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

Moon Miners' Manifesto

& The Moon Society Journal www.MoonMinersManifesto.com

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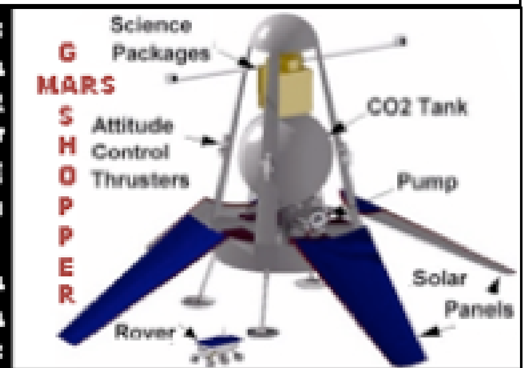
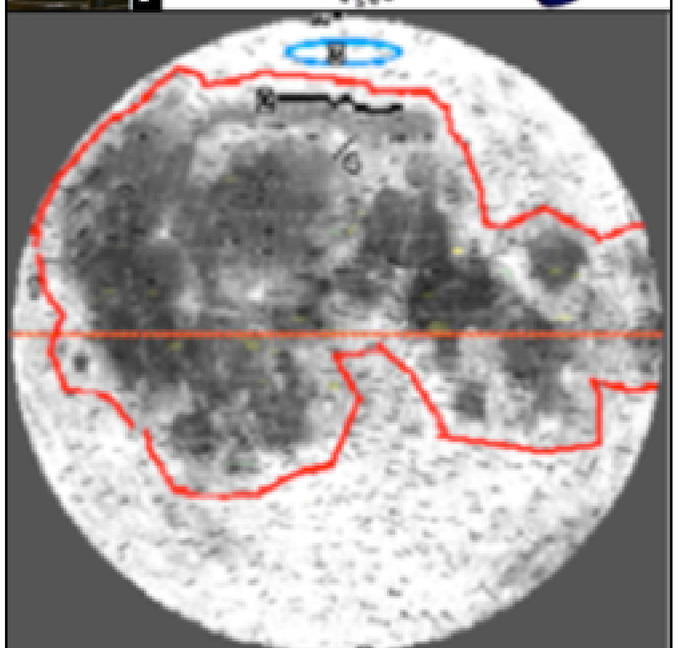


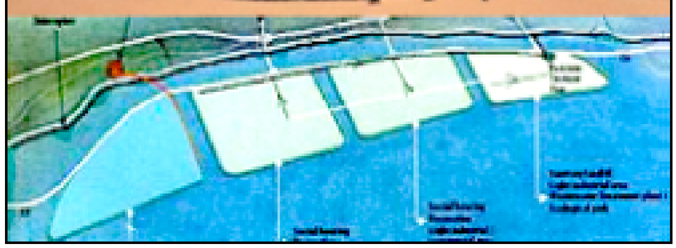
This year, MMM's 19th, feature articles covered a wide range of topics. Arts & Crafts were touched on in several articles. In one of those,, we discussed the promise of **AAC, autoclaved aerated cement, as a carving medium for Lunan pioneers**. The beautiful statue at left is an example of what is possible. The topic came up again in a major article on **Pioneer Hobbies** and Pastimes. We also ran an appropriate article on **musical instruments made from "junk."**

We covered some technical innovations as well as proposals for new launch systems, At left, a **Mars Gashopper** mockup was successfully tested. Another article pointed out how **humans and robots complement one another** and should not be seen as "rival options."



Major articles covered settlements within the Moon's **Nearside "Mare-plex"** (including the surrounding coastal highland areas) as well as in some **highland locations** offering special mineral, logistical, or tourist opportunities.

In an effort to get across the **major differences between settlements on the Moon and cities and towns on Earth**, we endeavored to compare lunar settlements with two types of unusual but well known settlements on Earth: the **desert oases** and the **Dutch polders**.

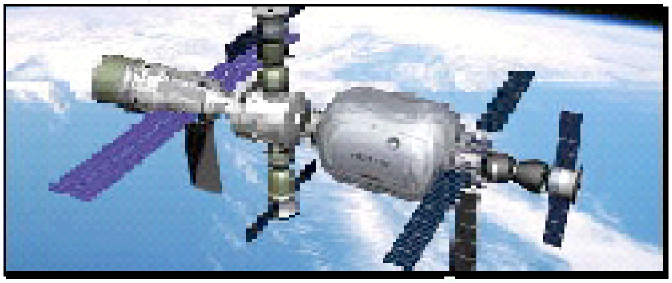


Other articles covered **two "wish lists" for further "aerial" exploration of Venus**; and how Lunan pioneers would **cook and prepare meals** *differently* from the ways to which many of us are accustomed.

In segue to the article on frontier hobbies and past-times, another article attempted to show that **the Co-op model might be a good way to transform some of these hobbies into startup cottage industries and enterprises.** After all, not all the pioneers will be engaged in processing moondust into products for export to earn hard credits with which to buy needed imports. On Earth, give or take 90% of the working population of any urban area is engaged in making products and providing services for one another.

We also published a major paper by a young student from Mumbai, India, the paper taking first place in a **"Moon Mission" Design Contest** co-sponsored by The Planetary Society of Youth (India) and by The Moon Society.

Another topic covered was **Lunar Analog Research**, in the light of the editor's first 2-week experience at the Mars Desert Research Station – MDRS – *and much more!*



The Nautilus Module Space Station Starter Kit

In this artist depiction, a full-size Bigelow Aerospace inflatable becomes a space station with the attachment of solar panels and docking adaptors. It is shown here with a Soyuz 3-person capsule docked on one end, and a future private enterprise personnel craft on the other. Addition of more 3,500 cu. ft. inflatable modules would soon make this starter station much larger than ISS.

Human-Robot Synergies

by Peter Kokh

When there are so many things we can do together, that neither humans nor robots can do by themselves, the "Humans versus Robots" debate is worse than useless. It's a waste of precious time and a mischievous diversion.

Not letting the "other side" control the discussion

Most of us get more than a little riled up when a planetary scientist, interested only in science data, gets on a soapbox to condemn the manned space program. Yes, they are shortsighted: in the long run, if not in the short term, we will learn much more about the solar system if humans are involved at the forefront of exploration, and, even more so if explorers are followed by settler pioneers. Compare what we now know about the geology, flora, fauna, and other aspects of the Americas with what we would know if Europe had had robot probes back then, and had only sent those. The knowledge that robots return from their planetary missions is indeed priceless - compared with no knowledge at all. But if we indulge in the "versus" argument we are letting our myopic friends control the debate.

Human Tool Partnerships are Primeval

We became humans while using tools. The tool is the extension of the hand. It can do things that fingers and fingernails cannot. But the tool without the human to use it is an admirable piece of art and no more. This partnership has taken on new meaning with the appearance of each new and improved tool. Nor is the idea of tools going where hands dare not something new. Consider the tongs that holds red hot iron over the anvil, or molten glass in the furnace. They take us places where we could not go without them. The canoe, the boat, the car, the plane - and the camel and horse before them, serve as aids. How often has not each of us felt them to be an extension of ourselves.

Humans vs. Robots in Space

Thus the idea of human-robot partnerships is hardly revolutionary, though to hear some speak, you might get that idea. Perhaps it arises because in space applications, robots are not things we wear, physically wield, or ride, but have become proxy scouts, going far beyond borders that we are not ourselves prepared to pass. But the pendulum must inevitably swing back. Thesis begets antithesis and ultimately synthesis. The synthesis of the human and robot space explorer is where we are headed.

Early robotic probes simply reported back to us. But gradually, we have found ways to give them instructions, even new instructions, changing their programming. We've had far more luck along this line with orbiting probes and probes coasting through space where time was not of the essence. But the radio link hardly reestablishes a hand and glove, hand and tool relationship. We've been able to do that clumsily for some time, with surface probes on the Moon where the time delay of under three seconds is something we can learn to master. I said "able" because we haven't had a surface probe on the Moon to teleoperate. On Mars we do, and Sojourner, Spirit, and Opportunity have amazed us with the data they have returned. But the amount of "work" each of these rover-probes is able to do in a day is much less than one percent as much as would be possible if the teleoperator was stationed on Phobos or Deimos a few thousand miles away, instead of on Earth, between 35 million and over 200 million miles away, suffering with time lags of 6-40 minutes instead of a fraction of a second.

Indeed, there is a strong argument for sending robots to prepare a site for human arrival, doing things well beyond return flight fuel production. They could grade sites, excavate hollows, pile up shielding berms, even make a supply of building blocks or sand bags. They could drill into the soil to tap the permafrost, possibly even tap liquid water aquifers deep below the permafrost layer. They could explore nearby lavatubes, mapping them, determining points of accessibility. They could construct a landing pad, and a road network. One could go on and on, but only if all this activity were teleoperated from a convenient perch on Phobos and/or Deimos.

Symbiosis Regained

While such prospects are interesting, we are totally missing the boat if we only see robots as remote agents to be teleoperated. Once both humans and robots are on the scene together, we will quickly reestablish the prehistoric role of the hand and tool, the rider and horse, the driver in his/her dream car - the paradigm of the extension of one's own being and capacities.

Humans and Robots will work together, each doing what they do best. In the Canadian High Arctic, on Devon Island, both at the Haughton Mars (NASA) outpost and at the Mars Society's Flashline Mars Arctic Research Station, crews on simulated EVA excursions have learned how helpful companion robots can be. Little tethered scramblers can go ahead, climb down and back out of crevices and gullies, scamper up cliffs and escarpments to take a look, even crawl under rovers to check for damage to the undercarriage from passing over boulders. Similar experiments have been underway with one NASA crew each season at the Mars Desert Research Station in Utah.

The Robot as an Idiot Savant Scout

The robot scout can be equipped with visual apparatus far more sensitive than the human eye, with a chemical sense of smell far more acute than that of a bloodhound, with texture discriminating senses far more attuned than the human finger, the elephant's proboscis, the octopus' tentacle. Imagine how helpful that would be to the prospector looking for valuable trace elements in unusual concentrations, to geologists and exobiologists looking for clues. Like any Idiot Savant, the robot will have no appreciation for what it has found, following its detection programming. But it will isolate and identify rocks and samples the accompanying human will want to inspect further, making the prospector or scientist far more productive on each sortie, wasting far less time looking at non-significant samples. To put it colorfully, the explorer with a robot companion will have to kiss a lot fewer toads to find the handsome prince. A prize sample found and presented to its master, the robot companion might be even more helpful by holding the sample so that the human master can work on it with both hands free.

Companion robots of this kind can work at the end of a physical tether, or at the end of an electronic one, so long as line-of-sight with its handler is maintained, either directly, or by it placing mini-relays at strategic points. Signals from the robot companion could be translated into audible intelligible form. Visual data could be flashed on a heads-up area on the visor of the human handler. Other data could appear on some sort of conveniently placed screen in various readout forms.

Robot companions will also go where there human handlers cannot, into hot nuclear piles, for example, into impassable rubble strewn lavatube entrances, spending hours, even days, in the hot lunar sunshine. But just as there will be close companion robots, and remote robots, so also will there be even closer associations.

Back to the horse, the canoe, the car

We don't think of any of the above as robots, but actually they are the antecedents of a class of robots where the human-robot synergy will be especially intimate and intensive: robots we wear, robots we ride.

Most pioneers will seldom be out on the lunar or Martian surface - both are extreme environments. Prospectors, rock-hound hobbyists, spelunker lavatube explorers, and crater peak climbers are among those who will frequent the out-vac, enjoy being washed by the cosmic elements. But their activities will be both more enjoyable and more productive if they wear or ride their robots. Far from being science fiction, we've been at this point without realizing it for some time. Nor are we talking about the recent cybernetic revolution that has put computer chips in everything from toasters, to washing machines, to automobile transmissions, and sewing machines. Think of the operator of a construction crane, or of an open pit mine steam shovel, or of an icebreaker, or of yourself on a garden or farm tractor, or the wheel of your car. These machines all extend our capacities, doing things we could not do with hand tools, even with hand-held power tools - and we wear them.

The buppet or body puppet or robosuit

Someday, lunar prospectors and scientists may go out into "the field" inside one person pressure capsules. They might have a variety of deployable transit modes from wheels, to tank-like tracks, to long jointed legs that can scamper up boulder strewn crater rims, or even bound over rille valleys. They will have appendages you operate safely from inside, appendages with interchangeable tools and finger like sensory probes. Inside your wearable robot, you will be warm when its bitter cold outside, cool when its scorching, protected from the glare ... and listening to the surround sound recording of your choice, the refrigerator close at hand. The buppet or bodybot and you will be more than a team. As you get familiar with it, and it gets familiar with your touch, you will bond, becoming one. And as a team you will get farm more done than either could do alone or in mere sequence.

Productivity and Conservation of Human Labor

No experiment is a failure if we learn from it. But to the extent that Biosphere II seems on first superficial glance to have been a failure, one contributor was the prior decision to have human biospherian volunteers raise all their own food, by primitive hand gardening means. On the space frontier, given the cost of transporting humans to and far away shores and supporting them with whatever they cannot (yet) provide on location, it will be especially important to use manpower wisely. Growing food, to the extent that automation, semi-intelligent robots (idiot savants) and teleoperated equipment can do the same job better with far less human man hours is surely one place were human-robot synergies must be applied to the utmost. We have already seen how companion robots can greatly multiply the productivity of prospectors and scientists in the field. Human-robot teams will do the mining and mineral extraction, the manufacturing, the construction of new habitat space, new factories, new schools, new agricultural units. HR teams will build new roads, explore and develop lavatube shelter spaces. They will deploy astronomical installations, giant solar power arrays, maintain nuclear power facilities, maintain the biosphere recycling systems. In short, the idea of humans or robots working alone in many areas of activity will become unthinkable.

The point of all this is that the future frontier of human-robot synergies are not a brave new world, a world that would be unrecognizable to our grandparents, or even to our pre-industrial age ancestors. Development of human robot synergies and teamwork and strategies and modes of interaction and integration - all this is but the logical extension of the quintessential human relation-ship with tools. Indeed, there is growing evidence that this relationship may have been pioneered by proto-humans, as we see more and more evidence of discriminatory tool use in Chimpanzees and other not-so distant relatives.

Working hand in glove with robots is indeed the way we will continue to explore "being all that we can be," because we cannot be as much as we can be without them. We must work to change the discussion from "humans **vs.** robots" to a more productive "humans **and** robots." **<MMM>**

Grasshopper inspires Mars Gas Hopper

http://www.pioneerastro.com/MGH/mgh.html

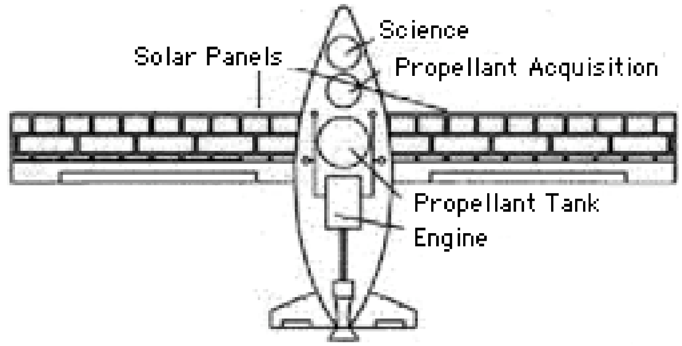
Commentary by Peter Kokh

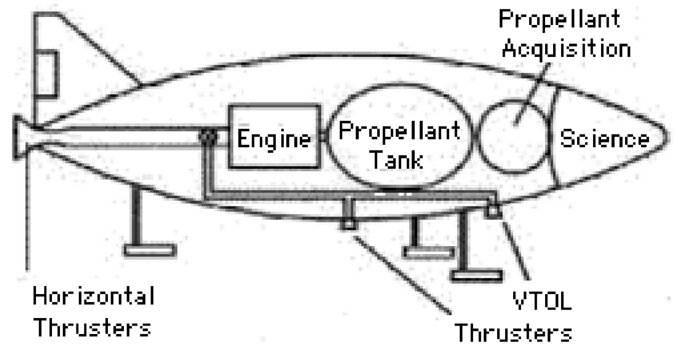
Combine a mastery of physics and chemistry, an industrious imagination, and and an inner drive to take us to Mars and the stars beyond, and it is no surprise that Robert Zubrin and his company, Pioneer Astronautics continue to brainstorm and develop breakthrough technologies. It always starts with a stubborn problem being accepted as a challenge. This time, the stubborn problem is that we can send at most a pair of robot rover investigators to Mars each window of opportunity, the windows being just over two years apart. If our probes land intact, as both did this time, they are still severely limited geographically in the amount of terrain that they can investigate, slowed down as they are by the speed of teleoperation over planetary distances. It would take a century at this rate to get a good grasp of Mars, if we want to call the grand sum of 100 sampled sites thorough. If my back of the envelop calculations aren't too far off, that would provide a spacing of 750 between sites on a hexagonal grid. A century!

Our present breed of probes, **Spirit** and **Opportunity**, are performing well-beyond expectations, but can't go on forever. Power supplies, even refreshed by solar energy, will run out - everything is becoming covered with a thin coat of dust as views o the sundial color calibration device on each rover clearly shows.

Enter (into the imagination the image of) the grass hopper, or its swarming cousin, the locust. They land in a spot long enough to recharge their energy reserves by eating g and off they bound for another location. This type of behavior has real survival benefits. The creatures don't run out of food. But that's not the point. The point is that they can hop and refuel, hop and refuel. Now if we could build robotic Mars probes on this model, they could sample many areas around the Martian globe, and baring mechanical troubles or injury, serve for many years.

