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

Moon Miners' Manifesto

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#221 | Starting our 23rd year! | DECEMBER 2008

Altair Lander Fuel Tanks: to reuse or to waste?

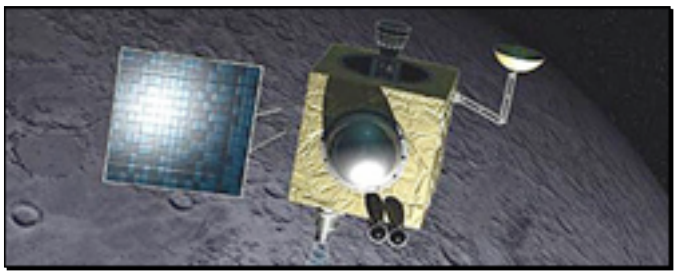
Feature Articles in This Issue

Chandrayaan-1's Science Mission

Criticized by many in India for being a "me too" mission that merely repeats what others had done, India's first lunar mission is "anything but." Its many instruments, including three from ESA and one from the US, have the capacity to map the Moon in much greater resolution than ever before, as well as discover much that we do not know, or suspect, about the Moon.

IN FOCUS India Becomes 5th Space Power to Orbit the Moon – 11/14/08

Chndrayaan-1, India's first space exploration probe, launched October 22nd, has entered its design lunar polar orbit and has begun its science mission, by releasing its Moon Impact Probe, which successfully impacted its target site near the Moon's south pole. This feat gathered a lot of publicity for largely symbolic reasons: the probe carried the Flag of India and impacted on the birth anniversary of the country's first Prime Minister, Jawaharlal Nehru. [=> p. 2, col. 2]



Moon Miners' Manifesto

Published monthly except January and July., by the **Lunar Reclamation Society** (NSS-Milwaukee) for its members, members of participating **National Space Society chapters**, members of **The Moon Society**, and individuals worldwide.

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⇒ In Focus Editorial continued from p. 1.

The flag, of course, was vaporized on impact. The real purpose of this exercise was to provide additional data from the analysis of impact debris and "splashout" to shed light on the possibility of lunar polar ice deposits suggested by the Clementine and Lunar Prospector missions. All of the current round of Moon Missions have south polar impactor components, in a cooperative effort to try to settle the lunar polar ice question. However, a series of ground-truth rover-lander missions will clearly be necessary down the road.

India's decision to enter the arena of space exploration with lunar and Martian missions, involves a choice. Many people had hoped that India would become a full partner of the International Space Station program.

India's decision was not between study of Earth and study of the Moon. Rather, ISRO had come to the conclusion that *more is to be learned about Earth* by examining the geological evidence on the Moon, where the record of bombardment over billions of years has not been erased by eons of tectonic, hydrospheric, and atmospheric weathering,

Yet, India *has been* represented on ISS. American astronaut Sunita Williams, of Indian descent, spent 195 days on ISS, a record for a woman astronaut. It is not surprising that Sunita has become a heroine in India.

As the world's largest democracy, with a population much greater than that of North America and Europe combined, India is a place where the public will help determine the future of its space endeavors. In contrast with the United States, however, public pro-space movement and space education outreach efforts are in their infancy. In comparison, real public input in China's space program is nonexistent. The government does what it wants to do, and does so without consulting citizen opinion. Of course, there is popular enthusiasm for China's recent accomplishments, some but not all of it "staged."

The point is that US-based *nominally "international"* pro-space organizations such as the National Space Society and the Moon Society, have had minimal presence in India. NSS has a Kolkata (Calcutta) chapter of unknown activity. The Moon Society briefly collaborated with the Planetary Society of Youth in India, on a student Moon Mission design contest.

The time to develop a real presence in India is at hand. To spearhead the Moon Society's efforts in India, the Society has launched a special offshoot of Moon Miners' Manifesto, the new **MMM-India Quarterly** with its first issue released on November 18th – see page 9.

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

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Initial reaction has been highly complimentary, especially from the heads of two Indian student space organizations. In time perhaps, we will have a cluster of Indian chapters. We encourage the National Space Society to follow suite.

It is of vital importance to build a groundswell of public and student support for India's infant space exploration program, and for its proposed manned lunar missions. The more players in addition to NASA, the more quickly and effectively the lunar frontier will open.

"To the Moon!" **<PK>**

LUNAR ENTERPRISES AND DEVELOPMENT

Especially prepared for *Moon Miners Manifesto*.

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Installment 5 - Conclusion

4.1 ***Lunar Start-up Enterprises***

Back in Exhibits 131 and 132, we indicated the possibilities. First, it will be in building housing and facilities, as well as providing survival systems for the lunar pioneers. These will relate to radiation protection, lunar dust, safety and wellness, water and food supplies, waste disposal, and especially communication systems, both on the Moon and to Earth.

Next the real industrialization processes will get underway – turning lunar soil with its oxides into oxygen and fuel; constructing transportation systems on the lunar surface; installing detection sensors against hazardous conditions, materials and objects, et al. In subsequent stages of lunar development, there will be a variety of undertakings – from scientific experiments and telescopes, to arranging for solar energy supplies, mining helium-3, and a host of necessary activities. The latter will include broadcasting from the Moon, lunar education and training, eventually tourism and settlement services. Should the initial lunar outpost be founded at the lunar south pole to take advantage of its shadowed craters, almost continuous sun, and view of the sun, a second site might be developed at the lunar northpole for s continuous communications center and observatory. Someday these two locations may be connected by a lunar "railroad."

Beginning with the individual responsibilities of lunar project managers and contract supervisors, regulators and administrators will likely growing in number. So will a security system of peacekeepers until a full governance system can be instituted. Whether in ground support services or orbital endeavors, terrestrial systems will have to be adapted for budgeting, funding, accounting, reporting, information management, and technology transfer. This is what we discussed as **macroplanning and management** in chapters 7 and 8

4.2 Earth - Support Enterprises

Obviously, spaceports will play a big role in lunar exploration, as Derek Webber reminded us in 7.2. Whether on the ground or in orbit, they will be critical for more than maintaining and launching spacecraft. Spaceports will be where spacefarers will be initially housed, fed, and processed before going offworld. An emerging market will be expertise in constructing lunar spaceports, beginning with the initial port of entry.. Contractors will be required to build each aspect of the lunar transportation system, from the ground to the lunar surface and around the Moon itself..

In his book, *From Footprints to Blueprints,* Michael Ross examines many dimensions of lunar development and private enterprise. 37 This Canadian engineer reminds us that all lunar activities will require support facilities and services on Earth, to a greater or lesser extent. Sometimes the stakeholders will have the necessary technical expertise within the sponsoring organization. But with increased scope and complexity of lunar enterprise, outside support will become necessary. He forecasts these emerging Earth markets providing

(1) Operational performance on the terrestrial surface;
(2) Monitoring of in-flight performance;
(3) Research and testing laboratories;
(4) Technology transfer consultation;
(5) Lunar-base simulations and mock-ups for testing layouts, ergonomics, and technical functioning;
(6) Facilities and services for lunar spacefarers, whether crew, workers, or settlers and eventually tourists (e.g., medical and psychological evaluation, etc.). To this end, the American Society of Civil Engineers has already recommended establishment of a Lunar Center for Extraterrestrial Engineering and Construction. 38

As always in any orbital undertaking, lunar space suits will have to be improved beyond those used in *Apollo* missions some forth years ago. That complete garment with helmet, gloves, and boots weighed over 200 Earth pounds, and today manufacturers can produce a suite of new, lightweight materials with improved life support and communication functions, as well as a radiation dosimeter, such as presently used for EVA's on the *International Space Station*. In addition, lunar surface vehicles and shelters will have to be designed, built, and shipped to the Moon with provisions for complete life support systems therein. Vendors will need to devise mechanism for inventory control, and monitoring, both on the ground and aloft, for all such critical equipment.

Telepresence:

One for the greatest opportunities for private enterprise is to create the necessary communication systems for people to use on the lunar surface, and between the Moon and Earth. The present mission control approach of space agencies will be obsolete by the time lunar operations are underway. Therefore, one promising possibility is the new technology available for telepresence. * To cut down on costly and sometime dangerous business travel, the old technology of videoconferencing has been updated and gone high tech, with increased speed and quality of transmission, as well as improved, high-definition screens and reception. It creates the impression among participants that they are in the same room, though individuals or groups may be very far apart. It would be the perfect communication technology to reduce the distance in cislunar space!

If the R & D were undertaken now between earthkind and spacefarers on the *International Space Station,* then it might be feasible to introduce a working system for the benefit of lunar workers and settlers by the end of the next decade. Such telepresence could not only improve business and management conferencing between Earth and the Moon, but benefit families and friends in both locations to maintain relations. It would be a counterpoint to the isolation and alienation that humans might experience on the Moon, so cut off from their fellows on the home planet.

Presently, the leading manufacturers are Hewlett-Packard and Cisco who have yet to appreciate the market prospects for their technology and services offworld. Hollywood's Dream Works is in the emerging business, using telepresence systems to make movies cheaper and faster by allowing creative types worldwide to confer without actually

* "Behold Telepresence – Far Away but Strangely Personal," *The Economist,* August 24th, 2007, pp. 57-58/

traveling to meet one another. Now imagine if this technology could also be used to transmit to the Moon the latest movies, sports, or entertainment events! The market will be there to capitalize upon in twenty years for the entrepreneurs who start now! Frost & Sullivan forecast that this innovative technology will develop into a $1.24 billion terrestrial market by 2013. Do some "mindstretching" about the market income prospects beyond Earth!

4.3 *Lunar Base Location and Expansion*

NASA, ESA, and other partners are conducting site searches for the best location of the initial outpost and/or base on the lunar surface. Some consensus is building for the South Pole near "Malapert" Mountains, but site confirmation will come after, automated mapping missions are completed.

