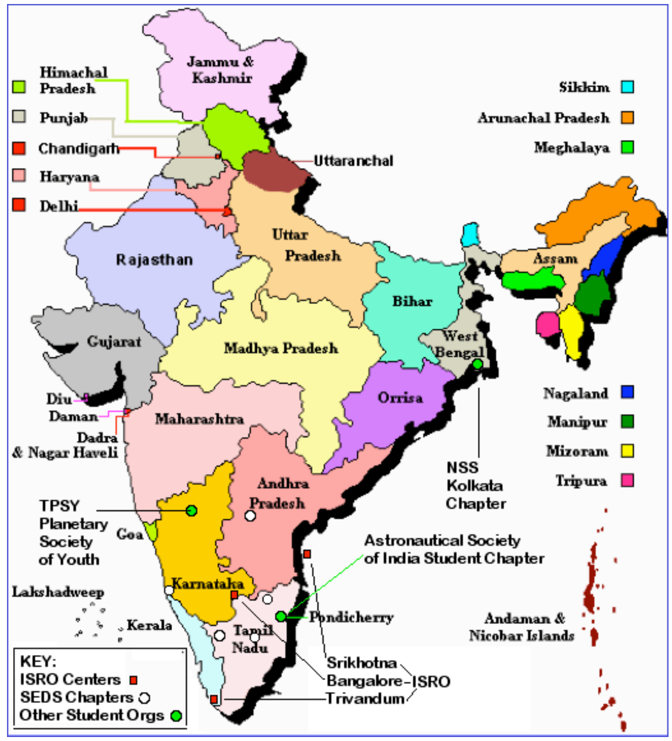

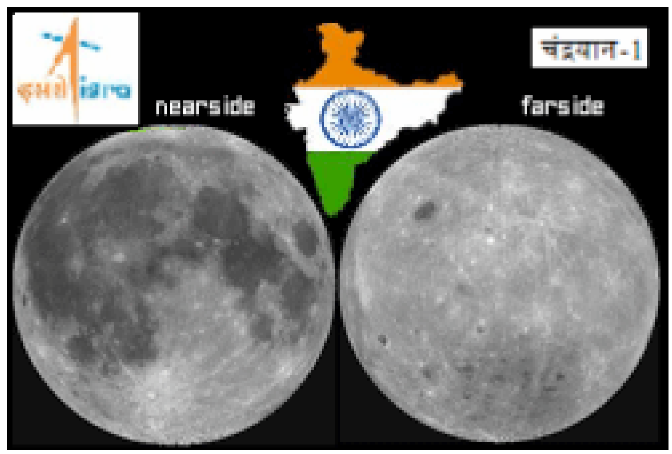

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