How do we do that. Pioneer Astronautics took up this challenge and has come up with a design (c. 2000) that has now caught the attention of NASA as one of 219 research projects selected by the agency for Small Business Research and Development contract awards. The Mars Gas Hopper, or "gashopper," is a novel concept for propulsion of a robust Mars surface hopper vehicle which utilizes indigenous CO2 propellant to provide Mars exploration with greatly enhanced mobility. The gashopper will acquire CO2 gas from the Martian atmosphere, and store it in liquid form at a pressure of about 10 bar.





When enough CO2 is stored to make a substantial ballistic trajectory hop to another Mars site of interest, the CO2 propellant tank will be moderately heated to raise it to 70 bar. The propellant is then run through a hot pellet bed to form high temperature gas that is expanded through a nozzle to produce thrust. The gashopper uses its CO2 propulsion system for major liftoff, attitude control, and landing propulsive burn(s), as required. Unlike chemical rockets, the gashopper's exhaust will not contaminate the landing site with organics or water.

The gashopper has a potential flight range of 10 to 100 kilometers. It can fly over terrain impassible to rovers, imaging as it flies, land to reconnoiter a remote location, and then fly again. Thus, it offers unique capabilities for Mars surface exploration.

Combined with greater intelligence, the ability to zero in on more interesting targets, and improved on site analysis systems, a fleet of Martian Gashoppers could vastly increase our current hit and miss picture of this fascinating planet, giving us a much better list of the best spots on Mars for Human-Robot teams to set up shop with confidence. about collocated resources and other considerations. Pioneer Astronautics built an anchored test stand to test its CO2 engine, and now has built a free-flying version to test its aerodynamic qualities and hopping abilities. For more on this project, go to:

www.universetoday.com/am/publish/mars_gashopper.html

Carving & Sculpting on the Early Frontier

by Peter Kokh

A Gift from Santa – AAC

December 1, 2004 - UPS just delivered a heavy box. An 8"x8"x24" piece of AAC, Autoclaved Aerated Concrete! It weighed 35 pounds (out of the carton) whereas the same volume of water would weigh about 57 lbs and of normal concrete about 127 lbs. I figured its specific gravity at 0.61 (water is 1.0, rock 2.8) and, yes, a chunk of it does float. I took it down to my workshop right away. With plenty of experience in carpentry and other home repair and remodeling skills,

I have been on the lookout for years for a substitute for wood that Lunar craftsmen and others could use. So when Dave Dietzler (frequent MMM contributor from the Moon Society St. Louis chapter) sent me an email some time ago about AAC, I followed the links and noted that one of the hyped characteristics of AAC was its "workability". That was my button! I had to have some to see for myself. Following the online trail, I sent out a few emails. The wait was worth it.

The Unveiling

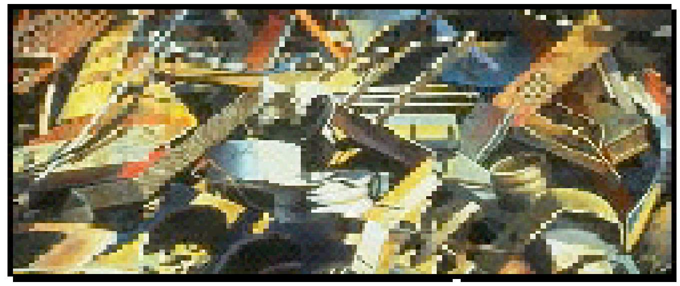
The block seemed to be heavy because it was so big. A couple of smaller chunks had cracked off in shipment, and picking them up you could tell it was lightstuff. I reached for my tools, and

- You can easily saw it with a hack saw, and even with a regular wood saw.
- You can carve it with a wood chisel or a shaping tool.
- You can cut it with a sharp knife (but it produces granular debris rather than shavings because, unlike wood, the material lacks fiber and an oriented grain.)
- You can easily drill it with a metal bit, and even with a paddle wood bit
- You can pound a spike into it without splitting the material.
- You can drive a screw into it
- Working AAC produces a "sawdust" more coarse than wood working dust, but, surprisingly, not very abrasive.
- You can sand it to produce a smooth surface

And so?

This stuff, if there is no problem producing it on the Moon, will certainly become popular with Lunan sculptors and not just with transplanted chain saw wielders. How easy is it to work? Let's put it this way. AAC is harder than balsa wood, softer than pine., much softer than oak.

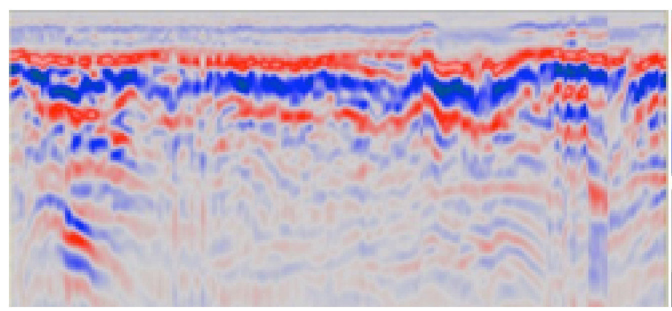
Now its ease of carving and shaping is a double edge sword. Being non fibrous, an AAC sculpture could break easily ion impact -- if you dropped it (low lunar gravity to the rescue?) and could be scratched, gouged, marred easily. Could you give it a protective coat or skin, using only inorganic materials producible on the Moon? The brainstorming and experimenting continues. **< MMM >**



From Junk to Music-Making on the Frontier

It takes imagination to see anything of use in a pile of "junk." Yet artists who cherish free materials have "dumpster-dived" for arts and crafts stuffs from time immemorial. Okay, but what about music? Now that takes a leap of imagination to be sure. But space frontier junk piles may be a major source of music-making artifacts. For more, read "Music from Junk" *Article below*

Exploring Moon & Mars Lavatubes with GPR: Ground Penetrating Radar



by Peter Kokh

GPR is certainly a tool that will be of great use by explorers on the Moon and Mars searching for lavatubes, provided we have first determined an area to be "tube country." On the Moon, certainly, the GPR unit might have to be significantly more powerful. Whereas on Earth, lavatubes may lurk only a few feet below the surface, it is estimated that to have survived intact from their formation on the Moon in the period of great lava upwellings 3.5 to 3.8 Billion (big B) years ago to the present, the ceilings must be of the order of 40 meters thick, enough to have withstood the average random meteor and meteorite bombardment through 38 million centuries.

If we can build such equipment, we can create low-resolution maps of lavatube fields. The next step would be to use these maps to locate drill holes down which instruments can be lowered into the lavatube voids for more detailed radar mapping of their surfaces: ceilings, walls, and floors.

We wrote about this in MMM # 100 Nov., '96, p. 6. **Robotic On Site Lavatube Exploration & Surveying**.

www.lunar-reclamation.org/papers/lavatubes_ccc.htm

Can a Permanent and Economical Human Base be Built on the Moon?

by **Theo Allan Fernandes**, Mumbai (Bombay), India

Foreward:

Every time we look at the Moon in the night sky it seems to be pouring white light on us and tempts us to reach it. It was a mysterious rock before the Apollo program. Astronauts have indeed left their footprints on the Lunar dust, the first being the Apollo 11 Mission on July 20, 1969 with crew members Neil Armstrong, and Edwin E. Aldrin Jr, (Michael Collins, Apollo Module Pilot remained in orbit.) And the last mission being Apollo 17 in December 1972 – the 6th U.S mission to do so. Just as he stepped off the Lunar Module Neil Armstrong proclaimed, "That's one small step for man one giant leap for mankind". He then said it from his heart and hence predicted the future of space exploration. Today, not only America and Russia, but several other countries like Canada, India, Europe, China and Japan have the capacity to participate in space science exploration and mission programs.

Galileo was the First to focus his telescope on the details of the Moon's Surface in 1609. He recognized mountains and large, flat, dark areas, which he called *maria*, the Latin word for "Seas". But still people were eager to learn more about Luna (Moon) which has fascinated mankind throughout the ages. Scientists too had unanswered questions, before Astronauts reached the Moon. The Apollo Astronauts brought back 380 Kilo of Moon rocks, along with other crucial, not previously known information. Further scientific study of these rocks answered some of these questions to give us our current understanding of the Moon's past and present

Formation of the Moon:

Before the Apollo Missions, Scientists had three different theories about the formation of the Moon. Each posed further questions, however.

- The Moon had been a wandering planet that was captured by the Earth, But how could a small planet like Earth capture such a big Moon?
- The Earth and the Moon had form from the same rotating cloud of rocks and dusts. But if so, why didn't the Moon have a big, heavy core like Earth?
- A chunk of the Earth split off and formed the Moon. But, if Earth was once spinning fast enough to lose a piece of itself then it should still be spinning much faster than it is today.

Questions raised by each of these theories remain unanswered.

- The fourth idea: The giant impact Hypothesis, according to which an object as big as Mars struck the Earth, destroying itself and blasting off a huge amount of materials into space. Some amount of this material remained in the Earth's orbit and clumped together, to form the Moon. This idea made sense after the Apollo mission. As big impacts were common in the violent past. A giant impact might have released enough heat to create the Moon's Core of Magma also giving the Earth a tilt and Spin. The heavy core of the Mars-like object might have become part of Earth's, which clearly explained why the Moon's core seems small and light as compared to Earth's

Description of the Moon (Luna):

The Earth's only natural satellite, the Moon has a diameter (3,476 kilometers) more than a quarter the size of Earth's. The Moon is 384,403 Kilometer distant from Earth surface. Its gravity is one sixth that of Earth's because of its smaller size, as we have seen demonstrated by the giant leaps of the Apollo Astronauts.

The Moon's top layer of crust and mantle is rock solid, about 800 kilometers thick, beneath which is a partially molten zone. Covering the Moon's crust is a dusty outer layer of rock called regolith. Both the crust and regolith are unevenly distributed over the Moon's Surface. The crust ranges from 38 miles on the near side to 63 miles on the farside. The regolith varies from 10 to 16 feet on the Highlands. There are many surface features such as craters, mountains ranges, rilles and lava plains. There are two basic types of terrain on the Moon's surface – the Maria and the Highlands.

The Moon does not possess any atmosphere, hence no wind and weather as on Earth. The temperatures on the Moon range from 100 degree Celsius at noon (when the sun is directly overhead) to 173 degree Celsius at night. The Moon outgases radon, a product of radioactive decay of elements in the crust, and possibly other gases, which may originate deeper within the Moon's interior. This outgassing may be one of the reasons for the sudden temporary glows, darkening and changes of color of the normally unchanging Moon.

The Moon does not produce its own light but instead reflects light from the sun hence looks bright. The rotation and revolution of the Moon both, around the Earth takes 27 days, 7 hours, and 43 minutes. As the angle of the sun is changing through this period, the length of the day/night cycle is about two Earth days longer. The lunar phase changes as the Moon orbits the Earth resulting in illumination of its different position relative to the sun as seen from Earth. The Earth's gravity has locked one Lunar hemisphere permanently towards itself. The Lunar sky is always black because there is no diffraction of light.

Some unanswered questions about the Moon:

1. Do albedo Swirls have magnetic origins?
2. Do the permanently shadowed areas on the Moon (Lunar Poles) harbor quantities of water ice and contain microscopic organisms that can live in extremely hostile conditions?
3. Does the Moon have reservoirs of trapped underground gases?
4. Can the Moon obtain magnetism from impacts by comets and asteroids

Purposes for future Moon Missions:

1. To conduct various scientific experiments and to study the Moon in greater depth.
2. To explore permanently shadowed regions at the lunar poles
3. To determine the bulk elements composition of the Moon as well as to identify potential Lunar resources, including water ice
4. To determine if life could evolve on the Moon given some basic conditions

5. To explore particularly a crater in the Moon's South Pole-Aitken Basin which may contain some of the oldest, if not the oldest, exposed material in the Solar System
6. To establish a large scale permanent human base supported by local resources on the Moon, which will be economically viable (feasible, possible and practical) and could even serve as a stepping stone for sending Astronauts to Mars and other planets of the Solar System
7. To find, and tap minerals (Lunar Resources) which could serve as a new and immense source of energy for Earth's growing power needs.
8. To establish global human settlement and perhaps terraform the Moon (make it conducive to life forms)

----------------- [Paper Proper] -----------------

Research Question:

Can a Permanent and Economical Human Base be Built on the Moon?

Facts that are already known or hypothesis about the science related to my purpose/research question:

The Moon base constructed at the beginning could not be a large city or village with buildings. At first it will be only small enough to support team or certain specialized space scientists and engineers, about 500 to 1000 in number. Later on, once we are making use of local resources to defray costs of Earth import, will we begin expanding the Moon base area.

The reason why my purpose is interesting and or important: Among many other purpose this purpose of settling up a permanent human base on the Moon is interesting and/or important for the following reasons:

1. Our return to the Moon and establishment of a presence there will provide the fullest possible support to the Mars Exploration programs
2. The Moon, if mined, will be an enormous supplier of rare earthly and industrially strategic elements and will also provide abundant clean energy for Earth's growing power needs and thus help solve its environmental problems.
3. The Moon's farside is permanently shielded from the Earth's radio noise. This makes it the best possible site for Radio Astronomy
4. What we're doing to our own planet is scary. And what this ever friendly planet might become is even scarier. Besides several types of man made catastrophe, there are indeed too many threats from Earth approaching asteroids waiting to hit our planet.

The types of missions I propose to send:

1. To search for evidence giving details about the Moon's violent past and its evolution to its present state
2. To more completely map the Moon's elemental and mineralogical composition prior to selecting an outpost site which would suit the best, with respect to various factors
3. To establish astronomical observatories, including radio telescopes on the Moon's far side which is shielded from Earth's electronic noise
4. To explore the unseen, ever hidden far side of the Moon
5. To search for water ice at the Lunar Poles

Why I am choosing these types of Missions

It is globally true there are too many present and future threats to our planet and to our civilization. These can be in the from of Global Warming or from Impacts by asteroids and comets, both which would change the weather patterns and eventually wipe out a considerable portion of the World's Population. Even if Global Warming is managed, and Earth is spared from a serious impactor strike for far into the future, the Moon can serve as a priceless source for minerals depleted on Earth minerals and for potentially valuable elements like Helium-3. Development of boundless clean – energy could be supplied to reduce Earth's Ever-Growing demand. On transforming the Moon to an Inhabited World, the Moon will become a center for Mars and eventually Solar System Exploration.

"*A single planet civilization cannot survive n the long term*" - Captain John Young.

The advantages and challenges of the types of Missions I am proposing are as follows: Advantages:

1. A permanent Moonbase would provide uninterrupted service and could be a center for long term investments
2. A permanently occupied Moonbase will be much easier to repair even if damaged
3. Many kinds of (research and construction) activities carried out on the Moon are much easier than in free space, because of the Moon's gravity.
4. Local Lunar materials and minerals would be useful for building up and expanding the Lunar base
5. Unique products may be producible in the nearly limitless extreme vacuum on the Lunar surface, in turn supporting Lunar Settlement.
6. About 45% of the Lunar soil and rock is made up of oxygen, and eventually can be used

Challenges:

1. What to do with the accumulated fuel waste, food waste and human waste on the Moon?
2. How can we enrich the soil for cultivating food crops on the Moon?
3. How can we obtain energy during nighttime
4. How can a life supporting system be used for the people on the Moon?
5. How can we extract Oxygen from the Lunar Soil?

I propose to address these challenges in the following effective ways:

1. These are all *carbohydrate* and other organic compounds and hence can be easily conserved, recycled and oxidized to give carbon-dioxide for photosynthesis of vegetarian food cultivation on the Moon
2. Organic methods including compost manures, worms, etc, are preferred for enriching the soil in a closed system on the Moon. Use of chemical pesticides will be strictly prohibited.
3. A small nuclear power plant will be constructed at a considerable distance from the Lunar base for providing energy during Nighttime
4. Life supporting systems require life giving elements: hydrogen and oxygen (for water), carbon and nitrogen. Plenty of oxygen is bound in silicate minerals of lunar

rocks (about 50% by volume) and solar winds (composed of hydrogen, helium, neon, carbon and nitrogen) provides the rest stored in the upper layers of the moondust, retrievable by heating .

5. Oxygen can be extracted from the Lunar soil with the help of the Lunar Oxygen Extraction Pilot Plant.

Unaddressed Challenge:
How to create air, water and organic things from minerals and inorganic matters?

Where am I planning to send my Mission?
I would like to set up the Moon base at higher latitudes on the Moon, because the higher the latitude the lower Earth will appear above the horizon for a nicer view.

Site Location considerations of key importance:

1. All future Lunar missions should be strictly in accordance with the "Moon Treaty". If needed, the Moon Treaty should be amended
2. The doors should be kept open for equal participation of private enterprises
3. The Lunar resources should be used up to the fullest extent without causing any environmental damage to the Moon
4. The site of the Lunar base must be most suitable to carry out various scientific experiments
5. Sites of historical and other significance should be protected

Mission Goals: The data to be collected and why and how we will collect it

A. To determining how much light will plants need during the nighttime

Why: In order to control lightning costs and increase crop growth/harvest

How: By experimenting on the following factors,

1. Amount of time in light or darkness
2. Moisture of the soil and air
3. Watering
4. Air and soil temperature
5. Type of soil preferably, organic
6. Volume of soil per plant

B. To develop and test new technologies

Why: To support human space exploration to Mars and other destinations

How: Use Lunar materials and other Space resources

C. To determine economically minable richer concentrations of industrially strategic elements and subsurface reservoirs of gases?