Some planners favor a lunar lava tube site that offers radiation protection and a constant temperature environment. There is much continuing, unresolved discussion among the experts on the size, design, and composition of the first lunar outpost. Obviously, much of this material would be prefabricated and have o be initially transported to the lunar surface for assemblage by both robots and humans. Whatever the composition of these first structures, they will be buried largely underground and covered with lunar regolith for radiation protection. Once we move beyond space agency needs for a small crew of astronauts, the base will unfold as more facilities are provided for scientific research, health care, and industrial operations. When the lunar population expands and commerce is underway, undoubtedly there will be satellite structures erected away for that base at other locations on the Moon.

It was encouraging in 2005 when Italia sponsored an international conference in Venice on " Moon Base – A Challenge to Humanity" (www.moonbase-italia.org). But until NASA and its partners issue a Lunar Architecture report possibly before 2010, we can only speculate as to how this generation will proceed with its return and settlement of the Moon. However, the scientific and engineering communities have provided the public with what to expect, as our many chapter references confirm.

We can anticipate a **lunar scenario** somewhat like this: 39

_ A series at start of unmanned missions for the purposes of transporting to the Moon, of robots, cargo, shelter payloads, plus telerobotic lunar rover capable of being driven from Earth or programmed for preliminary lunar construction tasks, such as erection of telescopes and observatory...

_ The first manned lunar landing since *Apollo 17* will initially focus on astronauts' deployment and completing their own outpost shelter; establishment of life support, communications, and transportation systems; inspection of previously placed telescopes; returning to Earth, robotic collections of further lunar soil and rocks for additional analysis (petrographic, chemical, and radiometric);on-site human inspections and evaluations; further emplacement and maintenance of geophysical and astronomical instruments, plus similar precursory activities toward base expansion…

_ Technology research and development by "technauts" trained to begin the utilization of lunar resources, from oxygen and water (H-E extraction), to solar energy and mining prospects (helium-3), to broadcasting special programs to Earth's inhabitants, to lunar farming and experiments on a "critter colony," etc…

_ Expansion of the lunar population beyond contractors and technauts, to tourists and recruiting settlers who agree to live on the Moon for a year or more – this involves pre-departure and onsite training of families, and providing sufficient support services while aloft, and upon return to the home planet. (Refer back to chapter 6.)

H. H. Koelle, a respected German researcher at the Technical University of Berlin, has published on the subject, "Steps toward a Lunar Settlement." 40 As chairman of a lunar development subcommittee for the International Academy of Astronautics, he had access to some of the best global thinking on the topic as he built a lunar data bank, so his insights are significant. After presenting a compelling rationale and objectives, he examined three options for lunar transportation, recommending a single-stage-to-orbit tanker and a ferry from LEO to a spaceport on the Moon (SSTO). Dr. Koelle favors beginning with a lunar laboratory which over fifteen yeas would be developed into an outpost and refueling center. As this was enlarged into a permanent base and settlement, he envisions leasing space to commercial interests who would pursue development of lunar resources, from liquid oxygen and hydrogen to solar energy and astronomy. In a period of the next 50 years, he forecasts a lunar population of some 2,000 and a settlement that is 75% self-sufficient by year 2100.

As lunar dwellers and their infrastructures increase, our dispersal beyond Earth into our Solar System will gradually lead to the creation of a spacefaring civilization!

5. CONCLUSIONS ON LUNAR DEVELOPMENTS

Flush with excitement of initial Space Age successes, Patrick Moore, British broadcaster and author, wrote a book in 1975 about *The Next Fifty Years in Space*. One Chapter was devoted to **The Lunar Base**, which he then forecasted would become operational between the years 1995 and 2000. With hindsight, one might ask why the U.S.A. did not follow up with plans for such an undertaking after the *Apollo* mission series ended? There were many political, economic, and social factors that prevented the nation from achieving such a vision by the end of the 20th century. Now space experts from NASA and the aerospace industry estimate that a lunar outpost might be functional by year 2020. From my viewpoint both as a management consultant and as a space psychologist, it would seem that **mindset** may prove to be the stumbling block, delaying and hindering the exploitation of space resources in general, and lunar resources in particular. To cultivate positive mindsets in both the world's political and space communities , as well as mass public support, here are some suggested activities to pursue:

- ***Place individual space missions in a larger context***—to think in terms of not just individual mission, but within the context of a broader strategic plan for lunar science and industrialization; emphasizing to the public near-term return on investment …
- ***FAct synergistically in global cooperation***—today no one country or space agency can effectively undertake space macroprojects without forming international

partnerships; the sharing of talent and resources ensure long-term "paybacks" from space enterprises…

- ***Facilitate intersectoral and interdisciplinary planning*** —space macroprojects require going beyond traditional interfaces, such as public and private, science and business; investment will be forthcoming, for example, if goals include both science and industrialization, involving industry, universities, and entrepreneurs with government agencies in planning for a permanent lunar return.

The above review of current trends underscores why the next major **space** investment and undertaking by the U.S.A. and its spacefaring partners should the Moon, underscroing reimbursement to be realized for all of humanity, especially the home planet itself. Many "Mission to Planet Earth" goals can be achieved best by using the Moon as a platform for scientific, environmental, and economic advantage. The Moon can become the laboratory for international cooperation, the launching pad of humanity into the universe. Expert consensus for this is emerging as confirmed in this statement from an International Academy of Astronautics report: 41

We believe the time has come that these global trends should induce responsible governments to take action deciding to continue the development of lunar resources and consequently to assign an existing multinational space organization (or establish a new one) the responsibility of returning people to the Moon permanently and developing its resources for the benefit of mankind.

The author concurs in these recommendations, but is convinced that a "new multinational space organization" or regime must be formed to sustain joint lunar exploration, one that goes beyond but collaborates with existing national space agencies. To this end, we have proposed here the creation of **a** Lunar Economic Development Authority, and have explored several alternatives for accomplishing this goal. LEDA is considered a prototype for future space authorities that could be constituted to develop eventually other planets and asteroids in our solar system, as well as for constructing orbiting colonies as proposed by visionaries, such as the late Wernher von Braun and Gerard K. O'Neill. 42 This strategy offers a bridge over troubled waters in contemporary space policy and law, and a mechanism for constructing and really financing lunar infrastructure through public participation. This legal entity with its own Board of Directors enables national sovereignties to act synergistically in the exploration and development of the high frontier. It could not only issue revenue bonds for this purpose, but such a lunar development entity could literally build the "bridge between the two worlds of the "Earth/Moon system" by:

- Leasing land, facility, and equipment rights;
- Fund raising and fee collection from investors and developers;
- Site planning and permits for habitats & industrial parks;
- Zoning and inspection to protect lunar environmental and ecological concerns;
- Long-term management and peace-keeping within lunar settlements;
- Administering a lunar personnel deployment system, while regulating tourism.

Such practical matters have already been researched by Charles Lauer, when at the University of Michigan College of Architecture with reference to real estate aloft. He has written extensively on the financial, legal, regulatory, and design aspects of business parks in orbit that have implications for a lunar industrial park. 43 Now he is a founder of Rocketplane, Inc.

Yet another strategy for moving toward Industrialization of the Moon would be for the U.S. Administration and Congress to convoke a **White House Conference on Lunar Enterprise** that would build appropriate consensus, as well as lunar policy and strategic planning (see Epilogue). Another action would be for the United Nations to sponsor a global summit for the world community to consider a lunar development agenda, possibly under the aegis of the UN Office for Outer Space Affairs. Like previous convention sessions, this might be called **World Space Congress 2010.**

If such official leadership is not forthcoming, then transnational enterprise will act to fill the vacuum and promote space resource development and commercialization. 44 Since the beginning of the Space Age, the military of several countries have lusted for bases on the high ground, especially the Moon. Better to delimit their role to helping with space transportation, construction, and peacekeeping! The prophetic Krafft Ehricke envisioned lunar industrializaton as our **extraterrestrial imperative**, warning of the consequences with no-growth policies .

Obviously, pursuing lunar development is a growth policy for our world. Right now within the human family, there is much chaos and international destruction. How much better it would be for humanity to turn people outward and upward toward the stars in the space exploration and development! It might pull the international community together in common cause, and give youth hope for offworld participation! The high frontier opens up all kinds of future possibilities, as Exhibit 11illustrates.

EXHIBIT 11 * FUTURE POSSIBILITIES

Future Possibilities – Humans offworld on other celestial bodies will engage in a variety of activities, some traditional and some never done before. An artistic rendering of "things to come." *Source:* NASA Headquarters

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The above essay, serialized in 5 parts, was specially prepared for ***Moon Miners Manifesto***. © Philip R. Harris, 2009

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www.moonsociety.org/publications/papers/lunarenterprise.pdf

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Investing in Fuel Tank Infrastructure in the Architecture of Lunar Exploration

November 2008
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Background

At the **ICEUM*** 10 Conference Dr. Harrison Schmidt made a comment made about the NASA Altair Lunar Lander s having a proposed ascent system using hypergolic fuels. His concern was that reliance on a hypergolic fuels system would strategically preclude the subsequent use of in situ produced fuels such as liquid hydrogen and liquid oxygen. [* **I**nternational **C**onference on the **E**xploration and **U**tilization of the **M**oon]

The ability to produce in situ fuels is one of the major strategic objectives that will enable the scientific exploration and utilization of the Moon. Dr. Schmidt was reinforcing a view shared by many in the Space Resources Roundtable and the Moon Society that oxygen production should be one the highest strategic priorities of the technology development roadmap. The discovery of concentrated ice deposits in the polar cold traps would accelerate this possibility by refueling both hydrogen and oxygen tanks as well as storing water.