Why: These minerals and elements will be helpful in building the Moon base and the excess can be exported to the Earth. Thus benefiting both

How: With the help of Neutron Spectrometer and Gamma Ray Spectrometer and other technologies

Additional data to be collected:

1. To study the effect of one-sixth gravity on cells, tissues and plants
2. What stage of embryonic development is sensitive to the reduced gravity level and why?
3. To identify the best location for an outpost from various points of view

Conclusion:

We should expand our civilization outward in space in a safe, supportable, sustainable, and unstoppable manner. The Moon represents the next vital step in this direction. It will be a land to be settled, a supplier of precious and important minerals for the development of clean energy in space and on Earth. Luna will be a location for soaring commercial enterprises. The Luna will be a training base for future explorer to Mars and other planets, hence shaping our future world.

Dream, Dream, Dream,
Dreams transform into thoughts
And thoughts result in action

"**Impossible**" is just a big word thrown around by small men who find it easier to live in the world they've been given than to explore the power they have to change it. Impossible is not a fact. It's an opinion. Impossible is not a declaration. It's a dare.

Impossible is potential.
Impossible is temporary.
Impossible is nothing

--------------- Student Work Sheet ---------------

Q 1. Do you see a future for a permanent human presence on the Moon? And if so, what shape do you see it taking? Science outposts only? Resource-developing settlements supporting themselves with experts to Earth and other outposts in Space, as part of an expanded Earth-Moon economy?

The past has already witnessed human presence on the Earth's only satellite – The Moon, the last being the Apollo 17 mission in December 1972, the 6th U.S. Landing Mission. The need of the present is a permanent human presence on the Moon, of which I am sure, will be accomplished in the next 2-3 decades, based on the following indications:

1. The Indian Space Research Organization (ISRO) will send its first unmanned mission to Moon in 2007-08
2. Japan has set itself a 30 year plan to establish a permanent Moon base. Japan is planning an unmanned lunar flight called "Lunar A"
3. China too has announced plans to go to the Moon. China would be putting a man on the Moon by 2010, establishing a Moon Base soon afterwards.
4. U.S. plans have been announced to build a permanent base for men on the Moon
5. The European Space Agency has launched an unmanned mission to the Moon called "SMART-1"

A Nuclear power plant for nighttime energy shall be constructed at a considerable distance from the lunar base. A power plant consisting of solar cells (photovoltaic cells) for daytime energy shall be stationed near the base. Local Lunar materials would be quite worthwhile for building up a Lunar base. Some methods like:

- Extraction of Oxygen from Lunar Soil will provide an important resources.
- Oxygen, Iron, Titanium and Sulfur production from ilmenite
- Iron and Steel alloy manufacturing

Low gravity mining of Earth deficient elements on the Moon (such as Helium-3) and exporting them to the Earth will help establish an Earth-Moon Economy which in turn will solve Earth's energy problems.

Q 2. What kind of Sports activities do you imagine on the Moon? Will there ever be any Olympic Lunar event?

The Moon being the top tourist destination of the near future will offer entirely new low gravity games developed specifically for the Moon. But some of sport events, the ones traditionally played on Earth would be modified for lower lunar gravity e.g. *heavier* javelins, shot puts, discus; and *higher* basketball hoops, high jumps poles. Yes indeed there would be an Olympic Lunar event called Lunar Olympiad would be held every half a decade (every 5 years) and would bring loads of people and participants skywards to watch and participate in this one of its kind event.

Q 3. If in the future, a Lunar frontier is opened for people, what positive psychological effects if any do you expect this may have on those of us who remain on Earth?

A lunar frontier of the future will not be large enough to provide shelter to a large portion of Human Population, due to lack of resources and other problems. Thus, most of us would not be fortunate enough to visit this sea of Tranquility. But this will surely make us proud to be a part of the most developed creation of God – Human beings, who with their hunger for achievements exceeding the limits, made it possible not only to land but to live on the Moon. Remaining on Earth will not make us feel isolated because it is where it all began - the Creation, the Evolution, the Development and the Achievement. We will be happy to see or hear about any of our friends or relatives who land on Moon. Though most of us may be eager and strive hard to visit the Moon oneday, some may be happy because they live more at ease than those who live on the Moon. As once said wisely after a day ends, one must come back to a place which he proudly calls Home Sweet Home.

Q 4. Should the Moon Treaty be changed to provide for the development of the Lunar resources, with due protection for the Moon's environment and its scientific, geological, and scenic treasures?

The "Moon Treaty" is a agreement governing the activities of states on the Moon and other celestial bodies which was opened for signature at New York on December 18th, 1979. The existing articles of the Moon Treaty should not be amended because it has already paid attention to these very important factors in its agreement of 1979 as follows:

- Article 6: State parties may in the course of scientific investigations also use mineral and other substances of the Moon in quantities appropriate for the support of their Mission.
- Article 7: State parties shall take measures to prevent disruption of existing balance of its environment…
- Article 11: ….. The main… shall include: The orderly and safe development of the natural resources of the Moon.

But two new articles should be added: In accordance with the Article 18 of the Moon Treaty

- New Article 22 stating protection of private enterprise and the role of tourism, and
- New Article 23 stating the areas visited by the American Apollo and Soviet Lunakhod Missions may be considered as historical treasures and must be protected.

Q 5. Would you like to take trip on the Moon? Why?

Yes, I'd like to take a trip to the Sea of Tranquility. The Moon, whose light shows me the right direction to my home sweet home when there's no light due to electricity problems. I would like to visit the Moon as the best tourist destination with half work and the rest play. I would like to sink in every imaginable (as though on Earth) sort of environment the Moon would provide. The Earth would be a splendid sight from its surface. It would be a trip of a lifetime.

The Lunar base would be the fruits of seeds sown by those who have achieved mastery in their respective fields. It would be a great adventure to be deeply connected with the satellite of the third planet from the Sun. On looking at out Home planet Earth from the Moon it would seem as if I have reached a place of Sanctity. I hope reading this, millions would like to visit the Moon one day just as I do.

Q 6. Do you think that putting an outpost on the Moo will be help to human exploration of Mars?

Mars being the closest place to look for life elsewhere, as well as the most promising place to look, will surely get great help and support from establishment of an outpost on the Moon. Lunar Mines and factories would be the supply source for various Metals and Equipments needed for manned and unmanned Mars Exploration. The Moon's resources can be used to manufacture items needed to support the Mars Initiative. A Moon base will play an important role as a stepping stone to Mars and eventually to other planets of the Solar System. **<TAF>**

NOTE: The above paper was the first prize entry into a studend essay contest cosponsored by The Planetary Society of Youth (India) and The Moon Society.

Theo Allen Fernandez was seventeen at the time.

Making Music without Importing Instruments

Music from Junk

Monster Musical Instrument Shop

by Peter Kokh

The Frontier Situation

Music without musical instruments? That's easy. Our computers can generate any music we want. That may satisfy some, but not all. Some artistic souls will want to generate music the old fashioned way. Yet musical instruments will be luxury items imported only at exorbitant cost. A ban on importation of musical instruments would not stop the music, however. Instead it would encourage and energize an amazing creativity.

In MMM #3 March 1987, "Moon Music*" we took up this challenge.

http://www.asi.org/adb/6/9/2/2/003/moonmusic.html

Republished in the first volume of MMM Classics:

http://www.lunar-reclamation.org/mmm_classics/mmmc1_Jul2004.pdf

We can make some kinds of instruments out of lunar materials, but. But forget anything made of wood, copper or brass. Iron, steel, aluminum, glass, concrete, ceramics - yes. wood, copper or brass - no. Wood incorporates hydrogen and carbon that should be recycled to maintain the biosphere. Copper, from which brass is made, exist on the Moon, so far as we presently know, only in economically irretrievable traces. That leaves out most wind instruments.

Ingenuity will come up with substitutes. Incredibly beautiful music can be made from a cut-off 55 gallon drum whose bottom is then beat with a set of sledge hammers into a complex concave shape capable of sounding from 3 to 36 full, round, vibrant notes. We can make music with glass tumblers and ceramic tubes etc. The article cited above had many more suggestions.

"Scrap" will be a "lunar material" also

But in addition from fashioning musical instruments from scratch out of processed lunar materials, some frontier artists may choose to simply make them from "junk" or "scrap." We recently read the article "Recycled Rhythms" in the column "One Small Step" in Sierra - Jan/Feb 2005. The article told the story of **Donald "the Junkman" Knaack**, Percussionist, Manchester Center, Vermont. Visit his website: http://www.junkmusic.org

Knaack uses only junk metal - wrenches, pipes,etc., chains, brake drums, hub caps, pan covers, seashells etc. - we can use items discarded by manufacturers as seconds and by consumers as broken, or just as "replaced", spent artillery shells, rifle barrels, Scrap metal parts of many kinds will lend themselves to percussion sounds.

Beyond Percussion

But some shapes, of metal, glass, and ceramic should yield bell-like notes with a distinctive pitch, A mix and match "full set" of them would allow the artist to render almost any melody of whatever beat.

Whereas traditional musicians attempt to use recognized instruments with fairly standardized types of sounds, Lunar and Martian pioneer "junk musicians" will be more inclined to experiment. And if their ensembles do a poor job of rendering known and cherished melodies, they will just create music specially tailored for the instruments they have fashioned. The "sound" will be unique. Junk Music could become a popular genre on both frontiers, adding much to the specialness of space frontier cultures.

The music will not be "refined" but neither will the spirit of frontier folk be refined. Refinement will come over generations, as frontiers become less rough and rugged, and survival becomes less problematical.

The Lunar & Martian Junkpiles

The junk will come from abandoned and derelict space ships, from broken down rovers and overland coaches and rigs; from fuel tanks and shipping containers. It will also come from the detritus of frontier industry. And surely, some of it will come from the consumer cycle. Agricultural "scrap" will also do at least temporary duty in music making. Hollowed out guords, bamboo pieces, just plan sticks, and wood, andreeds, and ... the list goes on.

The point is that junk is here and now, whereas specially designed and fashioned instruments made from the new suite of processed lunar and Martian materials will come on line more slowly. More importantly, "junk is junk-cheap." While instruments imported from Earth will be exorbitantly expensive, those carefully fashioned from the new frontier -processed materials will embody the costs of the processing and manufacturing, assembly and tuning, etc. Cheaper, but not free.

Frontier Junk Music as an Export to Earth

Junk Music is of terrestrial origin. What "the Junkman" has done is but to call fresh attention to a type of experimental musical expression that has always been with us probably since long before the dawn of recorded history. But it has definitely not been mainstream as more "cultivated" music has long prevailed. Fresh is good, however, and whether or not the Knaack's music catches on is not the point.

On the frontier, Junk Music may take on a prominence that it could never attain here, a prominence out of necessity. And it will be good, and fresh. It will inspire and enhearten the pioneers. Whether they gather to hear impromptu "junk jams" or practiced "junk concerts," this is a musical tradition sure to be on our road to the stars. At the outset at least.

One cannot believe that this raw, rugged, brash sound from the lunar and Martian burrows will have its devoted fans on Earth. There will be both recordings and live telecasts and webcasts.

Some terrestrial youth may be inspired by it to dream of joining the pioneers. Others will be turned off, probably for the better. The early frontier will be a rough place, where sacrifices are made, but the rewards of leading significant lives and helping launch new worlds will be great.

Starting a frontier tradition now

In the 1987 article, I proposed that chapters try to put together "lunar ensembles" that would use only those instruments that could be fashioned from readily available lunar-processed materials. Whether they only played "frontier filk" songs or also re-rendered popular terrestrial favorites, their music would give color, life, and detail to the otherwise blank visions of life on the lunar frontier. To our knowledge, no one has taken us up on this proposal.

An ISDC pipe-dream

When on the road trip home from ISDC 1993 in Huntsville, Alabama, Dave Dunlop and I decided to bid on hosting ISDC 1997 in Milwaukee (we lost this bid to Orlando by one vote, but successfully rebid for the 1998 event), a lunar ensemble was part of our grand design for the banquet entertainment. Alas, this, like many other planned special features, this was something that required both a lot of lead time as well as the right person to head it up.

“Lead time turned to lead (the metal)” as it is wont to do, and the right person never came along.

What about at M.A.R.S. or at M.D.R.S.?

Perhaps some individuals volunteering for future two week crew assignments at the Mars Arctic or the Mars Desert Research Station will take up the idea and get something started. Despite efforts to recycle, both facilities produce their share of trash laden with unsuspected potential: broken parts from machinery and equipment; tin cans and other containers: and more.

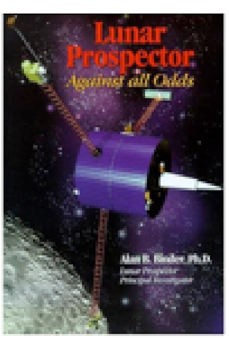
Willing crew members could experiment with this stuff, carefully collecting objects that produced distinctive sounds. If persons on following crews kept adding to the salvaged music making stuffs, eventually the “junk jam” that resulted would start to sound really good. A few recordings sold at Mars Society Conventions and at the annual ISDCs and the bug would start to catch on.

Others could experiment at home. Each new convention or ISDC could schedule a “junk jam” and perhaps a quickly rehearsed “concert.” And Voilà! A frontier tradition will have been born. As Robert Zubrin has remarked, there has been no frontier without its special music and heartening songs and event-remembering ballads. Music may seem the least important aspect of a frontier opening effort. But in some ways it might be one of the most critical elements of all. “Shall we jam?” **<MMM>**

THE SPACE book WORM

Lunar Prospector: Against All Odds
by Alan Binder, Lunar Research Institute

(Principal Investigator, Lunar Prospector)
(Member, Moon Society Board of Advisors)



This important book, chronicaling the nearly 15 year struggle to get a must-do project from paper studies to reality, as told by the man at the center of it all, has been published and can be purchased directly from Ken Press in Tucson (call 5220 743-3200 or email ken@kenpress.com).

The book costs $44.95, has nearly 1100 pages of text, over 70 B/W pictures, and numerous appendices. The author’s website (www.lunar-research-institute.org) has the color photos, an outline, the appendices, and the same ordering information.

MMM #183 - MAR 2005

The Mars Desert Research Station (MDRS) in Utah

The MMM editor spent two weeks in February at this remarkable facility in Utah. On pages 3-8 and elsewhere in this issue, he tells about the achievements, the frustrations, the opportunities. Most importantly, he lays out the case for other organizations to support the analog station effort in various ways. Much of what we discover in this effort will apply to Lunar operations as well.

A Broad-Based Effort to Expand the Scope of the Analog Research Station Program

by Peter Kokh, Editor of Moon Miners’ Manifesto
Life Member, the National Space Society
President, the Moon Society, Member, the Mars Society,
and MDRS Crew #34, The Junk Yard Wars Refit Crew

Both the Mars Arctic and Mars Desert Research Stations (FMARS and MDRS, respectively) established by the Mars Society, have been working magnificently from the beginning to create environments from which we could learn better field exploration techniques. We *have* been learning what techniques and what equipment, that look good on paper, work in the field, and what does not.

By the simple means of having all crew members wear “space suits” whenever they go outside the Hab, the illusion that they are on Mars thus created is strong enough to induce the crew members’ wholehearted participation in the experiments they conduct. Good choice of host terrain with minimal plant life, suggestive in coloration and land forms of what we expect to find on Mars certainly helps. The lack of phone and cell phone service as well as of TV all reinforce the illusion. Understandably, there is no effort to impose 6-40 minute time delays on Internet downloads and uploads (although that would be the case on Mars!) but a token 3 minute delay is worked into communications between the Hab and Mission Support in Denver or Ann Arbor.

We have learned that ATVsµňpressurized rovers” not unlike the Apollo Moon Rovers used on A15, 16, and 17 are essential: rather than be replaced by larger, faster, longer ranging vehicles with pressurized cabins, they are necessary to accompany the later, much as in a naval fleet, a lot of specialized smaller craft accompany the battleship.

Taking it a step further, we have learned that small tele-operated robotic rovers operating on tether leashes from the ATVs or PEVs are enormously helpful. They can scamper up hills and down valleys unnegotiable by the wheeled ATVs and PEVs to greatly enhance the exploration and examination of terrain traversed.

We have learned what instruments are helpful in exploration: GPS units, and software that tells the explorer what route from A to Z will get him to Z in the least time with the least exertion and the least risk. That is something that is not easily determined by visual clues from point A alone. We've experimented with different types of tools to do geological field work as well as biological tools to look for evidence of microbial life.

While much was learned about space suit design and performance in the Apollo experience, we've learned a few more things on Devon Island and in SC Utah. The ingeniously designed mock-up EVA suits have brought to light a number of design challenges that must be addressed if our pioneers are to function as efficiently as possible.

We have discovered a few things about the human life support system as well, for example that we only need a third as much water ration per person per day for hygiene maintenance as NASA paper studies had supposed.

We have learned how to better organize daily work schedules, how best to divide the workload, how best to combine work with attention to personal needs and inter personal relations.

In short, the Analog Mars program has helped uncover lessons that never would have been learned on paper. We are helping to contribute to the success of future efforts by NASA and other space agencies.

These efforts have also attracted much publicity, resulting in increased anticipation and support on the part of the public and the media. The Mars Society's strategy has been two-pronged from the outset.

How can we do more, and on a broader front?

At this point, we need to take a look at some serious questions:

Question: What can we do at MDRS to learn more - without tearing down the present hab and building a new one?

Question: What useful simulations can be done in settings that are not "Analog Mars," but which are more easily supported logistically?

Question: What useful work can be done at MDRS - and elsewhere - by other groups who share the goal of preparing the way for humans to establish permanent presence on Mars and other worlds beyond Earth? The past two decades have been ones marked by turf-protectionism, dare we say "turf-retentiveness," on the part of separate space enthusiast organizations and their leaders. Looking forward to a 21st Century marked more by collaboration, what can we all pitch in to help achieve in the area of outpost and outpost activity simulations?

Lessons from a working visit to MDRS

Last August, we announced a new Moon Society project to "rent" MDRS for a two week period in order to conduct a number of Lunar Outpost activity simulations. At first glance, there seems to be a good number of useful things we could do in south central Utah, some relevant to lunar outposts only, others relevant to outposts on both Moon and Mars. But without first hand knowledge of the facility, it would be difficult to plan an effective "Moon Mission." It was important to go see for myself. Having long been a Mars Society member as well, I applied as a "crew volunteer," and with the help of long time friend Ben Huset of the Minnesota chapter, we both secured a spot on Crew #34. This was especially fortunate, as this crew would not be a simulations and research crew, but a "refit" crew: our mission was to replace the Hab's wiring, plumbing, and heating systems -- bring them up to code and solving some major problems: repeated pipe freezing, uneven heating, etc. Crew #34 was an opportunity to learn how MDRS worked from the inside-out as assistant electrician and carpenter.

Necessarily designed as inexpensively as possible, and assembled as quick as possible to meet season use and publicity timelines, MDRS suffers as a result in some areas:

• **We cannot simulate a closed life cycle environment at MDRS**, even with a much more thorough biospherics module than the present GreenHab which recycles gray water from sinks and showers for use in flushing the toilet -- MDRS leaks like a sieve. It is not a sealed structure, and it would be cheaper to build a new one than to seal it effectively.

Air recycling and thermal management are not the only two casualties of the leaky hab. Dust control is all but impossible. Mouse control is a lost cause with a two inch gap under both front and rear hatch doors, besides oversize holes for pipes and conduits passing through the hab wall, and poorly sealed, uncaulked portholes, and a loose laying plexiglass door over the roof emergency exit hatch that flaps in the wind.

• **We cannot easily conduct Adequate Shielding Exercises** - First, the site is owned by BLM, the U.S. Bureau of Land Management, and our conditions of use require us to tread lightly on the site. Moving around large volumes of soil might not fly. Even should we get a "variance," shielding the Hab would be a daunting proposition. It is too tall. Sandbagging the Hab dome alone would be insufficient and futile. A spread out, one story "Mars Ranch" structure, set on or into the local surface, would be much more practical to shield.

And this situation is regrettable. While in Utah, we are not subject to the same cosmic radiation and solar flare threats from which Mars' explorers and pioneers must seek shelter, our "Field Season" is unnecessarily shortened by the impracticalness of cooling the MDRS Hab from the fierce summer desert heat.

On the Moon and Mars as well as in Utah, the principal co-benefit of shielding is thermal equilibrium. Face it, Mars' surface is as cold, or colder than Antarctica. Yet a few meters down, the soil temperature is the same year around, though the equilibrium temperature there is much lower than it is on Earth or on the Moon. Thermal equilibrium is the principal design benefit of underground housing on Earth. Soil-sheltered habitats simply make sense, however uninteresting they may look to the photographer or artist. And we do need to simulate this, to uncover design challenges that are surely lurking. For in fact, while we do have considerable experience from building earth-sheltered homes here on Earth, they are not designed to the same set of constraints we will face on the dry Moon or on wet Mars.

The Hab *has been designed for expansion.*

The Mars Desert Research Station Hab structure was designed with two EVA hatches. The rear one has been used principally for quick access to the generator and diesel fuel station, to the propane tank, and to the water tank. But from the outset, this extra exit was looked on as a point of future expansion. Now the time may have come to take a new look at this option -- for on Crew #34, all these utilities have been relocated to a new area, shielded from the Hab by a thirty foot hill. That barrier provides quiet (the gener-ator is a major noise contributor, day and night) and safety: should any of the fuel sources ever catch fire or explode, all of them would in a chain reaction -- the hill provides safety from the fireball that would result. Note: Crews 33 and 34 also installed a superior grounding system, a real feat in the low-conductivity soil, following the ideas and methods, .and using the tools developed by a young volunteer from Caracas, Venezuela, Gregorio Drayer, under his supervision.)

Expansion modules, hard-shelled or inflatable, if designed in one-floor or "ranch" fashion, might support emplacement of *removable (sandbagged)* soil shielding. This would provide a test of the thermal-equilibrium benefits and a basis for redesigning future analog Habs.

The Hab now supports some activities that get in the way of one another. While it is important to design multi-function space that will see more round-the-clock use, it is equally important that these multi functions not interfere with one another. My choice for first candidate to move to new added expansion space is the workshop-toolshop-fabrication area which could include an area in which to experiment with making things out of the local soil (even if it is chemically or mineralogically a poor analog of soils on Mars.) These activities are currently hosted by the Lab Science area.

A real Greenhouse engaged in food production as well as gray *and black water* recycling should be next. The principal impediment to growing food at MDRS is that the site is occupied only seasonally, primarily because of the desert summer heat, which could be managed by living undersoil. But that facility still could not recycle the air of the leaky Hab (one reason winter season heating bills are so high.) It must be added, however, that even if we overcame the heat problem in this fashion, the volunteer supply is not great enough currently to handle year around operations, unless skeletal crews are used in the summer season..

What else needs to be simulated?

• **Simulating Human Crew Systems:** No matter how good our equipment is, no matter how well we have developed our procedures and processes, the most important system of all, because it is central to everything else, has been simulated only on a hit and miss basis, with the result that lessons learned, while valuable, are trivial in contrast to the need. We must not downplay simulation of human crew systems.

• **Simulating the Mars Frontier Diet:** There has, in fact, been a hit and miss effort to simulate the kind of diet Mars Pioneers will surely face: freeze dried foodstuffs from Earth rehydrated with water from Mars, supplemented *occasionally* by fresh produce from the garden, and possibly by not too frequent treats of Talapia filets: Talapia are a species of fish which thrive reasonably well in gray water systems integrated with greenhouse food production. The problem at MDRS is that individual crew members vary greatly in their willingness to go *that far* in simulating the Mars experience. All too frequently, their shopping trips in Salt Lake City where they gather to begin their mission, end up with a lot of menu-buster treats. The pioneers on Mars will have no such luxury.

• **Simulating Frontier Recreation, Art, and Hobby Options:** In after supper free time, if there is any, crew members at MDRS can read, play games, watch DVDs. In fact most are busy at their laptops. Simulating realistic frontier recreation and hobbies is something that can happen at MDRS but seems to have been given no real emphasis. We contributed a Mars analog version of the age old African classic game known by various names from tribe to tribe, and most commonly in the west as Mancala or Oware. The board was crafted from wood, but painted to simulate Martian ceramics. A "pit and pebble" class game (rated as one of the nine best of all time in strategy), our version has been dubbed **Craters & Blueberries.** We also took a look at Scrap and Trash generated at MDRS. On the future frontiers, such humble materials will jump start frontier arts and crafts.

• **Simulating Ergonomic Alternatives:** Ergonomics is impor-tant for good crew morale and efficient operations. A major opportunity was missed by the decision, in designing MDRS' interior, to copy the layout of the FMARS arctic facility. A clean slate redesign, finding new solutions to the same design constraints, would have yielded useful ergonomic information, comparing experiences at the two stations. The interior of the Euro-MARS station slated for Iceland, has indeed been redesigned from scratch, and whether it has the blessing of the Society's founder or not is immaterial.

You can not learn if you don't vary the conditions of the experiment. It is that simple.

Happily, the Aussies are proposing a Hab that is not of the double tuna-can stack variety, but going back to an earlier design for a more horizontal, easier to shield structure.

• **Hab Interior Ergonomics:** Getting back to my recent visit, I had hoped to get input from my fellow crew members on what they would change about MDRS, if they had a magic wand: what areas could function better by mutual isolation, which by being collocated more closely. What functions of common areas would be better served by having a dedicated space to themselves? What activities, not supported by the current design should be worked into any proposed expan-sion. Alas, we seldom had free time after dinner. We were always behind in our refit schedule and worked often into the wee hours before hitting the sack. I was able to get only minimal feedback.

We hope to develop a questionnaire that future crew mission commanders can circulate on a voluntary basis, and thus get a wide spectrum of input. And by also circulating feedback forms to past crew members, we may get some return. Unfortunately, such debriefing will suffer from the staleness of memories. But it is also possible that some former crew members will have better digested their experiences and be able to pick out and identify things that bothered or irritated them that they might not have been able to "put their finger on" in a classical "fresh from experience" debriefing. Both fresh and digested experiences are helpful.

At MDRS, the interior of the Hab is very poorly simulated, along with living conditions. In the recent "refit" mission, we had no time to attend to even a partial facelift. There are materials other than wood and drywall that would simulate likely interiors at not too much extra expense. Right now, that is not a priority, though the money could be easily raised separately.

• **Acoustics:** The individual staterooms share the same floor as the wardroom common space: without any acoustic insula-tion, this is a problem for those early to bed and early to rise. Ear plugs are one way to cope. But this is a problem that could have been lessened with good design and involv-ment of an acoustics specialist. In fact, the Hab is a very noisy environment, and that can only dampen performance over the long haul. Relocation of the generator behind Engineering Hill has removed offender # one, however.

• **Logistics is important.** For MDRS, Salt Lake City, the nearest major air hub some 240 road miles to the north, serves as the staging point. (Denver and Las Vegas are both 400 miles distant. Grand Junction, CO at 160 miles is only a regional airport with higher air fares.) From Hanksville, the nearest hardware stores are 115, 160, 188 miles distant. Now remoteness from urban areas does have its advantages. It helps set the scene psychologically. And the MDRS clear moonless nights offer an awesomely star-spangled, Milky Way dominated gasp of what it must be like to be suspended in space, or on Mars or the farside of the Moon.

• **Dust Control:** A determined effort to identify all the holes and gaps in the Hab outer wall and bottom floor should be made, and a master plan developed to seal them with durable materials that blend in. A stop can be built into the hatch thresholds that will do away with the 2 inch gap along the floor that remains when the hatch is closed. And above all, let's put out the call for a donor to cover the need of fabri-cating new porches and steps and apron approaches to the steps out of grating. When it rains even a little, the plant-free surface turns to mud, and with only wood and plywood surfaces guarding the entryways, transport of mud inside is guaranteed. That the Society does not have enough money in its general funds is no excuse. If it's worth doing, and it is, we must ask for dedicated funds, special donations. People give more when they know it is going to something specific the importance of which they can appreciate. The porches and steps are a prime example of a false economy,

Maintaining "Sims" (doing all outside activity in EVA spacesuits; staying on Analog Mars): Remoteness of hardware supplies from lumber to electrical, plumbing, and water supply needs was a major challenge for our "refit" mission. But simulation and research missions are designed to be more self-sufficient. However, the crew members on hand may be minimally capable of meeting various equipment and other emergencies and reliance on intervention from nearby Hanksville is openly accepted.

We are making no progress towards simulating Real Mars Frontier Isolation from Earth.

MDRS is dependent on regular fuel supplies from outside: diesel fuel for the generator; propane for heating and cooking; and water. In short, we have not yet been able to upgrade MDRS to the point where we are generating our own fuels, Marslike, from the atmosphere, or tapping local water reserves underground. We use only some solar energy, for the GreenHab. We also depend on outside services to repair the ATVs, an all too frequent need. On Mars, the outpost will have to be equipped for such emergencies, and have trained personnel among the crew consist.

That we pretend that Hanksville is a Mars Orbiting Station, and that Salt Lake City is Mars' moon Phobos, does little to simulate real Mars emergencies and real lack of options. There has been some hit and miss effort to document "out of Sims" activities. To minimize these occurrences will take a many vectored approach. And in preparation for developing such portfolio of strategies we will need more consistent, more detailed documentation, both on the part of the Crew Commanders and on the part of our off-site support people.

These many improvements can only be phased in, one at a time. The important thing is to realize that we must make progress in that direction,

Place for a lower level of "Sims"

Not everything has to be harder. On Mars itself, if all the things that needed frequent and regular attention and access where placed under a shielded, but unpressurized canopy or ramada, those attending to this area could wear lighter weight, more user-friendly pressure suits. At MDRS, those attending to the generator or other outside utility sources are supposed to wear full EVA suits. One of the personal projects I chose for my time at MDRS was to investigate the practicality of a demonstration of this system in Utah. Now that all the utilities have been relocated behind a noise-, fire-, and blast-buffering hill, we at MDRS could assume that they are under such a canopy, and wear designated lighter overalls and a special gas mask to simulate the lighter suit. A study of the ergonomic benefits recorded would give feedback on the value of such an innovation. Walk areas thus protected could be marked with simple color-coded poles, for fabric pretend canopies would not last long in our Earth desert winds.

What can be done elsewhere to compliment the learning exercises at MDRS and FMARS?

The Moon Society looks forward to the day when it can establish its own analog research station in terrestrial locations more suggestive of the Moon's surface than that of Mars. But that is not our concern here. What can de done elsewhere, *in any type of host terrain* (even verdant farm-scapes and urban cityscapes) that will help us prepare for pioneering Mars (and the Moon)? While exploring the surfaces of other worlds, and examining their chemical and mineralogical makeup may be the most obvious, visible, and high profile aspect of early outpost activity, it is only the above-horizon tip of a largely hidden iceberg. Far more basic will be the successful operation of the systems that sustain the pioneers: life support, inclu-ding food production and recycling of water, air, and both human and agricultural biomass waste. And the systems that maintain both the physiological and psychological health of the pioneer *teams.* None of this depends essentially on the host terrain, at least not in ways that require some sort of visible match.

Life support, medical systems, human factors such as ergonomics, food menus, etc. -- all these can be simulated anywhere it is convenient to do so. Logistics: where do the principal investigators live? or where is it convenient for them to visit habitually Where are clusters of volunteers?

These questions are important. In Utah, only one person maintains real continuing presence to help ensure some degree of continuity between crews. Don FoutZ, a local resident of Hanksville and a strong supporter of the Mars Society's analog hab program is on call, ready to train incoming crews, trouble shoot problems with the balky generators, and fickle Internet uplinks, and so on. We are fortunate to have Don. Without him, the Hanksville-based facility would have collapsed after the first season, if indeed it lasted that long. Of extreme importance are both continuity in expertise and availability of critical personal who take ownership of ongoing programs that cannot be adequately managed from Mission Support in Denver.

It would be difficult to run a more ambitious Greenhouse Food Production and Water Recycling system without a principal investigator living nearby. That such a facility serves a crew of six persons engaged in exploring an analog Mars landscape is irrelevant. Whether this be a program managed by staff at some university or college or by a dedicated individual, continuity and dedication both demand that the site be convenient, on a weekly or more frequent basis by the person accepting responsibility, and responsible for the design elements, and with authority to make changes. For "load," such a system could be linked to any living space regularly occupied by the desired number of persons, six or whatever. There is no need for the persons imposing the load (food needs, waste generation) to be involved with Mars simulation activities of any kind, unless some such can be happily collocated.

A medical system designed to meet all reasonably expectable emergencies for a group of six (or whatever) adults could be tested in any isolated small community where access to medical services is extremely limited. Small Eskimo or Innuit villages might do, although most are *too easily accessible,* these days, by airplane or helicopter.

MDRS is both blessed and handicapped by its remoteness. But Mars will be significantly more remote. All the more reason to go beyond field exploration techniques to pre-develop all the systems that will be needed to survive on Mars long term, *without recourse to rescue or resupply.*

At sites near stable clusters of dedicated individuals, simulations can be run by long term crews Other groups, inside and outside the Mars Society, can conduct exercises elsewhere that complement work at MDRS:

- thermal management through soil (regolith) shielding
- identify and develop optimum models of outpost expansion and develop expansion architectures
- develop more tightly closed life support systems that recycle air, water and waste to provide fresh food
- develop realistic food-nutrition-menu systems that expand phase by phase in diversity and satisfaction
- experiment with different interior layouts to determine their ergonomic pluses and minuses
- develop crew recreation, arts & crafts, gaming, and hobby opportunities for greater crew morale

Fringe Benefits of Multiple Networked Simulation Sites

Distributing the simulation workload will allow the tapping of personnel and organizational resources not now accessible to the Mars Society's Analog Mars Program. That benefit is considerable: more talent, more money, more publicity. This united effort will not be lost on the public nor on Congress which will soon pick up on the signal that "those feuding space groups" finally have their act together.

Geographic dispersal of the effort will also model the development of a multi-site, multi-settlement Mars Frontier Economy. That too will help science popularizers sketch out just how a first human mission will evolve beyond flags and footprints into a second human home world.

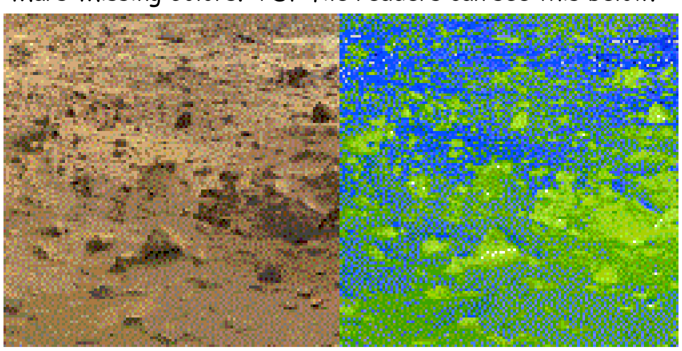
There are already strong dedicated concentrations of volunteers in the form of focused chapters within the Mars Society, the National Space Society, and the Moon Society that could undertake some useful bite-size project, however humble, in support of the broader effort. SEDS (Students for the Exploration & Development of Space), and other groups might be willing to help. We have grounds enough to launch an Analog Mars "Extension" Program.