The technology roadmap currently involves a demonstration goal of producing 1 ton of in situ oxygen. (1) Few would argue against the proposition that one ought to crawl before one walks, but by the same token it is important to look strategically at the plans for use of landed assets, or the lack thereof, and try to eliminate roadblocks to more rapid utilization of in situ resources and of use of infrastructure for a variety of exploration, research, and commercial purposes.

The strategic roles of tank infrastructure NASA's Tank Contribution The NASA's Vision for Space Exploration has resulted in a lunar exploration architecture that results in three Ares V missions to the Moon per year beginning in 2020 in the build up of a lunar outpost. (2)

Each Altair lander descent system will leave 4 oxygen and 4 hydrogen tanks on the lunar surface with a

capacity of 27 tons. Thus, each year, 12 oxygen and 12 hydrogen tanks with a combined capacity of 81 tons are delivered to the surface. Between 2020 and 2025 some 18 landers will be left at the lunar outpost with a total tank capacity of 1,458 tons. (3)

ESA Tank Contribution NASA has also been coordinating the development of its Constellation architecture with ESA so that there can be a complimentary effort. ESA is now studying development of a lunar cargo lander, based on the commercial Ariane V launcher, with the capability to deliver 1.2 tons to the lunar surface. Such ESA cargo landers will presumably also deliver a significant set of oxygen and hydrogen tanks to the lunar surface.

The other spacefaring members of ILEWG: CNSA, ISRO, JAXA, ROSCOSMOS, will similarly deliver tanks to the lunar surface with their landers. One hopes that similar efforts to coordinate the development of the lunar exploration architecture of these agencies in a mutually advantageous manner can occur as ISRO, JAXA, ROSCOSMOS, and CNSA etc. lay out their technology development roadmaps.

Valuing Tank Infrastucture

The value of these tanks is their necessity in getting to the lunar surface in the first place. Secondary utilization of these tank has great strategic importance. These empty tanks are potential beginning elements of commercial, industrial, and research infrastructure on the lunar surface. Potential uses include:

The fuel tanks, if refueled could potentially enable the reuse of an Altair vehicle. The capacity to refuel and reuse an Altair could enable sortie missions across the lunar globe. A number of such vehicles would also make for a redundant capacity for exploration or rescue of human crews on extended treks if needed.

The tanks if refueled can provide a "back-up" source for life support gases for habitation at the lunar outpost. These tanks could provide an operational reserve for crews whose life support systems failed or where some catastrophic accident has occurred with primary supplies. This reserve could buy the crew the time needed for a rescue attempt.

The tanks if refilled might provide refueling of other vehicles as a "lunar gas station." This fuel capacity serving all space faring nations involved in landing at a lunar outpost could provide the beginning of commercial activities on the Moon.

ILEWG could develop a collaborative model of the lunar supply chain to the lunar outpost involving all of the launchers and landers of its members. A whole systems model of fuel demands and of fuel storage on the lunr surface might be developed. This model could then "inform" the design of common service and support facilities.

A "**Lunar Port Authority**" could serve as the purchasing agent and thus acquire its "tank farm" from national space agency transportation providers. A Lunar Economic Development Authority (LEDA) could be a target of private investment capital in the creation of servicing facilities that facilitate both national missions and private lunar activities such as lunar tourism or commercial research. This type of model would allow a LEDA to create habitation facilities, and private laboratory facilities utilizing the BA330 units being designed by Bigelow Aerospace or possibly lab modules already flown on the shuttle by SpaceHAB, as well as tank farms and refueling facilities.

These considerations would be a proper issue for ILEWG to discuss as a matter of developing interoperability standards and hardware for gas exchange systems and tank farm infrastructure. The tanks might be used for storage of other in situ volatiles that would result from an end-to-end demonstration of processing in situ materials.

The designation of the ISS as a national lab facility by the US provides a powerful precedent for the creation of dedicated laboratory facilities at a lunar outpost. It would be logical to expect nations with human lunar programs to extend their program by adding research facilities just as has happened with both ESA and JAXA on the ISS. Tanks that have been used as part of a transportation architecture might also with modification do secondary duty in curation of lunar samples. They might provide a mechanism for transport of lunar samples (when fully purged) preserving the vacuum environment on return to Earth or as elements of a curation system storing lunar samples brought back to the lunar outpost in a sealed "protective" container to maintain their pristine condition in a curation environment on the lunar surface.

These tanks could be sold to the LEDA authority or another commercial entity thus recapturing a significant share of the capital invested in the transportation services. This secondary market for the tanks could therefore reduce the cost of transportation services. It also provides "price points" for those wanting to model the cost of acquiring lunar infrastructure and of the investment requirements of a lunar surface market.

There are no doubt other uses that can be suggested for these tanks. Dr. Schmidt's concern's only underscores the importance of taking these varied considerations in mind in the beginning engineering design of the tanks themselves and of identifying the secondary markets for these tanks.

No More Missed Opportunities for Commercialization

There were many suggestions over the years for the use of Space Shuttle tanks in LEO but no action was taken by NASA perhaps because no credible near term market existed for their use. Perhaps it is easier to envision many secondary uses for these tanks on the lunar surface in conjunction with growth of a lunar outpost. These secondary uses would represent the next enabling stages of the evolution of a lunar outpost into a lunar base.

Groups such as the Space Resources Roundtable, and LEAG, should consider the needs of the in situ resource research community for tankage as part of defining a laboratory facility capability for in situ research and demonstration. This definition should also information NASA's commercialization initiative and the need to develop both contractual and legal frameworks for secondary tank utilization. The design and engineering work of the Altair should "set up" the infrastructure of secondary utilization.

The same recommendation is made for ESA lunar cargo lander and the other members of ILEWG and OSEWG that are landing on the lunar surface. (1) (2) (3)

<DD>

PARADIGM SHIFT

Editorial Commentary on the Article Above

By Peter Kokh

We wholeheartedly endorse the proposal of David Dunlop that fuel tanks on the proposed Altair Lunar Lander, and all other craft being designed to land on the Moon, be designed for reuse on the Moon.

We have, in fact, called for the design of *all lander compo*nents not returning to space, to be pre-designed to serve other "post-consumption" needs on the Moon. See our article "Thinking Outside the Mass Fraction Box, I" in MMM #209, October 2007, page 3.

http://www.lunar-reclamation.org/papers/mass-fraction-box.html

We also touched on this design mandate in our series, "The Outpost Trap," particularly in Part I, MMM #198, September 2006. This series is now online:

www.lunar-reclamation.org/papers/outpost_trap.html

Dave has shown his paper to a number of notables inside and outside of NASA with very mixed results. Those coming from industry in general had a positive reaction, those from NASA, nothing but criticism. That's to be expected.

The problem is that NASA's eyes are focused on its narrowly defined mandate: to place an occupiable camp site (not an occupied moon base) on the Moon. Any money, however trivial, spent on tweaking a component's design so that it has some future use in a scenario of expanded operations cannot be considered.

Of "ladders and rungs": a lesson from ISS

This kind of thinking, looking at each "rung" in a ladder as an end in itself risks creation of a "rung-like" entity that does not lead to a next "rung." Witness the International Space Station, put by political compromise in a high inclination orbit that precludes its usefulness as a depot or staging point for deep space missions. The Station's only use is for Earth Observation. ISS is the pride and joy of "yo-yo space" or reflexive space or intransitive space. That is not to downplay its usefulness as such. But those of us who lobbied long and hard to realize von Braun's "stepping stone to space," got something quite different than what we wanted.

NASA mission planning and architecture is the miscreant pride and joy of a budget process that is incapable of looking forward. And those of us who waste our time lobbying Congress to do this and that do just that, "waste time."

The need for a "Paradigm Shift"

We need a paradigm shift, one designed to keep the ladder in mind, tasked with designing every rung to be pregnant with the next rung, and on and on. To get that shift, we have to widen the list of players. NASA and the US Government are useful, but cannot alone deliver, and must not even be allowed to play "the" anchor tenant role.

Thinking beyond NASA

We need to bring into play the space agencies of other nations: ESA, Russia, China, India, Japan, and others not yet at the table. But we also need to bring industry and enterprise, not just as "under contract" but as contractors and service providers, who will someday build their own facilities on the Moon to serve the various international agencies, enterprises such as tourism, mining operations, science installations, and more yet unforeseen.

Once we are talking cooperation between a number of agencies, a number of contractors, and a number of service providers, the logic of cheating the "Mass Fraction" limit on launched payloads, by designing every component needed for the journey *to* the Moon, for an after-life service *on* the Moon. That way, the "landed payload mass" includes not just habitat and needed equipment, but every last bit of the non-returning lander consist – tanks, struts, winches, platforms, legs, pads, ladders, cargo holds, and so on.

A lesson from poverty

Among the poor, the culture of using *everything,* and wasting *nothing,* is well known. In cooking a pig, one uses "everything, but the squeal!" Because building and expanding operations on the Moon will always be more, much more, expensive than similar operations on Earth, we must adopt the same philosophy, of "using everything but the squeal." *Every item we can reuse is an item we do not have to pay to ship from Earth.* Its freight was paid for in the shipping charges for the cargo per se.

"Making every step pregnant with the next" will lead to a timely, "inflationary" expansion at an ever accelerating rate. For NASA to create an industrial settlement on the Moon, one self-limited step at a time, could take centuries. If we shift the paradigm, we could have the start of a settlement within a decade of our first crewed return to the Moon. This will be inconceivable to those whose minds have become imprisoned in NASA-Congressional-Budget-Process-culture.

The Paradigm must shift not only as to what we define as "landed payload" on the Moon, but as to the current dismissal of the benefits of "leveraging" that come from refueling along the way and taking anything that could conceivably be reused to the next platform level: LEO, GEO, L1, LLO etc.