Benefits from many simulation exercises will apply with minor adaptations to both Moon and Mars. Others will apply only to one or the other. We call on other Space Organizations to endorse an expanded Analog Simulations Program and seek appropriate ways to contribute to it. This will grow chapters as well as public support. **<PK/MMM>.**

Testing Colors for Survival on Mars

by Peter Kokh, MDRS Crew #34

Representing the Wisconsin Mars Society Chapter, I devised a simple experiment to test which colors are most easily picked out against a Mars-hued background. I had my suspicions that lighter shades of green and blue would stand out most prominently. Why? If you take a color photo of a Marsscape and invert it in your paint program, that is what you get: light greens and blues: the opposite of Mars hues: "Mars' Missing Colors." PDF file readers can see this below.



http://members.aol.com/tanstaaflz/petesmars_projects.htm

First, I picked up one each of every color paper sheet my nearest Kinkos had in stock, some 19 different shades including many pastels and all the astrobrights™. Next I bought a 24-pack of transparent plastic drinking cups from Walmart. The purpose here was to find something stackable and compact for air travel. I cut the bottom off of one cup, cut down one side, rolled it out and made a template. Once on location, I used the template to cut out shapes from the color sheets. These I applied to the sides of intact cups, securing the paper with tape. I took my stacked color cups outdoors, found a pile of handy pebbles and put enough in the bottom of each cup to keep the cups from being tossed here and there by the wind. Then I looked for nearby hillocks and set the cups out randomly here and there in two different locations.

Later, results chart in hand, I stood at various distances from the cups, up to 200 yards. The round shape meant that sun angle did not matter much. I did return to check again at various times during the day, again at dusk.

I was quite surprised by the results!

- any colors outside the background color range are visible, but especially lighter and brighter ones.
- What really helps is that the cups are areas of solid consistent color and regular shape: both features stand out from random pattern and variegated coloration
- Yellows, blue-greens, pinks & fuscias (red is too dark), mid to lighter blues all arrested my sweeping gaze.
- In deep dusk, darker colors, even those well out of Mars shades, are hard to see. Light, bright, astro colors best.

Vehicles, spacesuits, road signs of <u>regular shape</u> and <u>solid colors</u> will be easy to see on Mars. **<PK/WMS>**

MDRS Scrap & Trash vs. Spirit & Opportunity

Report by Peter Kokh, Wisconsin Mars Society
MDRS Crew #34, the Junk Yard Wars Refit Crew

Scrap & Trash at MDRS

One of the items on my list of things to do at the Mars Desert Research Station was to take a look at any scrap piles that may be on the premises and also at what was in the everyday trash. I found the area known as Antarctica or the Engineering Area just south of the Hab, hidden behind a pair of natural mounds both from the Hab and its access road. There I found discarded PVC pipe and fittings (from the old GreenHab), some copper, aluminum and steel; also some wood, old 5 gallon paint drums, and discarded (probably non-functioning) equipment.

Daily life in the hab itself produces a significant volume of items that would normally be recycled. Alas, Hanksville is quite small, and rather isolated; there is no place that accepts recycling within a hundred miles. So there really is no practical way to recycle paper, plastic bottles, or aluminum cans, unless one hauls them back to Denver or Salt Lake City. These items are not sorted, but just discarded with other household trash. Plastics #1 and #2, glass bottles, and aluminum cans are regularly available as well as the PVC and other items stored in the scrap area because they are too large or bulky to fit in trash bags.

With the right "spirit," all of this scrap and trash becomes "opportunity."

How so?

On the frontier, art and craft will play a major role in making us feel at home. But the sort of preferred art and craft materials with which those with artistic and craftsman talent are used to working will be in short supply, exorbitantly expensive to import from Earth. But even on Earth, many an artist and craftsman cannot afford the preferred materials. When you have more talent than money, anything free that is workable will do. All you need is the appropriate tools for the chosen materials, and inspiration.

All of the materials mentioned above have been used by others to create art and artifacts. For inspiration, simply do a Google search; you will find websites with content to get your imagination started on aluminum can art, PVC art, plastic bag art, and more. You will find more help at your local library or arts and crafts store.

Now you might think that this kind of "crude" art is good mainly to teach children creative self-expression or to give bored old folks something to do. But it is really a matter of talent and creativity. People who have it have turned out some beautiful creations out of trash. There have been prestige exhibits that feature creations from recycled items exclusively.

Art & Craft at Mars Desert Research Station

What's any of this got to do with the Mars Desert Research Station? In the evening after the work of the day is done, we write our reports and the balance of the time before we turn in for the night is ours to use as we each please. We can watch movies, play games, get lost on the Internet, or -- work on some project. There is no reason why art and craft cannot or should not be engaged in.

Not every volunteer will feel the urge to express themselves in some physical medium. While there is great effort taken to balance the talents of crew members, and almost every crew will have some creative people, that doesn't mean that there will be a painter, sculptor or other kind of craftsperson.

But if you are the type, and are chosen for a crew, you should know that these possibilities exist. Of course, nothing in the rules or guidelines prohibits crew members from bringing along art and craft materials of their choice with which to pass free time hours.

Wisconsin Mars Society intends to assemble and ship a kit of tools and books for future crew members to use to try their hands at creating things from commonly available scrap and trash items at MDRS.

Art & craft produced at the Mars Desert Station can be brought home as souvenirs or sold at auction at a Mars Society Convention to help raise funds for the analog program. But it can also be used to decorate the common and private areas of the Hab itself. And that would indeed be simulating what will happen on the frontier. These options seem exciting to me, and I just thought I'd like to share that with you. **<PK/WMS>**

Our Own Lunar Analog Research Station? What we might want to do *differently*

by Peter Kokh

Even before my recent two-week stint at the Mars Desert Research Station in Utah, I started keeping a file of ideas under the heading "what we might want to do differently at our own Lunar Analog Station." Grant you, that is not a near term project. But planning ahead is good.

Location: there are two schools of thought here:

- Put it in the heart of a high traffic tourist area such as Las Vegas or Orlando or even Chicago.
- Set it in a location where the terrain is suggestive of moonscapes: on a lava flow sheet, with access to lava tubes, perhaps

I do not believe you can satisfy both objectives without serious compromise. Further, tourist traffic and serious research without tourist interference do not go hand in hand. We do need both, however. The answer is to build two stations (two identical stations are cheaper than twice just one.) We have one in a high traffic area for tourists and public education, the other in an isolated location where we can do serious work. Web cams at the research station will feed monitors at the tourist facility.

Logistics: While isolation is great, logistics can be a continuing problem. The closest major airport to MDRS is 240 miles away in Salt Lake City. Travel is over good roads, but only a quarter of it is by Interstate. The nearest hardware store is 115 miles away. The nearest home center 165 miles. Can we do better? Not sure. One site I looked at , the Black Rock Desert lava flow area in Utah is 150 miles S of Salt Lake City, almost all of it on I-15, but the terrain proved unsuitable. Craters of the Moon National Park and surrounding Bureau of Land Management area in Idaho are just as far from Salt Lake as MDRS, and only a little closer to Boise, only a regional airport. Bend, Oregon doesn't fare that much better. We have plenty of time to search.

Habitat Design – Profile: I understand the origin of the Mars Hab shape, but it is a mistake. The Mars Society has backed itself into a corner on this one. The two floor Hab would be a bear to shield (if the Mars Society wanted to do so.) I recommend we look for some sort of Lunar Ranch design. Shielding is essential on the Moon, both for radiation protection and for thermal equilibrium. By looking the other way on this, the Mars Society people have got themselves stuck with an unnecessarily short field season: a shielded Hab could *coolly* function throughout the summer.

The Artemis Moonbase triple SpaceHab is one floor but way to small to serve as a functional outpost, even as a starter outpost. Two or three of them, linked? Perhaps. Let's not be bound to the venerable SpaceHab design. We could either start from scratch, or sticking with the Artemis module for a starter core, add additional modules of the same or new designs, perhaps even an inflatable (so long as the height to width-length ratio is kept low.)

Hab Design – Function Space: The Mars Hab's two floors with a combined floor area over a thousand square feet or 110 m2 is already much bigger (c.4x) than the Artemis Moonbase core module. But it does not serve all functions adequately. MDRS is in dire need of expansion. (See my report this issue, pp. 3-7) We need a separate tool and fabrication shop, and perhaps dedicated hobby and "puttzing space." An isometrics exercise room would be great.

Acoustics at MDRS are very poor, more so because it was given no attention in design and construction. Dust control is also a severe problem. Our facility needs to be much closer to air-tight, relying on air-exchanges and plants to keep the air fresh, not loose joints and holes. Proper design of entrances (airlock-hatches) and their porches, steps, and aprons will help.

Hab Design – Utilities: It would be ideal to mimic the situa-tion on the Moon as far as practical. Heavy use of photo-voltaics (solar power) to run all the lighting (12 volt) and at least all the lower load outlets. Where we need appliances and equipment for which 12 volt versions are not available (yet) we will have to do with 117v AC power. MDRS uses diesel-fueled generators. Is there is a more appropriate option for us? We should look for one. Fuel Cells? Again, solar power is the optimum, and that means picking a site with a high percentage of sunny days. No propane stoves!

Hab Design – Interiors: The first Moonbase will be manufactured on Earth. But we have time to incorporate into our research station features that mimic what pioneers can produce on the Moon. No wood 2x4s or Drywall (sheetrock) when for little more we could buy steel 2x4s and Duroc (cement) panels on interior walls, and something like glassboard on exterior surfaces. If we are going to set the mood for simulating outpost life on the Moon, we owe it to ourselves to do it right *inside and out.*

Life Support: We cannot expect to be able to provide *total* life support on any reasonable budget. But we should work aggressively to go beyond the gray water (sinks, showers) treatment demonstrated at MDRS towards at least partial black water (toilet wastes) treatment combined with food production. The Wolverton system is a place to start. This ambitious goal implies year-around occupation or tending.

Medical Systems: MDRS has an excellent first aid kit and daily email contact with a doctor. Can we do better? It is worth discussing. In reality, many medical emergencies will have to be treated on location. On the Moon, transport to Earth is only an option for postponable procedures.

Crew Life Styles: We need prior commitment from our volunteers to participate wholeheartedly in experimental pioneer vegetarian food preparation and menu development. It's a matter of getting into the spirit and will generate good publicity. But we should also incorporate time, space, supplies and tools to allow experimentation with pioneer-appropriate arts and crafts.

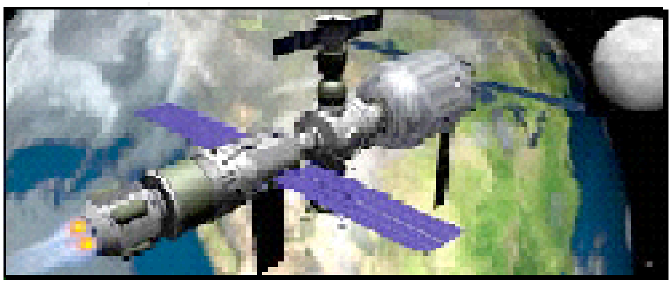
Facility supported research: Geology and microbiology are big items at MDRS, and that is quite appropriate for Mars. On the Moon, there is no question of life: those into biology are better occupied developing our biospheric life support systems. And we have already done considerable geological investigation on the Moon. More remains to do. The point, however, is that unlike a Mars base, where exploration is goal one, on the Moon, developing ways to tap local resources and start making stuff is at the top of the list. From that point of view, the visible appearance of the host terrain is less important than its geochemical makeup. Basaltic areas that do not necessarily remind one of the Moon will still do fine. If we can have both, better!

We need to prioritize the things we want to demonstrate: shielding emplacement; regolith handling; oxygen production; cast basalt technologies; ceramics; glass composites perhaps. There is a lot of things we can do.

Talented volunteers or ....? The Mars Society has done a splendid job of attracting talented students with masters and PhD thesis projects worth demonstrating at MDRS, projects in the fields of geology, biology, and astronomy. While we can attempt to do the same, changing the stress, however (especially in biology), what we want to do in the area of demonstrations suggests that we prime the pump by organizing engineering competitions on the college level: competitions for automated or teleoperated shielding emplacement systems, for example, with the winning team getting to do the final demonstration at our location. Such an effort would build enthusiasm and provides plenty of publicity at every step. It also builds local cores of support.

Summing up: I have been a very strong, ardent and outspoken supporter of the Mars Society's analog station program from the day it was first announced. They have done wonders on a small budget with volunteer resources. Their program deserves respect. Even after two weeks spent at MDRS in Utah, and seeing all the room for improve-ment, I am still a strong supporter. It will not be easy for the Moon Society to improve on what they have done. However, we have the benefit of time on our hands. We can afford a more deliberate, patiently methodical approach. Our needs differ in part. We can do it, given time, but only if we don't wait until we have the money to start brain-storming and planning. Let's start now. **<PK>**

MMM #184 - APR 2005



Bigelow Aerospace Tourist Moon Cruiser Concept

www.bigelowaerospace.com/images/mooncruise01.jpg

The exciting thing about this concept is that all the parts except the inflatable Nautilus Module are off the shelf, and the Nautilus is under construction. Regular suborbital tourism is a near-term reality. Next, taking tourists to orbit. Looping around the Moon will soon follow. All it requires is refueling and provisions for 7 days

Maritime Luna

by Peter Kokh

Mar•i•time: ***adj.*** 1. connected with the seain relation to navigation, shipping, etc. 2. of or petaining to the sea: *a maritime civilization.* 3. bordering on the sea: *maritime provinces.* 4. living near or on the sea. [from Latin mare = sea + timus suffix]

Mar•e [pl. maria]: [pron. mahr•ay, mahr•i•a] *n. Astron.* any of several large, dark plains on the Moon, thought by Galileo to be seas when first seen through a telescope in 1610.

The Moon's Earth-facing Nearside is very different from the side we can never see from Earth. Thirty-nine percent of the nearside is in the form of relatively low-lying basins that have been filled, some time after their forma-tion, with lava floods. These areas are known as Maria. (Basins on the thicker-crusted farside that were never filled by lava upwellings are known as thalassoids, from the Greek word for "sea.") Once these seas of liquid lava congealed, their surfaces became subject to "gardening" by the microme-teorite bombardment.

Over the 3 and a half billion years since, this has produced a blanketing layer of pulverized rock and powder known as the regolith. The mare regolith is considerably darker than that in the highlands, and so it is the lunar seas or maria that give us the familiar "Man in the Moon" naked eye appearance of the Full Moon.

To ignore whatever advantages that special aspect of the Moon's Earth-facing hemisphere might offer us, would be foolish for three basic reasons:

1. Topographical advantages: In comparison to the highlands, the mare areas are sparsely cratered as the maria were formed after the main era of asteroid bombardment by planetesimal debris leftover from the formation of the solar system had ended. The maria terrain is relatively flat.

But there are several features that break the monotony and will affect transport routes. In some of the shallower maria, we find ghost craters representing impact craters that formed in the basin before wholesale flooding. In this case just their rims, or portions of the rims protrude as "reefs" [Latin saxa, anyone?]

There are gentle "scarps," the edges of the various lava flows. And wrinkle ridges that formed as the lava fill settled. and There are rille valleys hundreds of meters across and deep that formed from collapsed lava tubes.

Some of these features may necessitate detours until we are able to do major earth-moving and/or build bridges. But in general it should be relatively easy to travel from one mare location to another anywhere on nearside, excepting the highland locked Mare Crisium and several lesser mare units.

2. Shelter advantages:

There is no particular advantage to covering a habitat complex with highland regolith rather than with mare regolith. However lavatubes, some of them with appreciable intact subsurface volumes, will be found in the maria only. They are formed naturally by the way the runny lava flows that filled these basins advance.

Intact lavatubes will someday provide ready voluminous shelter in thermally stable environments for whole settlements and their associated industrial parks and warehouse complexes, and the ultimate in long enduring archival space for all of humanity's records, artifact collections, and more with a lifetime of billions of years.

Lavatubes are the Moon's "Hidden Valleys"

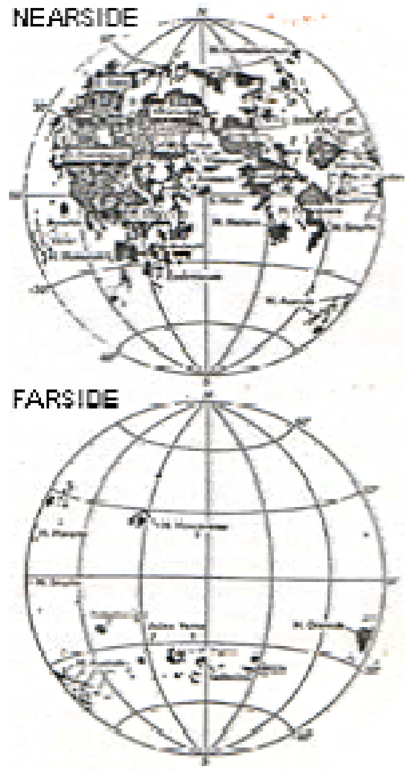
And again, there are none of these welcoming refuges in the highlands. Lavatubes may exist in multiple layers as in some areas the basin-fill has built up in successive lava sheets, each of them forming tubes..

3. Resource access advantages:

The basalt-filled maria are richer in iron and titanium whereas the highlands are richer in aluminum, magnesium, and calcium.

Locations along the mare/ highlands "coasts" have access to both suites of materials. This is necessary if we are truly interested in development of a diversified industrial lunar economy, able to provide the bulk of its own needs as well as producing a variety of products for export.

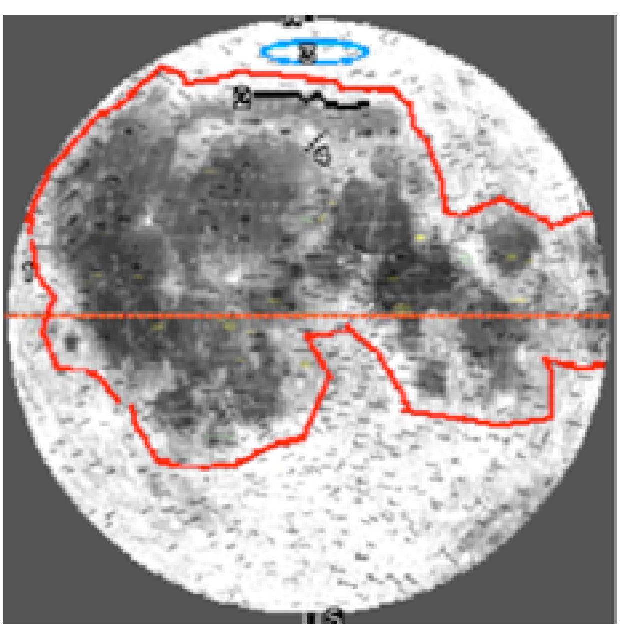
As to hydroge all lunar regolith top soils contain hydrogen as solitary protons adhering to the fine particles in



the gift of the solar wind, to the tune of one ton of hydrogen per then thousand tons of regolith. All that is needed to recovery this resource is heat. Further, the northern coast of Mare Frigoris, the long, narrow E-W mare north of Mare Imbrium and Mare Serenitatis, is only 200 miles from the southernmost north polar craters of 20 km or more in diameter that have appreciable areas of perma-nent shade, meaning likely ice deposits.

The maria themselves are not homogeneous. As successive magma upwellings poured out into these basins, its composition changed. Some lava flows are richer than others in various elements. You can see this online at:

www.lunar-reclamation.org/papers/mare_soilprovinces.gif



Bottom left: a high contrast image of the Moon's nearside shows the extent of the nearside "**mareplex**" Encircling it is an outline [**1**] of the near-coastal highlands hinterland within easy reach. A dark line [**2**] marks the **north coast** of the long E-W stretching northern sea, **Mare Frigoris**. Within two hundred miles or so of this coastal area, lie craters larger than 20 km (13 mi.) in diameter, just north of the 75° line, [**3**] with appreciable expanses of permanently shaded floor area, presumed to hold comet-derived water and carbon oxide ices and other cometary volatiles. Linking Mare Frigoris with Mare Imbrium to the south is the **Alpine Valley** [**4**], a major transportation corridor. Image: P. Kokh

The shadings that create the "Man **in** the Moon" naked eye impression, represent the territory that is destined to become the principal home of "Man **on** the Moon." Hmm! "Man in the Moon" - the "MIM-plex" anyone?

On Earth, humans spread across the globe following the path of least resistance: across prairies and steppes and along coasts and rivers. Mountain passes were pinch points. Those tribes established in areas from which expansion was easy, spread and grew and became dominant. Equally capable tribes caught in isolated areas or cul de sacs stayed small.

On the Moon, the maria could function as both seas and plains in this respect. There is a lesson here for us, and if we think that with all our sophisticated technology, we will not also do better to follow more easily traversed pathways to expansion, we are setting our "lunar initiative" up to become a footnote in history. Many a culture has unwittingly chosen oblivion, following some intoxicating siren call.

All coasts are not created equal: There are well over ten thousand miles of highland/mare coast in the mareplex. But:

- Some coastal areas will be handy to passes or easy routes into highland areas, or even lead to coasts on nearby maria: example. sites at each end of the Alpine Valley.
- Others may be near clusters of intact, usable lavatubes.
- Not all mare regolith is the same. Color filter photos show clear "provinces" of regolith which are differently enriched or deprived of various elements. A coastal settlement astride a boundary between soil provinces will have an edge up over those not so placed. See the link at the bottom of the previous page. Some mare areas are titanium-rich (ilmenite) and others enriched in potassium, rare earth elements and phosphorous (KREEP).
- There may be coastal sites with both advantages: gateway to the highlands; astride a mare soil boundary.

The needs of orderly industrial diversification:

A lot will depend on the priorities set for the most efficient path to lunar industrial diversification. At first, it may be easier to produce steel than aluminum (for which the preferred alloy ingredients are rare on the Moon) or it might be easier to start with titanium. Access to both primary and secondary elements will be a factor. As diversification continues, and it becomes necessary to begin production of additional elements, new sites will become secondary towns. The needs of orderly industrial diversification, not scenic or scientific interest, will determine the routes along which our presence on the Moon spreads.

The spread of Lunar Highways

With few exceptions, coastal settlements will be more numerous. prosperous, and populous than sites either in mid-mare or that are highland-locked. So it seems natural that the original lunar highways will follow the coasts, enough "off-shore" to minimize unnecessary bends, etc.

Where wrinkle ridges, impact debris fields, or rilles block the logical way, they will detour around, at least at first. These coastal roads will in time, be joined by spurs into industrially significant highland areas. Trans Mare and Inter Maria express routes will be built eventually.

The first vehicles may be "**toads.**" The crew cabins of ferries from LEO or LL1 may be underslung between the engines and below the cargo platform, so that they can winch down to the surface on the wheeled chassis provided and taxi to an outpost, then back to the ferry for take off.

Some of these "amphibious frogs" will stay on the Moon becoming "toads," the first lunar motor coaches and Greyhounds. Double duty, use-reasignment is the game.

The first roads will be minimally improved, raked of boulders, that's about it. But dust control is important, and so, eventually, will be speed. Lunar roads will be graded, compacted, and sinter-fused into a pavement all in one process without much need to drag along paving materials, other than possibly fiberglass mats.

Junctions will be logical sites for automated selfservice wayside facilities as well as flare-protection sheds. One could recharge batteries and fuel cells there, replenish water reserves, sign out tools, etc. In time, these waysides may become tended, the nucleus of a commercial "truck stop" and eventually another town.

Where the Junction is a shortcut gateway, as in the case of the Alpine Valley, we are likely to find a major settlement at one end or the other. I'd predict that the southern approach would be the greater commercial hub.

Where mare areas are separated by an "isthmus" of highland terrain, roads are likely to be pushed through, saving many hours taking the longer, easier route around.

Examples are from Sinus Aestuum to Mare Vaporis in central nearside to Mare Serenitatis; Mare Crisium to Tranquilitatis on the west or to Fecunditatis on the south and then on to Mare Nectaris; western Oceanus Procellarum to Grimaldi and on to Mare Orientale. But "eventually" is the operative word. Until then, highland-locked Mare Crisium may see little development. Alas, it has always been my favorite spot on the Moon, the easiest to identify, and also Greg Bennett's favorite: its northwest bay, Mare Anguis becoming his "Angus Bay" of Artemis Project™ fame.

We might also see cableways catering to tourists, running along the mare ramparts. The arching ramparts of Sinus Iridium might be a great spot for that.

A Variety of Settlements

As the lunar economy expands and diversifies, so will the the reasons that underpin a settlement. The first settlement will try to provide all basic spartan needs. In time settlements with access to materials that will allow each to "specialize" its own industrial repertoire will arise, sparking healthy inter-settlement trade. That is much as it has been on Earth since the end of the last ice age.

The coastal mareplex offers enough mineralogical diversity to support a vigorous and diversified industrialized society on the Moon. In other words, the Mareplex can support a "world." If lunar settlement doesn't reach that "world" status, it is likely to implode psychologically and morale-wise as well as industrially and economically. There will be many places to "get away" and to "see something different." A "world" can be defined as a complex of horizons, from none of which you can see all the others. [Note that an O'Neill cylinder doesn't meet that definition.]

It is not so much a global lunar presence we are talking about as a geographically, industrially, economically, extended presence. Cultural diversity will follow as each settlement decides on its internal climate, flora and fauna, crops and industries and encourages its own artists and craftsmen and musicians to express themselves. It takes variety to make a world, as well as to spice it up.

At the same time, intercourse between the settlements must be not be discouraged by isolation over difficult terrain. True, even in the highlands, there are expanses of "inter-crater plains." But they are spotty and discontinuous. The highlands, the further they are removed from the nearest "coast" will be the boondocks.

Where traffic routes converge, we are likely to see major settlements develop. Chicago, at the south tip of Lake Michigan, is an example, Detroit is another. Of course, we are talking relative size to other settlements, not actual population!. There may be only two or three major spaceports and a scattering or "regional" ones, with the other settlements served by overland transport. Do read the article "Harbor & Town," referenced below.

Settlement density will hardly be even or regular along the highland / mare coasts for all the many reasons given above. There will be definite clusters, some of them larger and more prosperous than others. Political and economic cooperation is likely to follow suite.

The first Lunar "National Parks" and Monuments

The first scenic treasures to be set aside are sure to be the coastal and near hinterland ones in or just off the path of settlement expansion. There will be no need to rush to protect isolated spots deep in the highlands until new road-ways make them accessible. The Alpine Valley, which must do duty as a transportation corridor, will probably be restricted from further development, only regulated and licensed traffic-serving "concessions" being allowed. For this is a scenic and geological treasure unique on the Moon.

There are quite a number of especially scenic craters along or near the coastal transportation routes: too many to name them all (Plato, Aristarchus, many more). But we will be wise to scatter our preserves wisely, and not try to protect each and every one. In fact, larger craters will protect themselves as topographically and mineralogically unsuitable for development, with exceptions made for the few, if any (we will be most fortunate to find even one) craters that were formed by copper-nickel-platinum rich impactors as happened at Sudbury, Ontario, Canada..

Conclusion: The poles, however vital, will be the backwaters of lunar civilization, much like our off-shore oil rigs, and underground coal mines. The mainland of lunar civilization will be the nearside mare complex and its hinterland fringes.

Relevant Readings from MMM's past:

MMM#15 MAY '88 "Rural Luna" included in MMM Classics 2 download from www.lunar-reclamation.org/mmm_classics/
MMM # 56 June '92, p 3. "Harbor & Town"
MM Review #13, Aug. '93, pp. 9-15 "Lunar Railroads," Peter Kokh, Doug Armstrong, Michael Thomas, Bill Bogen, Charlie Moore, Andy Reynolds - *online at:*
http://www.lunar-reclamation.org/papers/rr_moon.htm
MMM #79 Oct '94 pp 13-14. Lunar Roads: Beating a Path"
MMM #81 Dec '94, p3 "Lunar Roads Surface Vehicles & Transportation
MMM #117 Aug '98, p 9 "Cruising Mare Crisium"
MMM# 140 Nov '00, pp 4-6 "Transportation & Town Sites"
MMM # 167 Aug '03,: www.lunar-reclamation.org/mmm_samples/mmm167_AUG2003.pdf

Venus

Visiting Hell & Living to Tell About it:
Mission Goals for Future Venus Probes

by Peter Kokh & David Dietzler

See "Rehabilitating Venus as a Human Destination"
www.lunar-reclamation.org/papers/venus_rehabpaper.htm

Synopsis: Manned aerostat outposts are possible on Venus, floating just below the cloud deck where temperatures and pressures are manageable and from where the Veneran surface is visible. The atmosphere and clouds can be mined for carbon, oxygen, nitrogen , sulfur, hydrogen, and other elements to make building materials for outpost expansion or replication. Tourist hotels could be built in this way to serve tourists taking "window shortcuts" between Earth and Mars via Venus.

Goals of ESA's Upcoming Venus Express

Condensed for MMM from http://sci.esa.int/science-e/www/area/index.cfm?fareaid=64

In large part based on the successful Mars Express orbiter, weighing 1270 kg = 2794 lbs., Venus Express is set for launch Oct-05 on a Soyuz-Fregat rocket and intended to operate for 500 days in a polar orbit around Venus.

The Venus Express payload comprises a combination of spectrometers, spectro-imagers and imagers covering a wavelength range from ultraviolet to thermal infrared, a plasma analyzer and a magnetometer. The aim is to enhance our knowledge of the composition, circulation and evolution of Venus atmosphere. The surface properties and the interaction between the atmosphere and the surface will be examined and evidence of volcanic activity will be sought.

• **ASPERA-4** (Analyser of Space Plasmas and Energetic Atoms) will investigate the interaction between the solar wind and the atmosphere of Venus

• **MAG** The Magnetometer instrument will provide magnetic field data and study the interaction of the solar wind with the atmosphere of Venus.

• **PFS** (Planetary Fourier [infrared] Spectrometer) will perform vertical optical sounding of the atmosphere, to:

- Perform global, long-term monitoring of the 3-D temperature field from cloud level up to 100 km
- Measure concentration and distribution of known minor atmospheric constituents
- Search for unknown atmospheric constituents
- Determine the size, distribution and chemical composition of atmospheric aerosols
- Study global circulation, mesoscale dynamics & waves
- Analyse surface to atmosphere exchange processes

• **VeRa** (Venus Radio Science) is a radio sounding experiment to examine the ionosphere, atmosphere and surface of Venus by means of radio waves. The instrument will determine the dielectric characteristics, roughness and chemical composition of the planetary surface.

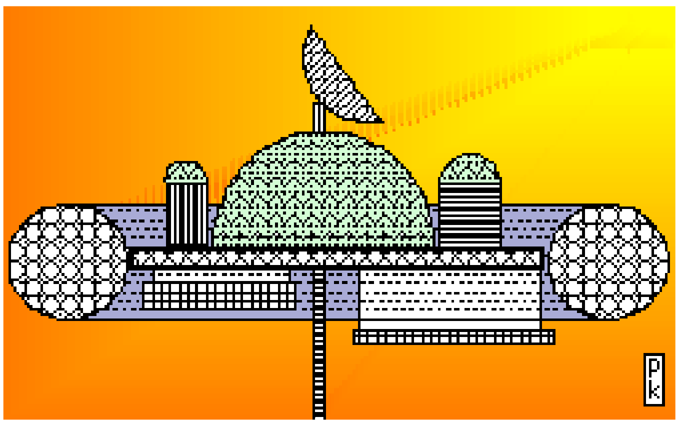
• **VIRTIS** (Visible and Infrared Thermal Imaging Spectrometer) in the near ultraviolet, visible and infrared parts of the spectrum to analyze all layers of the atmosphere and clouds, make surface temperature measurements and the study of surface/atmosphere interaction phenomena.

• **VMC** (Venus Monitoring Camera) operates in the ultraviolet, visible and near infrared spectral ranges. VMC will map the surface brightness distribution and search for volcanic activity. VMC images and movies will make a significant contribution to the public outreach program.

Top Priorities Beyond Venus Express: – Kokh's List:

- Temperature hardened and corrosion resistant components for future Venus & Mercury landers with enhanced viability (months instead of minutes) and redesigning chemical / mineralogical sensing equipment, and heatflow drill taps, etc. accordingly

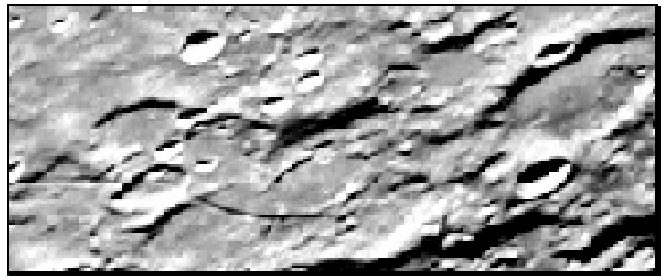
- A fleet of balloon probes (100s) tin Venus' atmosphere at various levels to map circulation cells and patterns, wind speeds, and variations in atmospheric chemistry at different levels, for data to locate any "sweet spot" - a best tradeoff between lower temperatures & pressures (higher up) and better visibility of the surface (lower down). Ideal pressure (1 ATM) and the best temperature (50-70 F?) may not occur at the same level..
- A balloon borne processing unit to demonstrate production of carbon, carbon composites and carbon-based compounds, sulfur and sulfur-based compounds, etc.
- A subsatellite lowered from a tether from a high-floating balloon for low-level high resolution surface photo atlas as well as high resolution geochemical mapping, from which to create a short list for priority sites to test future ground probes and rovers



Top Priorities Beyond Venus Express: – Dietzler's List:

- Map light intensity and spectrum at various altitudes in different locations longitudinally and latitudinally for future agricultural and solar power generation needs.
- Determine risk from lightning and up/down drafts to floating outposts.
- Test a Veneran Atmosphere Thermal Energy Gradient Convertor power system on balloon borne probes.
- Surface samplers to locate, qualify and quantify mineable surface resources.
- A spectrometer capable of locating industrially interesting resources not just geologically interesting ones.
- Measure solar flare radiation influx at various altitudes (Venus' weak magnetic field generates no Van Allen Belt shield, and we are relying on the atmosphere for radiation protection. Secondary particle generation when ions from solar flares hit the Venusian atmosphere could be pretty bad. Venus is also much closer to the Sun so solar storm particle fluxes are more intense there. We'd want to examine this in detail before we plan high-floating human science stations and outposts. **<PK/DD>**

MMM #185 - MAY 2005



The Formidable Lunar Highlands

There are places in the Lunar Highlands that we will want to integrate into our frontier economy. Much of this area is crater-pocked to the saturation point. The challenge facing us now, and *something we can do without waiting for further data,* is to develop overlay maps of the highlands that highlight contiguous areas less difficult to traverse as targets for early development. *Article below*

How and Why we will Also Settle the Lunar Highlands both Nearside and Farside

By Peter Kokh

In last month's MMM, in "Maritime Luna," I tried to lay out the case why the Moon's nearside "mareplex" should be the site of our first lunar outpost, *picked to have all the advantages necessary to evolve into our first major settlement on the Moon,* one actively developing local resources as a basis for industries that will support the settlement's own needs as well as income-earning exports. It is our firm belief that the Nearside Maria will be home of the great bulk of the Lunar Frontier population for as far as we can see into the future.