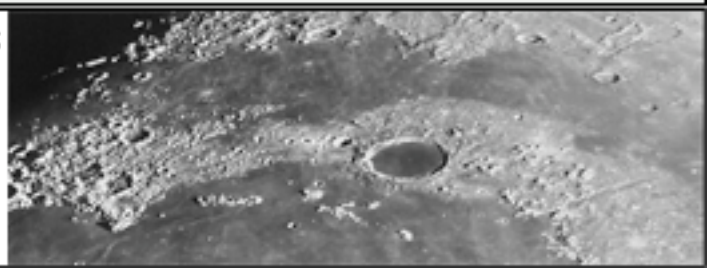
NASA dismisses "refueling" and "fuel depots" as inefficient. Yes, if you are only looking a one mission, or a very limited series of missions, rather than an every growing and evolving "inflationary" build-out of operations on the Moon. Change the goal, and the equation changes with it. If NASA will not or cannot change its concept of the goal (each rung as an end in itself, not necessarily leading to another rung), then NASA must be demoted as "the player" to the status of "a player."

The Moon Society's role

At the top of our homepage there is a declaration that we were "formed to further the creation of communities on the Moon involving large-scale industrialization and private enterprise. Following the link, we are pledged to complement "NASA initiatives and goals by looking for alternative options to advance research goals NASA is no longer able to undertake." Not all of our members are aboard yet, but our role is clear. **<PK>**

The Moon Society www.moonsociety.org

An international nonprofit 501(c)3 educational and scientific organization formed to further the creation of communities on the Moon involving large scale industrialization and private enterprise



Objectives of the Moon Society

include, but are not limited to:

- Creation of a spacefaring civilization which will establish communities on the Moon
- Promotion of large-scale industrialization and private enterprise on the Moon
- Promotion of interest in the exploration, research, development, and habitation of the Moon, through the media of conferences, the press, library and museum exhibits, and other literary and educational means
- Support, by funding or otherwise, of scholarships, libraries, museums and other means of encouraging the study of the Moon and related technologies
- Stimulation of the advancement and development of applications of space and related technologies and encouragement their entrepreneurial development
- Bringing together persons from government, industry, educational institutions, the press, and other walks of life for the exchange of information about the Moon
- Promoting collaboration between various societies and groups interested in developing & utilizing the Moon.
- Informing the public on matters related to the Moon
- Provision of suitable recognition and honor to individuals and organizations which have contributed to the advancement of the exploration, research, development, and habitation of the Moon, as well as scientific and technological developments related thereto.

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.

Our Full Moon Logo above:

The Moon in its natural beauty, empty and deceptively barren, waiting for human settlers to shelter and to mother as their adopted second human home world. We have work to do!

Masthead Design: Charles F. Radley, Society Vice-president

Our Decision to launch a new publication:

MMM - India Quarterly

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

By Society President and MMM Editor, Peter Kokh

At the November 5th meeting of the Moon Society Management Council, MMM Editor Peter Kokh floated an idea: creation of a special MMM-India Quarterly publication in pdf file format only, with totally free download access targeted at space supporters and enthusiasts in India, but available to anyone, anywhere. The reaction was unanimously supportive.

Thirteen days later, on November 18th, the eve of the next Management Council meeting, the first edition was released and notice sent to all the email addresses we could find for people in India interested in, or involved in India's space program, and in India's Chandrayaan-1 Moon mission currently in progress. This orbiter had begun its science mission just four days earlier. Speed was essential if we were to introduce MMM-India Quarterly at the crest of public enthusiasm in India.

The rationale behind this initiative is stated in this month's In Focus Editorial. India's space program will grow or whither depending upon public support. Yet, prospace organizations and public space outreach and space education in India are undeveloped when compared to the long history of such organizations and activities in the United States.

It was also time to take the Society's declaration that it intends to be International in scope to the next stage. We have to quit waiting for international members to find us. We have to aggressively expand our presence and programs, in India – for starters!

In the Draft Strategic Plan to Grow the Society, growing the Society's international profile is a key item. Outside the US, we have only a few scattered individuals – "Outposts" at best, no real "Chapters." Again, we must be proactive and aggressive. Wishing will not make it happen. Attracting Indian contributors and assistant editors is essential.

We do not know what this new effort will lead to down the road. A family of Indian chapters, with an autonomous council? That would be ideal. We are already working on the next MMM-India Quarterly issue, and on expanding our email circulation list in India. We also want to market "m3IQ" ito Indians living and working in the United States (and to their friends and families "back home.")

Is this something, if successful, that we can try elsewhere? We're working on it! Stay tuned. **<MSJ>**

Reports from busy Society Leaders

A New Conference?

Our ever busy Vice-president, **Charles F. Radley**, is working with **Rich Thoma** on a new conference to concentrate on Space Based Solar Power. The target venue and date is Las Vegas, NV in mid-February 2010. There will be an amazing 300,000 sq. ft. of exhibit space.

To help, contact Charles Radley charles@stratowave.com and/or Rich Thoma at richthoma@gmail.com.

Name TBA

At first dubbed the "New Space" Conference, but the name is in use by the Space Frontier Foundation.

A Big Tent: A conference for members of all groups, with as many co-sponsors as possible.

Themes: Partial List:

- Hope for Sustainability issues on Earth through the Private Commercial use of Space
- How we got Here -- What we are Doing Now - Where we are Going

Concurrent Events:

- Space Tech Transfer - Space Law - ITAR - Venture Finance & Risk - Space Tourism - Space Public Policy - Space Treaty Pro & Con - MicroGravity - Launch Systems, Software & Space Materials - Engineering Space Structures - Space Based Solar Power - NASA Road Map

Forum Events

- Moon / Mars / Asteroid - Debate Forum
- Economic Returns & Green Returns from Space - Space Jobs Outlook -

Conference Topics

- Space Tourism 2010 - Options & Time lines
- Destination Moon 2010 - Short Stay to Communities
- Mining the Galaxy - Minerals & Gases to Solar Power
- Manned Mission to Mars - a Bridge too Far ?

Speakers TBD

Where is our Solar Power Beaming Demo unit now?

Board member and society Director of Project Development, **David A. Dunlop** had brought the Society's Solar Power Beaming Demonstration unit back with him from Florida, where he had exhibite it at the ILEWG-sponsored International Conference on the Exploration and Utilization of the Moon (ICEUM) at the end of October, to his home in Green Bay, Wisconsin, planning a series of show & tell events in Wisconsin and Illinois and perhaps elsewhere in the Midwest. Meanwhile, as the unit needed repair as well as re-packaging prior to its next showing in Milwaukee at the 22nd anniversary holiday party and potluck of the Lunar Reclamation Society in Milwaukee on December 13th, Dave brought the unit down to the home of **Peter Kokh** in Milwaukee. (LRS has been the publisher of MMM since December 1986.) Peter has has now made some repairs as well as developed a much more compact yet damage-resistant packaging system for transit and shipment of the unit. Our experiences with the unit's fragility and packaging challenges are useful in making upgrades in a "new and improved" version that will be the basis of "online kits" that will allow other groups and individuals to reproduce SPB demo units of their own. The more units out there, the more people will get a chance to see them, and understand the promise of space based solar power. **<MSJ>**

Swedish Moon-Mine Project Advances

A Lunar Analog Research Facility in the making

http://www.moon-mine.com/

From Niklas Järvstråt niklas.jarvstrat@hv.se

Notice the new mage link down the right hand column on the Moon Society's homepage.

See previous report in MMM #215, May 2008, page 11

In planning by the Moon-ISRU Consortium since 1994, this Moon-Mine will be a demonstration facility to show that it is possible to create a self-sufficient human community on the Moon.

The mine is located in a very pretty part of middle Sweden. The coordinates are N 59*30'44" and E 14*58'41".

This ambitious project will convert a long unused mine into a Lunar Analog Research Facility. The empty sections of the mine are an analogy not just for lava tube installations, but for all lunar 'underground' living spaces, even those deployed on the surface, then covered up with a protective blanket of moondust 2-5 yards/meters thick.

Ideas that could be pursued in a mine environment:

- Habitation and agriculture design - layout and design to make a tunnel "feel" like outdoors and open space.
- Artificial light agriculture - or even better, agriculture using fiber-transmitted sunlight.
- Collecting and distributing sunlight for agriculture
- Low equipment production facilities (Extracting iron from the low-grade ore that might still be available in this mine and using the iron for producing metal parts.)

The **home** page contains a schematic of all the various elements it will take to create a viable human settlement. The **Photos** page has photos of the various surface structures as well as some from inside the mine. The **maps** page sketches a cross-section at the 110 meter (360 ft) level as of the end of active mining in 1967.

A translation of the **Draft Plans** page (now only in Swedish) is in the works. We look forward to that and we will keep members and readers posted. The sponsors and friends page, in alphabetical order, includes the Lunar Reclamation Society, Moon Miners' Manifesto, and The Moon Society, as well as a divers' club, a printing service, a developer of mine automation systems, and a university specializing in research in manufacturing process development and automation, with more to come.

At left: Niklas Jarvstat

If developed as proposed, this analog facility will be by far the most ambitious ever attempted. But it can start small and grow feature by feature.

The Moon Society Management Council voted on December 3, 2008 to endorse this effort and help attract attention to it. **<MSJ>**

NASA's New Analog Station at McMurdo Sound, Antarctica

MMM Special Report – reference:

www.ilcdover.com/products/aerospace_defense/habitats/lunarantarctic.htm

Last year, we caught wind of NASA's plan to set up an inflatable Moonbase structure in Antarctica. When we saw a photo of the structure, we contacted the manufacturer, ILC Dover, for the price of a similar unit, along with specifications important for outfitting. Of course, thinking big, we thought this might be an ideal structure with which to launch the Moon Society's own analog research station, albeit in a friendlier climate, with much lower logistic costs. We did not get the courtesy of a reply. That means either that we appeared to be off the wall, or that "if you have to know how much it costs, you can't afford it." Probably both.

So much for pipe dreams. But it is worthwhile to take a look at NASA's new station, which was set up this past Janurary. Many persons, myself included some years ago, have pointed out the unbeatable suitability of the Antarctic Dry Valleys (*not McMurdo sound!*) for Mars analog research station activities. Now while NASA is, at this stage, still "nominally" intent on setting up shop at the Lunar South Pole, the relevance of Antarctica simply on the grounds that it is polar and has ice, escapes us. What does not escape us is the extreme cost of the logistics involved in getting people and equipment there and back. Of course, it is a walk in the park compared to the logistics of getting things and people to the Moon and back. The point is, us amateurs need not apply.

Above: the unit test-inflated in Delaware

NASA's use of an inflatable structure is encouraging. Actually, Bigelow Aerospace would not be where it is without having been given a license by NASA to use the TransHab technologies it had previously developed in Houston. In turn, I believe, Bigelow must share with NASA all the improvements it has made on the technologies it acquired. That said, we must remember that on the Moon, and even on Mars, the demands of over-pressurization, in comparison to the vacuum (or thin Mars air) outside, will require cylinders, not flat-bottom Quonset-reminiscent shapes. Yet we can pretend that the latter is fully cylindrical with the lower half set into the surface and thus unseen. Certainly, that was our own intent in suggesting that we use manufactured Quonset huts for our own lunar analog research station, still on the drawing board for lack of resources.

We have no quarrel, then either with using an inflatable, or with using one so designed: *we wanted one of our own to play with!* Below are some more photos taken on location in Antarctica.

Unit arrives Un-inflated and weighs 1000 lbs or 455 k

The habitat can be erected by 4 people in under an hour, and can be packed and redeployed many times, and can sustain 100mph winds.

Ready to use in no time by crew of eight. Mt. Erebus volcano in background.

Oops! Can't forget the Airlock!

The plain, undivided interior

We have found no reports on NASA activities on location since this structure was erected. We will report when we learn more. **<MMM>**

What is an "analog mission?" A set of activities in an environment somewhat similar to the target location.

Chapters & Outposts

Moon Society St. Louis Chapter

http://www.moonsociety.org/chapters/stlouis/
Contact: Keith Wetzel kawetzel@swbell.net
Meetings **2nd Thursday** monthly, Buder Branch Library
4401 S. Hampton, in the basement conference room
Next meetings Dec. 11th, Jan. 8th, Feb. 10th

Moon Society Phoenix Chapter

http://www.moonsocphx.blogspot.com/
U.C. – http://www.moonsociety.org/chapters/phoenix/
Contact: Craig Porter portercd@msn.com
Meeting the 3rd Saturday of the month
Saturdays **Dec. 20th, Jan. 17th, Feb. 21st**

In the **Music Room**, **Borders Book Store**, 1361 S. Alma School Rd. and Southern, Mesa, AZ 3 PM. – 2 blocks from Bookmans where we had been meeting,

We are trying a dual meeting setup: Craig will run meetings in the East Valley, **Chuck** in the West Valley. Our new member, Donald Jacques has volunteered to be our new webmaster (site *"Under Construction"* above.)

Chuck Lesher was interviewed for 30 minutes Wed. Nov. 12th, on **Space Based Solar Power** by Steve Kates, known here as "**Dr. Sky**" http://teentalknetwork.com/sky.htm

Moon Society Houston Chapter

http://www.moonsociety.org/chapters/houston/
Contact: Eric Bowen eric@streamlinerschedules.com
Next Meeting Place & time: TBA

Dec. 1st Meeting Report: The major topic of discussion was a presentation by our Treasurer, Ken Sweeney, on the requirements to seek nonprofit 501(c)3 status and the possibilities which that would open up for us. Ken is thinking well into the future, five or ten years down the road. Some of the goals which have been mentioned that we may pursue include:

* **Seeking research grants** on space-related technical problems, then acting as a go-between to funnel those funds to researchers.

* **Hosting a fair or expo** intended to connect the developers of technology (NASA, universities, independent inventors) with entrepreneurs and others seeking to market new technology.

* **Providing assistance to startup entrepreneurs** in developing a business plan and directing them to possible sources of capital.

College of the Menominee Nation-Green Bay* Student Chapter (*Formerly, Green Bay, WI Outpost*)

Contacts: Dan B. Hawk hawkd_0212@menominee.edu
David A. Dunlop dunlop712@yahoo.com

Meeting some Friday afternoons at the College of the Menominee Nation, 2733 South Ridge Rd, Green Bay, WI

===== Moon Society Outposts =====

Moon Society Tucson, AZ **Outpost** (now w.3 members)
Contact: Ben Nault bnault@comcast.net

Bay Area Moon Society, CA **Outpost** – South Frisco Bay
http://www.moonsociety.org/chapters/bams/
Contact: Henry Cates hcate2@pacbell.net

Moon Society Longview, TX **Outpost**
Contact: James A. Rogers jarogers2001@aim.com

Moon Society DC Metro, DC-MD-VA **Outpost**
Contact: Fred Hills Fredhills7@aol.com

Milwaukee, WI **Outpost** (MSMO)
www.moonsociety.org/chapters/milwaukee/msmo_output.htm
Contact: Peter Kokh kokhmmm@aol.com

Currently, in the US, we have 3 regular chapters, 1 Student/Campus Chapter, and 5 Outposts.

See Map: http://www.moonsociety.org/chapters/chapter_outpost_map.html

Why not start a Moon Society Outpost in Your area?

All it takes is one person – you!

Write: ***chapters-coordinator@moonsociety.org***

Get ideas from: ***http://nsschapters.org/hub/***

CHAPTER RESOURCES

By-Laws model (make appropriate modifications):
www.moonsociety.org/chapters/phoenix/ByLawsPhx.html

- Meetings and Agendas • Downloadable Flyers
- Chapter Websites • Events Calendar
- Downloadable Slide Sets • Image Libraries
- Projects Unlimited • Downloadable Transparencies
- Chapter Merchandise • Display Blueprints
- Chapter Scrapbooks • Models & Exhibits
- Growing Your Chapter • *and much more*

http://nsschapters.org/hub/

For news of our NSS Partner Chapters in

Portland – Oregon L5 Society
Milwaukee – Lunar Reclamation Society
Minneapolis/St. Paul – Minnesota Space Frontier Soc.

turn to pages 17-18.

Moon Society DUES with ***Moon Miners' Manifesto***
Electronic MMM (pdf) **$35** Students/Seniors: **$20**
Hardcopy MMM: U.S/Canada **$35** Elsewhere: **$60**
Join/Renew Online - www.MoonSociety.org/register/

Moon Society Mail Box Destinations:

Checks, Money Orders, Membership Questions
Moon Society Membership Services:
PO Box 940825, Plano, TX 75094-0825, USA

Projects, Chapters, Volunteers, and Information
Moon Society Program Services,
PO Box 080395, Milwaukee, WI 53208

< End Moon Society Journal Section >

GREAT BROWSING

Mars Wobbles Created Climate Swings
http://www.space.com/scienceastronomy/081204-mars-climate-cycles.html

Invisible Auroras on Mars Mapped
http://www.space.com/scienceastronomy/081202-st-mars-aurorae.html

Mars Science Laboratory Mission delayed to 2011
http://www.space.com/news/081204-msl-launch-delay.html

ESA delays ExoMars Rover to 2016
http://www.marsdaily.com/reports/Europe_delays_ExoMars_mission_again_999.html

Spacecraft detects buried glaciers on Mars
www.nasa.gov/home/hqnews/2008/nov/HQ_08-304_MRO_BuriedGlaciers.html

China shows most complete, most detailed Moon map
http://news.xinhuanet.com/english/2008-11/12/content_10347379.htm

ESA launches YouTube site for public
http://www.youtube.com/esa

Revisiting "Island One" Space Settlement Concept
http://www.thespacereview.com/article/1238/1

From the Garage: amateyr technology R&D
http://www.thespacereview.com/article/1239/1

Project Manhigh 50th Anniv. of highest Balloon Flight
http://www.thespacereview.com/article/1237/1

"NewSpace" vs. "OldSpace" Companies
http://www.thespacereview.com/article/1242/1

Obama & the transition from Politics to Policy
http://www.thespacereview.com/article/1249/1

=A Russian Resurgence? Part 1
http://www.thespacereview.com/article/1246/1

A Russian Resurgence? Part 2
http://www.thespacereview.com/article/1251/1

Review of Phil Harris' new book "Space Enterprise"
http://www.thespacereview.com/article/1250/1

The future of Canada in Space – suggestions from 7 young Canadian space enthusiasts
http://www.thespacereview.com/article/1261/1

Space Solar Power for remote military bases as well as for unconnected impoverished nations
http://www.thespacereview.com/article/1255/1

India on the ISS: it starts with a rack
http://www.thespacereview.com/article/1253/1

Space "Sportilization"
http://www.nytimes.com/2008/10/31/sports/othersports/31space.html?em

Improvements in "Virtual Telescopes" for computers
http://cosmiclog.msnbc.msn.com/archive/2008/11/11/1669213.aspx

Tickets to "edge of space" drop to $95,000
http://www.newscientist.com/article/dn16185-rocket-company-offers-95000-trips-to-space.html

How Big Is the ISS vs. Science Fiction Spaceships?
http://gizmodo.com/5099175/how-big-is-the-iss-compared-to-science-fiction-

Nuclear Moon Bases?
http://www.popsci.com/military-aviation-amp-space/article/2008-11/nuclear-moon-bases?page=

GREAT SPACE VIDEOS

MOON COLONY VIDEOS – The Moon Society

30 plus thought-provoking videos, produced for the Moon Society by Chip Proser (Celestial Mechanics, Inc.) can be found at.
http://www.moonsociety.org/video/
or at:
http://www.mooncolony.tv/
http://www.stickymedia.com/

ASSORTED SPACE VIDEOS

ASU Lunar Reconnaissance Orbiter Team Video
http://lroc.sese.asu.edu/EPO/Team/Bios.php

Video on India's Chandrayaan-1
http://www.youtube.com/watch?v=043KLT0zoHY

Zero-G Sports Video
http://video.google.com/videoplay?docid=2064113917561527 59

Space Industrialization Video
http://www.youtube.com/watch?v=CqtCdqaDM04

!9 minute Video on Space Based Solar Power
http://www.thefutureschannel.com/dockets/realworld/space_based_solar_power/

The best way to predict the future is to be busy creating it.