That said, there are many reasons, access to water-ice and other comet-derived volatiles in the polar regions being just the most obvious, that we will also establish scattered outposts in the Highland areas of both the Nearside and Farside. So if last month's article was the *Yin,* this one is the *Yang.* Balance is essential.

Above all everyone should come to realize that "The" Moonbase is just as absurd and indefensible a goal as "The" Space Station. Activists who fall into the "The" trap, unwittingly become part of the problem, all their best of intentions notwithstanding. We must get beyond thinking in "The" terms. *"The" is an alias for "first and last."*

If we fail to realize that, we seriously undercut our very own dreams. The "first step" then inevitably gets short-designed to become the "only step." History is ample testimony to that. "Those who would ignore history are doomed to repeat it." Dismount the high horse.

Key to the Moon's "high land" regions is Ease of Access

The 61% of Nearside, and the vast majority of Farside (and of the Southern Hemisphere) are "highlands." The highlands represent the more ancient original lunar surface sculpted by an early era of wholesale bombardment by the leftover debris of planet formation. Most of this crater-saturated crust remains. After this era of major cratering, a lessor number of larger impacters erased some of this early crust, creating the great basins, most of which were, still later, filed with lava flows, forming the familiar low-lying maria, or "seas." In general, the highland areas that remain, are, in comparison to the maria, much more hostile to overland transport and travel. Steeper gradients and large scale impact debris abound.

Now if it is a question of putting a first moonbase in a highland area, the ability to go overland to other areas of the Moon from the point being considered, may not be a paramount consideration. Myopia. If we do not want to be limited to a*ccess from or through space*, by landers and suborbital hoppers, we must tackle the overland transportation challenge posed by the lay of the "high" lands.

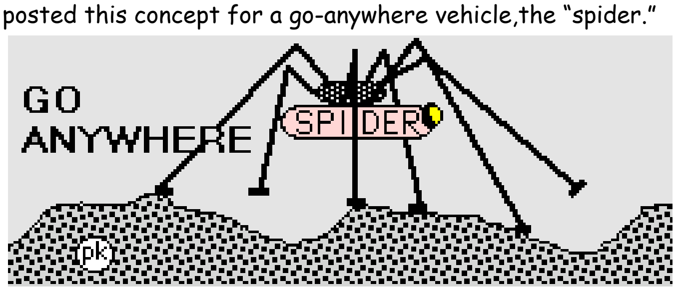
This suggests two pragmatic approaches:

- We develop overland transport designed for handling this kind of terrain.
- We try to identify contiguous (inter-continuous) areas where the gradients are low, and the "roughness" of the terrain is considerably lower and more negotiable.

1. Lunar Transport Vehicles for Rough Terrain

This is an area that has not been given much attention. Designs for Lunar Rovers, pressurized or not, have commonly included large steel mesh tires to handle small boulders and rocks of a foot or less in height. That will do for the maria areas we are familiar with, as well as the one inter-crater "plain" visited on the Descartes mission. But much of the highland surface has abundant impact debris of larger scale. Finding a negotiable route will be torturous.

In MMM #79 Oct '94 before "Wild Wild West" we posted this concept for a go-anywhere vehicle,the "spider."



"One model from nature of a creature that can go just about anywhere is the spider. [snip] the mobility architecture of the "Daddy Longlegs" or "Harvestman". The Spider's "body" would consist of two superable components: the "trunk" would contain the "hips" for the six legs and associated "musculature", and the power, fuel, and motive plants. Underslung by a "dead man's winch" would be the crew cabin. This position gives it shielding protection from the locomotive complex above as well as an unobstructed view of the terrain below. If power should fail, the crew cabin would automatically winch to the surface in a controlled descent. This deployment could be overridden, if there was any reason to remain aloft.

"The scale of such a contraption ... the larger the better within practical limits. The legs ... long enough to elevate the central pod complex some dozens of meters above terrain obstacles below. This height would also be of great advantage in scouting a pathway ahead. The computer-controlled gait could bionically mimic that of real spiders and include a cautious grope as well as a trot ... when the going permits." .

Decades down the road, when the growth of inter-settlement traffic warrants, a team of spider-cranes could deploy the pylons and cable for elevated cableways. We invite further development of these concepts as well as of whole new highland-suitable transport designs.

2. Mapping smoother, low gradient highland areas.

We now have fairly good **altimetry data** covering the whole Moon, from ***Lunar Prospector***. That data should allow us to produce lunar map overlays, color-shading areas of low gradient changes. These areas will be scattered and in general, not that extensive, including the so-called "inter crater plains." Where we find relatively large contiguous areas of such topography, we may have found highland areas especially favorable for development, even if access to the main nearside mareplex is difficult. Such a larger highland "transportation valley" could have its own regional spaceport for access by landers from Earth (or elsewhere) as well as by suborbital hoppers from elsewhere on the Moon.

But altimetry data alone do not guarantee smooth going for wheeled lunar transports. On a large scale, the terrain may appear smooth. But on a scale relevant to transportation, it can still be rough, saturated with boulders of a size that cannot be simply wheeled over. The great radio telescope at Arecibo on the north coast of Puerto Rico has done a 70 cm wavelength radar mapping of the nearside with a spatial resolution of 300 meters, which shows areas smooth on the 70 cm scale (28") as dark, and areas rough on that scale as bright. For an example, check out

http://www.lpod.org/LPOD-2005-05-26.htm

Now we can argue about whether that is the appropriate scale, but right now we have such a map and one of different scale would be just a proposed project. So we need a capable person to create overlays of those bright and dark areas to further filter the information from the altimetry data. *Then we will have a map which shows which areas of the highlands should be prioritized for early development*, and which are best left to future pioneers..

So this is a project, one of minimal cost, which can be done now, this year. Until we have that map, discussions of highland settlements remain, in our opinion, a matter of "gigo," "garbage in,garbage out."

That said, Madhu Thangavelu has in fact tried to follow altimetry clues in plotting future lunar railroad routes expanding from the South Pole northwards to the North Pole. This exciting plan is contained in the book:

The Moon: Resources, Future Development & Colonization, by David Schrunk, Burton Sharpe, Bonnie Cooper, and Madhu Thangavelu; John Wiley & Sons 1999; ISBN: 0471976350

The route proposed follows 15° West (or 345°) via Mare Nubium, Mare Imbrium, along Plato's west rim, etc.

Now we can revisit this first routing map given the new radar roughness data. That first attempt may be vindi-cated to some extent. Railroad bed placement requires more careful routing and a more extensive construction effort than do roadss, especially those not built for speed.

Access given, what types of highland sites are attractive?

a) the Poles: Polar sites, of course, given the promised availa-bility of frozen water ice and other comet-derived volatiles (carbon oxide and nitrogen oxide ices) and very local not quite total availability of sunlight *at or immediately above the horizon, are on everyone's list.* But it behooves us first to fly, and land, ground truth probes, that can drill into the regolith in permanently shaded crater areas and with-draw and analyze drill cores.

What percentage of water-ice is there in the soil? How hard it it? What kind of mining and recovery efforts seem most practical, energy efficient, and breakdown free? Until we have encouraging answers to all these questions and several more, talk of polar moonbases is fine, but planning to go there is prema-ture. Again a case of "gigo - garbage in, garbage out."

It is our read of the Lunar Prospector data that the find of polar ice will be vindicated. The radar scans that did not see ice layers mean little, as no one seriously proposed that that is what Lunar Prospector had found. Once we have designed, built, and flown such a "ground truth lander" or two or three, the findings, even if positive, may be discouraging for a near term assault on the polar ice resources. The technological difficulties of mining and producing water and hydrogen from such a resource may be more ambitious than we expected, and best left until lunar settlement (elsewhere) has reached a higher level of development and is able to provide on location support.

b) locations of concentrated elements, otherwise rare

Not having undergone billions of years of tectonic processing in the presence of water (a hydrosphere), the Moon, unlike Earth, has not evolved concentrated "ores." That said, the mantle magmas on cooling, *have* separated out elements that are "insoluble" in the hot mix. So in the maria especially, we will find regions richer in this set of elements and regions richer in other sets, while all basaltic. KREEP, an acronym for Potassium (K), rare earth elements (REE) and Phosphorus (P) is the most widely known. This kind of mining diversity will be found in the mareplex.

But what about in the highlands? Since the high-lands sport the great bulk of still exposed impact features, the chances of finding non-native, asteroid-donated lodes of elements in which the Moon in general is deficient, is much greater than in the maria. Finding a feature on the Moon analogous to the 2 billion year old large astrobleme at Sudbury 200 miles east of Sault Ste. Marie in Ontario, Canada, would be tantamount to wining the Cosmic Jackpot. It is difficult to imagine how lunar industry can develop beyond the early Industrial Age (mid 19th C) level without access to copper, lead, zinc, gold, silver, and platinum. But the six Apollo and two Soviet Luna sites sampled so far show these elements present only in parts per billion. To gain insight into what is needed to detect such unique lodes from orbit, we will be taking in part of the Planetary & Terrestrial Mining Symposium in Sudbury, June 5-9, 2005 for one day.

Note; Our expectations at this event were to be dashed. It is the unanimous opinion of Sudbury geologists that these lodes of copper, nickel, and other ores are not the gift of the impactor, at least not directly. The service that the impactor performed was not to bring those elements to Earth, but to crack the crust open to such a depth that the magma below, which apparently was rich in these elements, worked its way up through the fractures in the fresh crater rim. It is only there, in the rim, that they are to be found. This suggests that we look for copper and platinum not on the surface of the Moon as debris from mythical platinum-rich meteorites, but in cracks in the rims of craters large enough that the impactor had shattered the crust all the way through to a still molten magma ocean in which such elements may have still been dissolved.

PK – June 10, 2005

We had early on detected Thorium in and around the large Van de Graff crater NE of Mare Ingenii on the Farside, but Lunar Prospector found vastly more in the much larger region surrounding Mare Imbrium. Thorium mined to breed (in fast breeder reactors) into fissionable Uranium 233 might someday be a huge industry on the Moon, fueling nuclear rockets opening up Mars and the asteroids. But this will not be a highland venture.

There are isolated mare flows within the highlands. Might these be mineralogically and chemically any different from those in the principal nearside maria? Unlikely, but evidence from orbit should be looked at.

c) Unusually spectacular Scenic Attractions:

There will be plenty for tourists, both from Earth and from among the pioneers to visit and appreciate in the craters, rilles, ridges, scarps and other features within the mare areas or in the immediate hinterlands to satisfy most of them for some time to come. Still, on Earth, we have a breed of tourists that craves to go off the beaten path, to see things "out of the question" for the rest of us softies. Serving this elite clientele is big business. In time, access will be forged for tourists to visit the best the highlands have to offer, and predictably, remoteness, will be as attractive as the scenic specialty of the site itself. If two or more such treasures are to be found in an easily reached "cluster," that will help.

d) Scientific assets: We may need to put **observatories** intended for dedicated research on certain objects within certain lati-tude ranges, either north or south. But that gives enormous leeway to actual siting of the facility in question. For large array type **radio interferometer installations** modeled after, but larger than that at Socorro, New Mexico, or patterned after the suggested Cyclops array, only a rather spacious site in *deep* farside out of sight of either L4 or L5, and there are not many such places. The Mare Ingenii / Thomson Crater complex looks to us to be the best bet even if it is 30 some degrees south of the lunar equator.

e) Isolation for Isolation' Sake On Earth, especially in the more recently settled areas of North America, but also elsewhere, we have seen many instances of "Intentional Communities." Under strong determined leadership, a band of followers tries to extract itself from the ambient (objectionable) culture and set up an isolated community where it can do its thing without interference. Jonestown, and the Branch Davidians in Waco come to mind, but there are many many instances with less tragic results Among those that have had some measure of success are the Amish communities. But in all most cases, isolation is incomplete, and the culture becomes diluted, and eventually fails.

If isolation is the key, what better place to shepherd one's followers than on the Moon? (Actually, a high inclination orbit asteroid like Hidalgo or Pallas would be much more out of the way and much less likely to be contaminated by unwelcome visitors.) On the Moon, there are many nooks and crannies in the maria complex that will be sufficiently off the beaten path for generations to come baring unexpected mineral finds. So that in itself will not draw most cult leaders to the highlands. Yet some will want the ultimate in isolation and the northern hemisphere farside highlands look like the ultimate boondocks.

Now there are also well established religious intentional communities, such as the Benedictine and Carthusian (Trappist) Monks. These all male celibate communities dedicate themselves to useful work that they can pursue in isolation, yet earn the income needed to sustain the community. Manning farside SETI posts might be appealing.

To be sure, there are those for whom inaccessibility is the ultimate mantra. Who has not been attracted to such mythical places as ***Shangrila!***

For cultural isolation, nothing will beat the Moon's farside from which Earth can never be seen. Out of sight, Out of Mind. *The Farside is the "Obliviside."*

It all comes down to transportation:

It a settlement is to be served only from or via space, then the availability or feasibility of surface transport for supplies and local products is of no concern. But that seems like a dead-end mentality. As the settlement population grows, and the number of settlement locations multiplies, and the trade between them develops, overland routes and the vehicles that ply them will be developed.

It is short-sighted to plan any outpost where overland access is an uncertain eventuality. But if we do the mapping project suggested above, we will be able to identify many suitable highland areas for future development.

A bigger obstacle seems to be a general failure of the imagination. Even most space enthusiasts think of lunar settlement as involving a few thousand people at best.

Our read is in the high hundreds of thousands, if not more

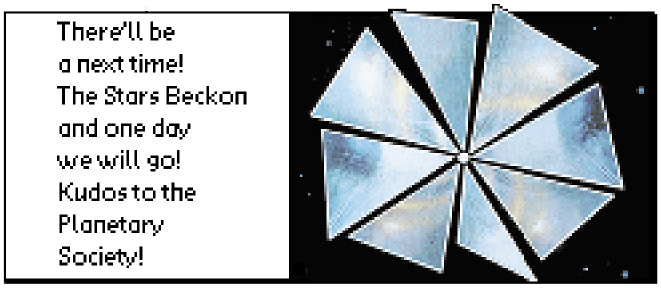
if so, while there will certainly be regional spaceports, surface transportation of people and goods is absolutely essential. It will include roads, cableways, railroads, maglevs, and systems we cannot yet imagine. (Star Trek Transporters not among them, unfortunately.)

Just as in the western United States, northern Canada, northern Siberia, or much of Australia, there will still remain major trackless boondocks on the Moon. The reason is simple: inaccessibility. We need to determine the whereabouts, extent, and boundaries of pockets of accessibility in the lunar highlands. **<MMM>**

Relevant Reading from MMM Issues Past

#10 NOV '87, Farside: Front-Line 21st C Astronomy
#15 MAY '88, "Rural Luna"
#66 JUN '93, p 5. Superconductivity
#79 OCT '94, p 13. Lunar Roads; p 15. Lunar Waysides; Service Center & Inns
#81 DEC '94, p 3. Rural Luna: Surface Vehicles & Transportation; p 4. Over the Road Trucking Rigs; p 5. Toad-mobile Conversions; p 6. Beyond the Beaten Path: Skimmers; Spiders; Camping Under the Stars
#82 FEB '95, p 7. Rural Luna: The Beaten Path
#83 MAR '95, p 5. Rural Luna: "Tarns"
#84 APR '95, p 7. Rural Luna, Tarntecture, Ghost Towns
#85 MAY '95 p 7. Rural Luna: Wasyside Tarns; Farm Tarns; Mining Tarns
#86 JUN '95, p 7. Science Tarns, Recluse Tarns; p. 8. Relayside; p 9. Rural Luna's role in Moon as "World"
#98 SEP' 96, p 15. Advantages of Farside for Radio Telescopes, W. Cochran
#119 OCT '98, p 8. Mini-Magnetospheres on Farside;
#131 DEC '99, p 8. Settlement as Intentional Community
#135 MAY '00, p 10. First Moon TourS - Farside "Loop"
#140 APR '01, p4.Transportation and Town Sites

MMM #186 - JUN 2005



The Personal Story behind Cosmos I

Beginnings are always cloudy. It's not until much later that some small incident proves to have been the birth of something big. It was back in 1983 that Roald Sagdeev, a plasma physicist and head of the Space Research Institute (IKI) in Moscow visited the United States in hopes of forging better ties between American and Soviet scientists, and met Carl Sagan. The rest is history.

The Hercules Project
at the University of Southern California

With permission by Madhu Thangavelu, Moon Soc. Advisor

Introduction:

- How do you make people realize that mankind's destiny is in space?
- Propose an idea that invigorates the space program, generates plenty of support through public involvement and private enterprise.
- A series of manned races that culminate in a race on the Lunar surface
- DARPA race, Xprize, American prize provide heritage, guidance, and proof that the race/space idea works.

During the Fall 2004 semester, the students of the graduate astronautics class ASTE 557 (formerly AME 557), Space Exploration Architectures Concept Synthesis Studio, outlined a vision that returns humans to the Moon for a sustained presence, fueled by commercial involvement and public support. The rationale for this vision is to tap the elements that elicit the most response from broad segments of humanity, such as competition, excitement, personal involvement and commerce.