Help us put MMM in a Library near You!

Whether you are a member of an NSS Chapter or of a Moon Society Chapter or Outpost, or a Moon Society member at large, you all get Moon Miners' Manifesto as a membership benefit.

A library subscription to a library in your community will help spread the word, whether about local or national or international Moon-focused programs and projects.

For chapters and outposts such subscriptions will be good advertising for your local efforts.

For Moon Society members, as all copies of MMM include the Moon Society Journal centerfold section, community library or school library copies of MMM will help grow name recognition and invite readers to join.

As no membership services are not involved, the cheapest way we can do this is by submitting these subscriptions directly to the publisher at a cost-minus rate of $10 a year, available for libraries only.

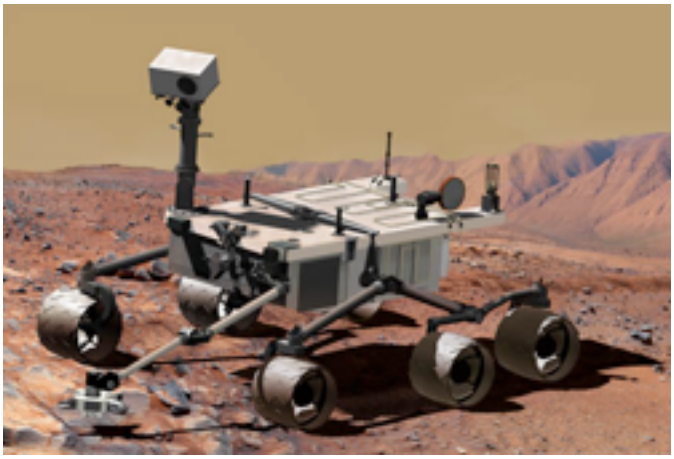
How to participate in this program

- Send *by postal mail only*
- Your check of money order for $10.00/per year
- With the complete name and address of the Library,
- Made out to

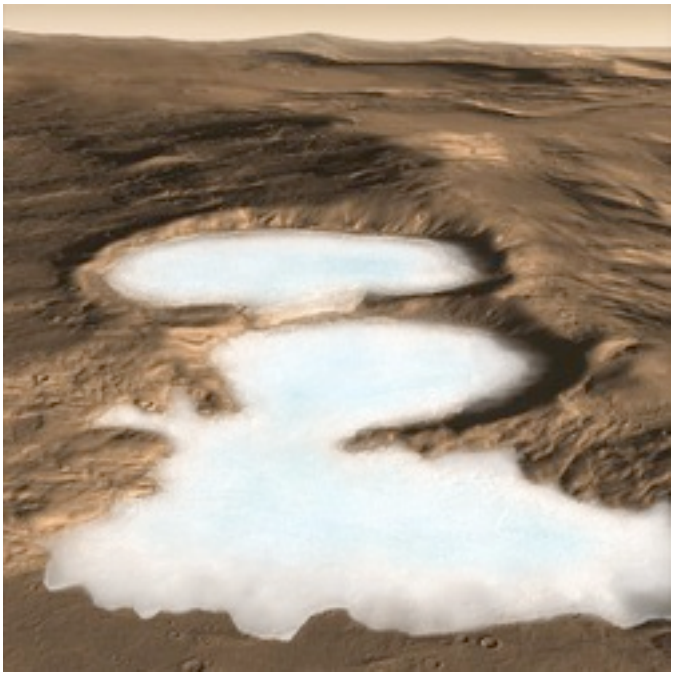
"Lunar Reclamation Society"
Attn: Library Subscriptions
PO Box 2102
Milwaukee, WI 53201

MMM PHOTO GALLERY

"Invisible" Auroras Mapped on Mars
www.space.com/scienceastronomy/081202-st-mars-aurorae.html

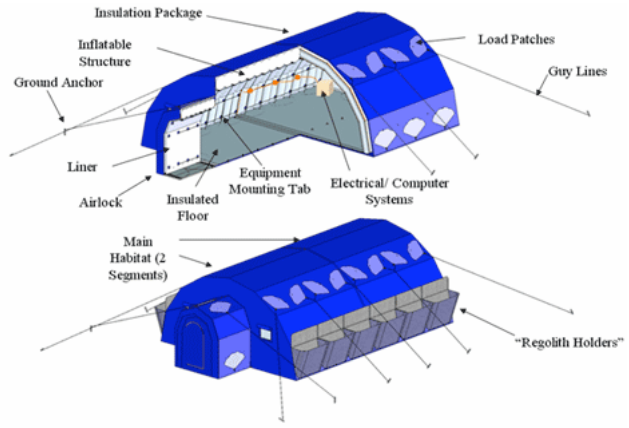


Nuclear-powered Mars Science Lab with extended mobility – launch delayed to 2011



Artist concept of buried Mars Glaciers revealed
http://www.spaceinfo.com.au/mars20081122.html

A rare photo of the Soviet N-1 rocket, developed for its manned lunar program in the 1960s, being rolled out to the pad. (credit: Asif Siddiqi) – Space Review



Structure of NASA's Inflatable Lunar Analog Station at McMurdo Sound, Antarctica *See report, page 11*

Former Wash. *Redskins* line-backer Ken Harvey dreams of 0-G sports http://www.nytimes.com/2008/10/31/sports/othersports/31space.html?_r=2&em

Re: "Extra-Terrestrial Engineering" in MMM #218, September 2008, pp. 6-7

I wish to comment on the article by Gordon Haverland, entitled Extra-Terrestrial Engineering, which appeared in your September number. Certainly his main point is well taken. Engineers on the lunar frontier must accommodate great differences from terrestrial practice, not only in conditions but also in materials & processes. Some of his specific cases, however, deserve further consideration. I hope that the following somewhat discursive discussion will be a useful contribution.

I find reason for more optimism regarding metals & metalworking than Mr. Haverland displays. It seems clear that lunar industry will not use much steel. The grades of steel which form the backbone of terrestrial industry & engineering contain, in general, between 1‰ and 5‰ of carbon by weight, with specialty steels rising as high as 15‰, while carbon-free soft iron is quite limited in its applications. Since carbon is both necessary to the life cycle & scarce (to the best of our knowledge) in Luna, the carbon for large tonne quantities even of low-carbon steel certainly cannot be spared. As certainly, however, the use of steel will be available to applications which demand it.

Mr. Haverland expects the "cold of the lunar night" to produce the low-temperature crystalline phase transition in iron & its alloys, making implements of these materials uselessly brittle. The surface of the Moon, however, is not the valley of the St. Lawrence — without air or water to carry the heat away, equipment can only lose heat via conduction to the ground or radiation to space. The first mechanism is slow, given the insulating qualities of regolith, & can be made slower yet by a well-chosen foundation system. The second dominates the cooling behaviour & can be largely frustrated by covering the apparatus with a tent made of reflective material, e.g. aluminum foil ; metal surfaces will, absent deliberate blackening, exhibit low emissivity, so steel parts will lose heat principally by conduction to parts of the apparatus which are more effective radiators (but, in general, less effective conductors).

Industrial machinery in active use will usually be in more danger of overheating than of freezing in any case. Part of the reason that extrusion dies are generally made of steel, for instance, is to withstand the high temperatures & heat production of the extrusion process. The core of an electrical transformer, ordinarily made of thin plates of a steel- like iron-silicon alloy, is kept warm by I2R losses in the windings & (due to eddy currents) the laminations themselves, while motors & generators generate heat from mechanical losses as well. Only rarely should keeping a steel part above the transition temperature require going so far as affixing a small resistance heater to it.

As Mr. Haverland observes, the addition of nickel to iron reduces the susceptibility of the alloy to low-temperature embrittlement. Such an alloy can probably be furnished from lunar sources. Native iron occurs in lunar regolith as microscopic grains, & particularly in soils formed from low-iron minerals, much of this is meteoritic detritus, well-known to be rich in nickel; a search with an ordinary metal detector would probably turn up substantial numbers of visible siderite fragments as well. Even if the nickel or the complete steel part must be imported, however, lunar industry is not necessarily placed at too serious a disadvantage, as with proper mechanical design steel components can be held to a few per centum of the overall equipment mass in many cases. It is, for example, not difficult to imagine an aluminum extrusion machine in which the extrusion die is of steel, but the other parts are largely of aluminum itself, titanium, or even glass or stone. Even in a rolling mill, the backing rolls at least could probably be of titanium. Early lunar-built machinery will probably be direct adaptations, via straightforward rescaling & material substitution, of terrestrial types, with a distinctive character gradually emerging in subsequent generations as new design principles are developed.

Titanium is an interesting case. Space industry will have at least one major advantage over its terrestrial counterpart, in that titanium is much easier to work in a vacuum — not only does it oxidize enthusiastically, at elevated temperatures it even combines with nitrogen. Considering the refractory character of the metal, handling it by noncontact means in the weightlessness of an orbital workshop would be ideal. Nevertheless, at least three techniques suited to lunar-surface industry can be proposed for converting titanium from the powder or sponge produced by the reduction process to workable dense metal. The first is the use of the noncontact induction furnace, the second an adaptation of the method used by Davy for melting refractories, & the third a concept of my own. The cold-crucible levitating induction furnace needs little introduction, except to say that in low gravity it will probably be suitable for charges much larger than the tens of kilograms common in terrestrial practice. By cutting off the heating effect while maintaining the levitation, the white-hot molten titanium can be gradually cooled by radiation to a hot solid suitable for working under the hammer. The Davy method involves the use of a "liquid crucible" of some substance lower-melting & denser than titanium & not reactive with it, a difficult requirement which might be filled by a molten salt of some metal higher in the electrochemical series. A solid crucible is filled partway with the liquid & rotated at a high enough speed that the liquid rises up the walls, & the titanium is charged into the depression thus formed. The titanium is melted, e.g. by an electron beam, & solidifies when the heating is withdrawn. The temperature gradient in the liquid layer (which may even freeze against the wall of the solid crucible) changes the problem from one of temperature resistance to one of heat transfer, to be solved e.g. by the circulation of a coolant such as liquid sodium through channels just under the wetted surface. The effectively incompressible liquids transmit the structural loads to the solid crucible even if its wetted wall is rather thin, allowing the use of a construction metal with imperfect heat-transfer characteristics, such as titanium itself or nickel-iron (the necessary temperature range is probably too high for aluminum).

A third possible method arises from the observation that, under lunar gravity, an object can be kept in weightlessness for a considerable time with a fairly small impetus — for example, if it is projected vertically with a velocity of 18 meters per second, it will fall freely for 22 s, rising to a height of 100 m. A projectile of sponge or compacted finely- divided titanium, either of which is satisfactorily black, its trajectory lying at the focus of a

vertical trough-shaped reflector, may absorb sufficient heat to melt it, forming (due to surface tension) a sphere of molten metal. While the size of each pellet will be limited by thermodynamic considerations, catching a succession of them in a titanium receptacle provided with a suitable heat sink will permit building up a large billet of fully-dense metal, albeit with some likelihood of lamination defects. This technique would probably not work for aluminum, since the thermal conductivity of sponge & compacted powder is considerably less than that of dense metal, so that the outer layers would melt first ; at the low melting point of aluminum, the surface formed would be reflective & prevent further heating, whereas the incandescent surface of molten titanium is ispo facto one of high emissivity. As the melting point of titanium is close to the dissociation temperature of titanium dioxide, a modification of this method could be used to prepare titanium from the oxide ore, if that notably white material were darkened sufficiently, e.g. with an admixture of finely-divided metal. Capturing the oxygen released would require carrying out the process in some type of enclosure, kept evacuated to prevent recombination, & the product metal would probably be in the form of small pellets requiring remelting.

In a previous letter I have described alternatives to the ordinary terrestrial rail- carriageway of two metal rails cleated to crossties laid on a ballasted roadbed, & why I consider that these may be particularly suitable to lunar applications, with some reference to the problem of thermal expansion, but I consider a few specific remarks to be in order. Firstly, Mr. Haverland's invention of variable-density powdered-metal rails for taking up thermal strains is certainly ingenious, but there is some reason to think that the granular surface of such rails would produce a considerable increase in rolling resistance over that found with a continuous surface. If accommodation to thermal strain is desired, it might be better found in the use of overlapping joints between rail segments, e.g. a system of interlocking fingers or something similar to dovetailing. Conventional rails are laid at high temperatures, to prevent kinking, but I believe Mr. Haverland correct in suggesting that his variable-density rails should be laid at low temperatures, as the low-density segments should maintain their cohesion better under compression than tension ; the mechanical expansion joint system would probably best be laid under moderate temperatures, in the middle of its accommodation range.

Secondly, the idea of a metal-regolith composite, which he proposes in the context of crossties, is a valuable one which opens up some interesting possibilities. It may be considered a specialized form of concrete, not unlike the type produced for certain terrestrial applications by substituting a polymer for Portland cement. Although it is difficult to see using it in the large volumes of terrestrial construction projects, the combination of ductile matrix & sharp-edged aggregate suggests mechanical properties which will make the material broadly useful. It also suggests two additional material types of interest, glass-regolith composites more closely resembling concrete, and glass-metal composites. The latter category (as distinct from metal-ceramic composites) has not been pursued to any great extent, so far as I am aware, neglecting some work on jewelry use of the glass-gold system. The generally inferior mechanical properties of glass compared to metal make the use of glass reinforcement in a metal matrix questionable, except possibly to add tearing resistance in thin sheet ; on the other hand, a glass matrix cast in place over a metal fiber reinforcement could have mechanical properties comparable to those of the metal but lower thermal conductivity & coefficient of thermal expansion.

Thirdly, the question of bonding between metallic surfaces deserves close attention, as a potential source of problems reaching far beyond transportation — it would be intolerable, for example, if airlock doors were to seal themselves to their frames. While I cannot claim to have researched this issue extensively, I have found nothing to suggest that it will be one of the major difficulties in the way of lunar development. I welcome corrections to any misstatements in the following matter, which summarizes the facts as I am aware of them.

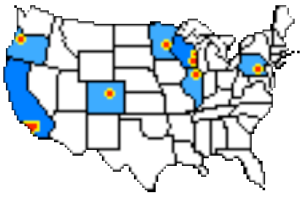
The phenomenon of vacuum cementation or surface-contact bonding is rarely encountered in practice, even in space applications — the "wringing" of Jo-blocks, sometimes cited as an example, is actually due to the adsorbed film of air on the metal surface. The bond formed is stronger in normal strain than in shear, with the result that wheel-type contact will tend to experience, at most, an increase in rolling resistance: if the contact patches do not pull apart, the forward motion of the axle will slide them apart. The bonding process is quite slow except at the elevated temperatures where diffusion bonding becomes important. It proceeds more rapidly where the contact between the surfaces is intimate, i.e., under high contact pressure than low, & with smooth or polished, clean surfaces than rough, irregular ones. It also proceeds more rapidly between metal surfaces than oxide surfaces or metal-oxide pairs, between surfaces of the same metal than of dissimilar metals, & between surfaces of pure metal than of alloys. So, for example, two "aluminum" surfaces will bond much more slowly if one is Al-5% Mg alloy and the other Al-5% Ti than if both are pure Al. While the wet anodizing process of terrestrial industry will probably be difficult to apply, some form of surface oxidation treatment should be feasible, perhaps involving silent electrical discharge in a low- pressure pure oxygen atmosphere. In other words, this problem appears to be manageable if we are prepared for it.

C.D. Carson
publius@lunarcc.org
November 23, 2008
Forth Worth, Texas

There will be no MMM next month.
January and July are our two semi-annual burnout-prevention and regeneration breaks.

Look for **MMM Classic #19**, a re-edited compilation of all the non-time-sensitive articles from our 19th year, issues #s 181-190 covering December 2004 – November 2005

a free access download pdf file



News & Events of NSS "MMM" Chapters

Space Chapter HUB Website:
http://nsschapters.org/hub/

Lunar Reclamation Society, Inc.

P.O. Box 2102
Milwaukee
WI 53201

www.lunar-reclamation.org

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To the Stars through our own hard work!

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TREAS./ Database – *Robert Bialecki
bobriverwest@yahoo.com 414-372-9613

LRS News

● **November 11th meeting:** We watched "Saturn-V" and "Command Module" from the Series "Moon Machines."

LRS Upcoming Meetings & Events

Saturdays: Dec. 13th, Jan. 10th, Feb 14th 1-4 pm
LRS Meeting, Mayfair Mall, Garden Suites Room G110
AGENDA: www. lunar-reclamation.org/page4.htm

December 13th – *Everyone Welcome!*
Pre-Holiday Potluck & Classic Sci-Fi Film

● **Joint event** of LRS and the Wisconsin Mars Society with former members and NSS members invited
● **Exhibits:** The Moon Society Solar Power Beaming demo
● **Pot luck** 1-2 pm: B something to share, home made or purchased, hot or cold, solid or liquid, your choice.
● **Feature Film 2-3:40 pm "MOON ZERO TWO"**

(1969) A space salvage expert and his partner become involved with a group of criminals intent on hijacking a small asteroid made of sapphire and crashing it into the moon for later recovery.

COLORADO

Denver Space Society
(FKA The Front Range L5 Society)
1 Cherry Hills Farm Drive
Englewood, CO 80113
http://www.angelfire.com/space/frl5/

Eric Boethin 303-781-0800 eric@boethin.com
Monthly Meetings, every 2nd Monday, 7 PM
Next: December 8th, January 12th, February 9th
Englewood Public Library, Englewood, CO 80110
1000 Englewood Parkway, First Floor Civic Center

OREGON

Oregon L5 Society
P.O. Box 86, Oregon City, OR 97045
voice mail / (503) 655-6189 -- FAX (503)-251-9901
http://www.OregonL5.org/

Allen G. Taylor allen.taylor@ieee.org
Bryce Walden moonbase@comcast.net
(LBRT – Oregon Moonbase) moonbase@comcast.net
* **Meetings 3rd Sat. each month at 2 p.m.**
Bourne Plaza, 1441 SE 122nd, Portland, downstairs
Next Meetings Dec 20th – Jan 17th – Feb 21st

WISCONSIN

Sheboygan Space Society
728 Center St., Kiel WI 54042-1034

c/o Will Foerster 920-894-2376/h astrowill@tcei.com
SSS Sec. Harald Schenk hschenk@charter.net

>>> **DUES:** "SSS" c/o B. P. Knier
22608 County Line Rd, Elkhart Lake WI 53020
http://www.tcei.com/sss/

● **We meet the 3rd Thursday of the month 7-9pm**
Dec 18th – The Stoelting House, **Kiel**
Jan 15th – UW-Sheboygan, Sheboygan, @room 6101
Feb 19th – The Stoelting House, **Kiel**
Mar 19th – UW-Sheboygan, Sheboygan, @room 6101

ILLINOIS

Chicago Space Frontier L5
610 West 47th Place, Chicago, IL 60609
Larry Ahearn 773/373-0349 LDAhearn@aol.com

MINNESOTA

Minnesota Space Frontier Society
c/o Dave Buth 433 South 7th St. #1808
Minneapolis, MN 55415
David Buth (w) (612) 333-1872, (h) (612) 529-9871
Email: info@mnsfs.org
www.mnsfs.org/

MN SFS News & Pictures

MN SFS Year in Review 2008
http://www.freemars.org/mnfan/MNSFS/2008-12-Review/

MN SFS Election pics
http://freemars.org/mnfan/MNSFS/2008-11-Election-Meeting/

STS-126 display pics
http://www.freemars.org/mnfan/MNSFS/2008-11-ISS-18-STS-126-Display/

Pics from StJohn's Sci Fair
http://www.freemars.org/mnfan/St-John%27s-Sci-Fair/2008/

PENNSYLVANIA

Philadelphia Area Space Alliance
PO Box 1715, Philadelphia, PA 19105

c/o Earl Bennett, Earlisat@verison.net <<***new***
215/633-0878 (H)

http://pasa01.tripod.com/
http://phillypasa.blogspot.com

• **PASA regular business luncheon/formal meeting 1-3 pm**, the **3rd Saturday of every month** at the **Liberty One food court** on the second level, **16th and S. Market.** Go toward the windows on the 17th street side and go *left*. Look for table sign. Parking at Liberty One, 17th St. Call Earl/Mitch 215-625-0670 to verify all info.

Meetings: Our next meeting is December 20th, at the Liberty One food Court Our **January** meeting is on the **17th**. We have not yet scheduled further 2009 meetings

Event notes: In lieu of our regular meeting at Liberty One, we went to **Philcon** at its new location: **The Cherry Hill Crown Plaza.** This is on route 70 in the township of Cherry Hill, NJ. This week before Thanksgiving event was great! The hotel was fantastic, the brunch was excellent and the staff was very helpful. And there were three other events during the same weekend. The only negative was the need to drive to the other side of the highway (not pedestrian friendly) for restaurants. However: **Dotty** and **Larry** showed us *The Gateway to Asia* Indian Restaurant (very good!) on the same side of the highway. We had dinner there Saturday but had insufficient members for a quorum.

Activities: we had two members act as panelists at this event and a number helping with the event or attending.: these included the aforementioned Dotty and Larry, **Hank Smith**, our Sci-Fi coordinator, **Mike Fisher,** who judges at the science fairs, and **Dennis Pearson**, who had obligations that kept him away 'till Sunday. We saw **John Ashmead,** once and future group member (we hope), and **Mitch Gordon,** who was also on panels, as well as your correspondent.

We had a table in the high traffic area near the main panel presentation areas with lots of interesting talk with attendees. We brought a number of display items, including the Lava Tube Habitat and a Cube Sat model as well as Mitch's' ***Ad Astra, World Futurist*, and *Popular Science*** covers book. Our tables where covered with literature and freebies, such as bumper stickers and pencils. Our backdrop was Dennis Pearson's Return to The Moon justification panels that include using Helium 3 in fusion power plants. Dotty and Larry often staffed the table and could talk of other things than space such as webwork and costume craft, and much more.

Mitch Gordon and I appeared as panel members on several days, beginning with "Non Chemical Space-craft Propulsion" with Earl, Charles E. Gannon, Mark Wolverton and Frank O'Brian as moderator. We had a wide ranging talk that concentrated on things that will be buildable with available technology. We did discuss, and dismiss, in atmosphere nuclear drives (fission) although that did work. It releases too much hazardous byproducts at present. Other systems discussed include an interesting electric hybrid system described by Charles E. Gannon (an electrically, or laser driven plasma system), Ion Drives, "Mag Sails" (see Bob Zubrin's work), Magneto Plasma Propulsion, (see Wing Lee's articles), The Slingatron , (reported in Moon Miners' sometime back), The Mass Driver, (in the L-5 and other publications), and ion drives and, minimally, Light Sails. We excluded Clarke Towers since they are more vertical railroad lines than prime movers and not buildable for several decades at any event. We talked about this due to audience questions, as was the nuclear pulse engines (we don't have fusion yet).

Earl was also on panels about engineering: "To Engineer is Human", with an interesting cast of members: Rock Robertson, John Ashmead, Gary Ehrlich, and Earl Bennett. It says something about the work many of us do in that most of the panelists were managers of projects, and had heavy involvement in software development and analysis. Process flow and organization of when things get done are extremely important in many large projects and these panelists spoke from various backgrounds: aircraft, spacecraft, physics research. Earl was also on a Nano-Materials panel with Dr. Paul H. Shuch, Dr Jay Wile, and Mark Wolverton. Interesting talk and well-informed people.

And finally Earls last panel was " The News from Mars", with Dr. Jay Wile and Mary Robinette Kowal, science writer and pupeteer. Earl was the moderator and quickly realized that we had a well-informed audience who wanted to ask questions about Mars exploration in general, as well as current efforts. Dr. Wile and Ms. Kowal fielded a number of the questions of both general

interest and technical detail, with Earl adding in or making points not raised by panel members or audience.

The difficulty of living on the exposed surface of Mars, at present, was brought up as a result of questions from the audience and the concept of Lava Tube habitats both on Mars and the Moon was pointed out the ability to do the things we want and simulating them was brought up as well as how far our technology has come in relation to the "intelligence" of the planned Rovers. Ms. Kowal held up her new Net phone and pointed out that it had as much computing power as NASA had at the time of the Apollo program: this due to a question about the Mars Science Lab and the subject of autonomous vehicles. (Post event note: something has happened to slow the Science Lab deployment and it will be delayed till 2011 launch, instead of mid 2009). This was a great experience with a knowledgeable audience. A future benefit to our promotion of science education may be the addition of Mary to the roles of the Ambassador to The Solar System program in the New York City area.

Mitch Gordon served on two panels, one by invitation and one by request of the Philcon Organization on the spot: the first was " Does Science Fiction Inspire Invention?" with John Ashmead (Physicist), writer and Artist Jack McDevitt, futurist and author Ian Randal Strock, and Jay Wile (Dr. Physics). The question is not clearly answerable yet since the Inspiration of many inventions were not clearly noticeable. We have one example in our pockets and purses however: "I want that Star Trek Communicator" must have occurred to many of the audience for that show; and a few were able to move the technology needed from fantastic prop to everyday annoyance, *er,* convenience.

Mitch's other panel was "Science Fiction, Religion and Reason," Mitch an added panelist. It was an interesting group with Dr. Wile volunteering again, along with Tim Powers, Judith Moffett, Ef Deal and Richard Stout (as Moderator). The majority of this panel where writers of science fiction and fantasy with Mitch being PASA's futurist and philosophy author. His latest interest in the human spirituality area is the Overview Effect as reported by the various space travelers who have looked back on our world from Out There. Here the technology gives us a way to see our entire human society in its tiny warm home against the scale of the Universe. Talk to Mitch for more on this, and Alex Howerton; who is an organizing member of the Overview Institute (a .org on the web)

Philcon was a great event at a new location and had many other great and fun panels that included Tom Ligon and several Princeton physicists on the future of fusion and the current state of the art, Tom's demonstration of the Farnsworth Fusor. Tony Rothman was one of the two guests and he had invited a friend. Tom thinks a working proof of concept plant (400 Mega Watts) could be built for $150 million. Among the other great presentations was one on the **Kepler Mission** to find extra solar planets. The presenter was Patricia Boyd with musical backup for the Astronomy and science lecture by her group, The Chromatics! The addition of explanations of some of the basic details of how the planets are actually looked for was wonderful. You may find there CD's on line (they have five acapella discs).

In addition: Larry, our webmaster is progressing on his understanding of dot.net software technology and may be able to apply it to our web and blog sites in the future. He has fixed the image problems

Previously reported. Dotty brought her report on The Smithsonian Institute events including a book signing on December 13 by Robert Zubrin: "How to Live on Mars", 2-5 p.m. Gallery 101 museum shop, in the National Mall Building. And much more! Thank you Dotty and Larry and all of our members.

Report submitted by Earl Bennett, President, PASA

CALIFORNIA

OASIS: Organization for the **A**dvancement of **S**pace **I**ndustrialization and **S**ettlement

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Regular Meeting 3 pm 3rd Sat. each month
Next Meetings Dec 13th – Jan 17th – Feb 21st

Information: OASIS Hotline, 310/364-2290; website.

Saturday, December 13, 2008 – 3:00 pm

OASIS Board Meeting, potluck holiday party to follow at 6:30 pm, at home of Bob Gounley & Paula Del Fosse, 1738 La Paz Road, Altadena, CA 0101

Saturday, January 17, 2009

OASIS Board Meeting 1:00 pm, followed by 3:00 pm public lecture, El Dorado Public Library, 2900 Studebaker Rd., Long Beach – Lecture by David E. Barnhart, Assoc. Director, Space Engineering Research Center – "**Not your Parents' Lunar Lander; USC's Project Leapfrog**" – Admission free

Fri-Sun Feb 13-15, 09 President's Weekend

Gallifrey 2009 – Dr. Who (& other SF media) **SF con**, LAX Marriott Hotel – OASIS will be providing space programming and will also have a fan table.
http://www.gallifreyone.com/gallifrey.php

Saturday, February 21, 2009 3:00 pm

OASIS Board Meeting 1 pm, at home of Steve Bartlett and Tina Beychok, 7108 East Peabody, Long Beach

Monthly Star Parties

LAAS (los Angeles Astronomical Society maintains an active calendar of Public Star Parties in front of Griffith Observatory Satellite.
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2800 East Observatory Road, Los Angeles

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