This led to the vision of a series of races to culminate in a manned race on the lunar surface. The race series is called HERCULES, an acronym for Human Earth-Moon Rover Competition to Upgrade Lunar Exploration Systems.

The races on Earth, one in the Sahara and the other in the Arctic, allow the contestants to evolve their capabilities in a spiral manner. It also allows corporate participation and sponsorship as the race matures, and sustains public interest over a period of time.

Minimal infrastructure is needed on the Moon, to minimize delay and reduce cost. The hardware that is required will flow into future missions and capabilities. Small base camps are landed a priori at the lunar equator and the South Pole. Lunar medevacs enable emergency rescue of stranded rovers in a very short period of time. Resupply depots are landed at several locations along the route, and also act as breakdown and solar flare shelters. A robust communications and navigation system allows good situational awareness and live, commercial, consumer grade televising of much of the mission. The Earth-Moon transportation system is assumed to be a commercial version of the launchers and spacecrafts baselined in NASA's Vision for Space Exploration. The system is designed for safe, versatile and affordable transfer of crew and cargo to and from anywhere on the lunar surface.

And in the spirit of competition, two rover groups of students were formed to design entrants for the race. The two teams, SELENOPEDE and ARTEMIS, took quite different approaches for their designs. Each addressed several aspects of the challenges these rovers would have to face, including propulsion and locomotion, thermal dissipation, radiation shielding, and crew operations.

The team presentations were presented to a select panel that included former Moonwalker Dr. Buzz Aldrin, Ron Creel (Apollo rover design team), and several other distinguished members from NASA, industry, and creative professsions. [End Introduction]

The Vision In order to reinvigorate the human space program, captivating ideas that enthrall the public imagination are needed, those that restore space as that unique and awesome arena of interdisciplinary human endeavor, portraying new hope and a glorious future for all of humanity. The HERCULES race is such an idea. It involves a series of progressively harder races that culminates in a race on the lunar surface. The competition will excite people, and enhance innovation. The public gets involved by either competing in the races directly, or by interacting with the crews. Use of cameras and media is heavily emphasized to better connect the public to "immerse them" in what's going on. It also provides a big source of money to tap into given advertising and its revenues. Corporations can become sponsors of these race teams, and new companies, ones that have never before been engaged in space activity, will bring new blood and work on the race. This momentum and infrastructure buildup will not end with the race but rather used as a new beginning for future missions including a viable Lunar eco-nomy with mining, transportation, and tourism at its core.

The Architecture

The architectural concept is simple: a progressive race that will concurrently build up public interest, tech-nical sophistication and achieve a lunar presence through a series of publicly sponsored events. We begin by setting the challenge to the world for a chance to compete in the worlds biggest arena, the Moon. There will be a series of three competitions each with increasingly more difficult design and operations requirements.

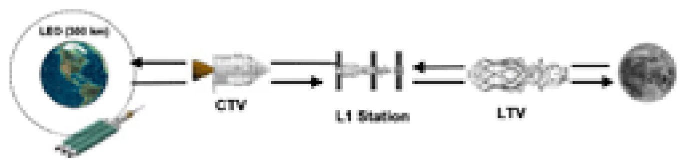
We start simple:

a race across 3800 km of the Sahara desert in which any team in the world can compete. The design requirements are basic and require that teams focus on dust mitigation, vacuum operated power systems, speed, and overall rugged-ness. The competition will be a battle between many Davids and many Goliaths with the top 10 teams advancing to the second round set in Antarctica. With teams narrowed down to 10, the stakes are higher and so are the design require-ments. The rovers entered in this race must contain their own life support systems, offer pressur-ized crew cabins, withstand thermal extremes, and have the capability to support EVAs. Similar to round one, this race will take place over 4000km of harsh terrain and will test the abili-ties of not only each team's rovers but the robustness of the HERCULES race logis-tics and support infrastructure. Addi-tionally, each team is responsible for finding corporate sponsors to fund the development of their rovers as well as the entry fee for each competition. The top 5 teams in the Antarctica race will move on to the final and most presti-gious round : a race the moon. Five teams from around the world travel 384,000 km to compete in a 4000 km race from the lunar equator to the lunar pole. The team that completes the race in the quickest time wins, and winner takes all.

Logistically, there is an enormous amount of back-ground work behind each of these races which is being handled completely through the HERCULES Company. HERCULES Inc., is conductor of this symphony and we have put together a comprehensive outline of Race Rules. With the funds raised through the entry fee and separate HERCULES funding raising efforts and sponsorships, we are orchestrating the development of all the separate functions of this race. From transportation to communication to lodging, HERCULES is the world's ticket back to the moon. In the following abstracts, you will see abstracts for the basic strategy, design and operations of our subsystems.

Earth Moon Transportation System

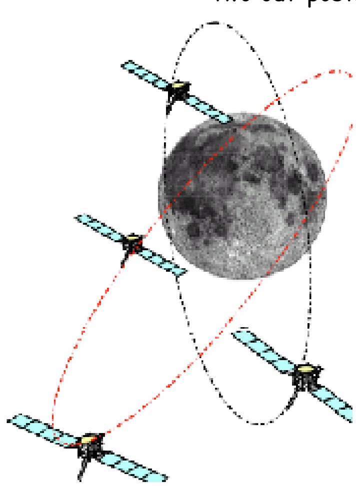
The team goal is to provide transportation for humans and cargo to any-where on the lunar surface safely and cheaply. The choice was made to transport the cargo and crew separately for safety and cost reasons. An array of possible types of transfer concepts is presented, followed by a selection for each of the crew and cargo systems. For the crewed mission, rendezvous at L1 is selected. For the cargo mission, a low energy and low thrust transfer is chosen.



The transfer architecture and mission sequences are discussed, followed by a description of the components involved in the mission. The advantages and disadvantages of the selections are then discussed. It is concluded that the transfer selections combine to form a very robust transportation infrastructure.

Habitat & Waypoints in Support of First Lunar Race:

To support the exciting first lunar race, two out-posts will be required at the finish and start points as well as waypoints equally distanced along the way. This architecture will yield all the necessary functions, supplies and safety related preferences that would be required for such a hazar-dous traverse across the lunar surface and consists of two bases, one at the equator (starting point) and one at the Southern Pole (the finishing point). In conjunction with these outposts, fifteen waypoints will be strung along the general race path to provide various supplies as well as for safety and communication purposes. CTV L1 Station LTV LEO (300km) CTV L1 Station LTV LEO (300km)



The bases will be designed around the general living and working quarters, the habitat. These habitats will be landed autonomously and deployed in a similar manner. The structural shell will unfold and an internal bladder will be inflated to provide a pressurized vessel. A separately shipped robotic rover will then pile lunar regolith upon the habitat to provide radiation and micrometeoroid shielding. All the supplies and materials that will reside within the habitat will be shipped separately and brought into the habitat once constructed. Connecting tubes and airlocks are also designed in a modular format and will be landed on site and installed separately to complete the overall habitat design. The primary source of energy will be of nuclear derivation and be complemented by solar array backups. Separate rovers for people and cargo transport will also need to be shipped to site and implemented.

The waypoints will be number in the region of fifteen and be distanced approximately equally along the route. They will provide all the resources that the rover teams will require during their extended lunar traverse. A docking ring will allow the rover teams transfer all the gaseous and liquid resources directly to their rovers without enduring an EVA. Panels will open from the sides of the waypoint for access to solid resources, tools, etc. There will be four boxes on each panel, one for each team, and for panels yielding 16 teams per waypoint total. The teams will be able to predetermine what they want in their individual boxes and at which one of the waypoints. They may be taken from the waypoints by the rover teams using a remote manipulator system or EVA; it is up to their discretion. The waypoints will also provide a 30 meter light tower with three optical beacons separately placed equally along the length that will rise into the lunar sky and will be a visual cue and provide a distance gauge for the rover teams as the come over the curve of the moon's surface. First aid and an independent communication system will also be present for emergency use.

Communication and Navigation

Communication – The purpose of the communications system is to provide real time high definition television feeds between the lunar race (rovers) and the Earth. Also, to provide communications between the crew (in transport), Earth and Moon. A comparison between RF (satellite based), Laser Com (satellite based) and Tower communications systems was performed. The results showed that a combination between RF and Laser Com was the optimum solution that satisfied the com needs. Thus, the system will have RF communications between the rover and lunar orbiting satellites, laser com between the lunar and earth orbiting satellites, respectively, and RF communications between the earth satellites and tv stations.

Navigation – The purpose of the navigation subsystem is to meet the navigation requirements needed for the lunar race at minimum costs. To accomplish this, a comparison between a satellite-based system to a beacon and buoy based navigation system was performed. Results of the comparison showed that the simpler beacon and buoy based system met the requirements of navigation. Also, this was achieved without having to incur added satellite (need 4 satellites in line of sight at all times) system costs. The system will be made up of beacons at bases, beacons on rovers, beacons at waypoints, RF buoys dropped by rovers and image terrain navigation for rovers.

Extravehicular Activity Suits

Extravehicular activity will be crucial to a manned presence on the moon and eventually Mars. The HERCULES Lunar Rover Race will serve to accelerate EVA suit design and spur innovation. The development of rover concepts will drive, and in some cases, be driven by suit design. Supporting the race requirements will force suit evolution for focused needs and lead to diversified suit choices.

- The EVA suits requirements to support the current race architecture are:
- Suits must have camera capability to provide face shots and exterior shots
- Suits shall have direct voice com independent of rover
- Suits must provide EVA time of up to 10 hours
- EVA suits will be provided by HERCULES staff
- EVA capability and the events involving EVA (scouting, crew transfers, etc.) are crucial to the race appeal.

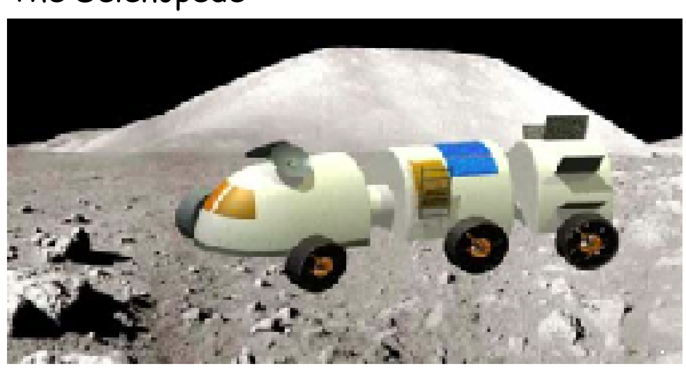
Rescue Capabilities

The danger inherent in the rover contest calls for advanced rescue capabilities. Prioritization of quick response to any emergency led to the selection and preliminary design of a ballistic medevac vehicle called MoonHIND. Key features include rescue EVA systems that are fast, flexible, and robust, dustmitigation during landings near vehicles in peril, and suggested integration with ongoing ISRU activities to compensate for high propellant consumption.

ROVER COMPETITION:

With the HERCULES Group working together to put together an overall race architecture, we decided the best way to test it was to design two teams to compete. In the next few sections you will see how our teams approached the design of their lunar rovers.

The Selenopede ®



The mobility offered by long range pressurized rovers is an essential step toward opening the lunar frontier to further exploration and exploitation. Bridging the vast distance between the equatorial region and the lunar South Pole in a lunar race will be a trail blazing event, analogous to the Golden Spike experienced with the U.S. transcontinental railroad. The establishment of long range mobility on the rugged lunar terrain will promote the development of advanced rover technologies. The design and operational strategy of the winning rover will set the standard for lunar mobility for years to come.

The Selenopede ® rover was designed to take advantage of key technologies, innovative concepts, and race-winning strategies. It will consist of a 3-segmented articulated frame powered by a Dynamic Isotope Power Supply (DIPS) to allow mobility over treacherous terrain during both lunar day and night. A constant high-output power supply is essential for high-speed mobility, life support and environmental thermal control (especially during lunar night). The Selenopede weighs approximately 5 metric tons and is 13 meters long by 3.5 meters wide. It will carry a crew of three at a nominal speed of 15-20 km/h, depending on terrain. EVAs will only be needed in case of emergencies and the crew will be protected from solar events through innovative shielding strategies.

The first 2 segments are pressurized and connected by a flexible passageway. The power supply is housed in the third segment. This segment shields the crew from harmful nuclear radiation and provides radiators for thermal control. As with any competitive race, a carefully designed strategy and ingenuity will be the deciding factor.

ARTEMIS This rover is an awe inspiring vehicle designed to win the HERCULES race on the moon. Equipped with techno-logy for the next generation, this vehicle will take the competition by surprise. Powered by the sun and fuel cells, ARTEMIS cruises at a top speed of 25 mph, which is faster than any existing vehicle known to humans on the moon. This vehicle also enables a comfortable crew of 3 to traverse the harsh lunar landscape for weeks at a time, day and night.

ARTEMIS has three innovative techniques designed to cut down on dust and radiation. The first is a new wheel design that throws dust away from the vehicle as it navi-gates the dusty moon. The next innovation uses the lunar regolith as a radiation protection shield. Before the initial expedition, the mechanical arm can be used to scoop rego-lith into the Kevlar bags that surround the crew living space. The final innovation uses the cameras that surround the vehicle for sight. There are no windows on the ARTEMIS, but multiple cameras are projected onto many LCD screens that enable the crew to navigate with ease.

Even though ARTEMIS comes loaded with all the best capabilities, it still is not a huge vehicle. The interior is 14 x 6 x 6 feet with a pressurized living space of 6.5 x 6 x 6 feet. It comes equipped with 4 feet diameter wheels and 2.5 feet of ground clearance to plow over small craters and obstacles. ARTEMIS only weighs c. 1 ton as well, which is less than the Hummer vehicle, a close but inferior relative.

Ladies and gentlemen, boys and girls, welcome to
The Hercules Program for Return to the Moon.
HERCULES Mission Control to Artemis and Selenopede :
start your engines !

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Instructor Biography Madhu Thangavelu is a co-author of the book "The Moon: Resources, Future Develop-ment and Settlement", John Wiley &Sons 2007, 2nd edition.

- Conducts the AE557 graduate Space Exploration Archi-tectures Concept Synthesis Studio in the AME Dept. at the USC He also teaches the Arch599 Extreme Environ-ment Habitation Design Seminar in the School of Architec-ture where he is also a graduate thesis adviser.
- Educational background is in Architecture (Masters in Building Science, USC School of Architecture) and in Engineering (Bachelors in Science and Engineering, India). Versions of his masters thesis (conceived during ISU '88 at MIT) entitled "MALEO: Modular Assembly in Low Earth Orbit. An Alternate Strategy for Lunar Base Establish-ment" were published in several journals worldwide
- At USC, he was mentored by and worked as a research assistant under Dr.Eberhardt Rechtin, Prof. of Electrical, Systems and Aerospace Engineering, considered the chief architect of NASA's Deep Space Network and President Emeritus of Aerospace Corp.
- Since 1992, he is a creative consultant to the aerospace industry in this newly evolving field of space architectures complex concept synthesis. Mr. Thangavelu's concepts have been reviewed and appreciated by NASA, the National Research Council, the National Space Council (Bush Sr. Administration), and his work has been presented before the National Academy of Sciences.
- A visiting lecturer at the International Space Univ. (ISU) and co-chaired the Space Systems Analysis and Design Department at their California 2002 summer session. He continues to present and publish original concepts in Space System Architectures; chairs related conference sessions .

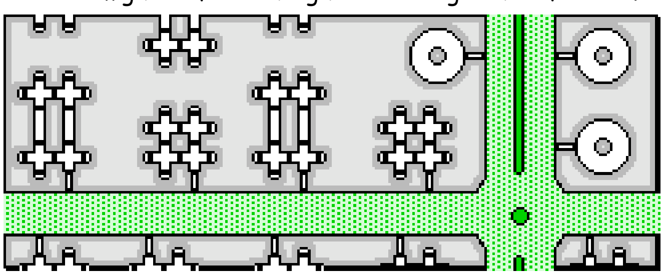
Former Vice Chairman for Education, Los Angeles Section of the AIAA. Director of Space Exploration Projects at the California Inst. of Earth Art and Architec-ture. Most recently, Mr. Thangavelu's concept creation work was greatly appreciated for proposing ideas that pointed to the "leading-edge sensor concept" for return to flight of the space shuttle fleet. Mr. Thangavelu, his spouse, space system architect Catherine Girardey and children Chloe Saras(10), Chelsea Manon(7) and O'Paul Roy(16m) live in Palos Verdes Estates, California. **</MMM>**

Favorite Hobbies, Pastimes, & Activities:
Pioneers won't have to give up "Everything"

by Peter Kokh

The Moon is quite a different environment than our familiar home planet. You can't go out under the open skies without a space suit. The sky isn't bright blue or even cloudy. There is no "weather" as we know it. The sun does not set every 24 hours, nor rise at that pace. There is no native vegetation nor wildlife. No outdoor sports, no nature walks. No planes flying overhead. No oil, no coal, no gas. No rivers or lakes or beaches. No forests, no grassy plains, no snow-packed ski slopes. *"Boring!"* as the young would say.

That said, we will establish local biospheres, and, if they are to survive & thrive, ones with substantial 'middoor' spaces filled with diverse vegetation and even with a carefully selected wildlife ecosystem. So whereas 'the' outdoors on the Moon, the famous "magnificent desolation" is quite inimical to life and unprotected pursuits of any kind, the pioneers will enjoy a created "outdoors" within the biosphere airlocks, an environment that falls neatly between the indoor spaces of individual residences, shops, factories, schools, offices, etc. and the "out-vac" airless spaces of the Moon's surface, exposed to the vagaries of cosmic weather. The middoors will offer much, but hardly all, of the pleasures we might at first thought be leaving behind forever.



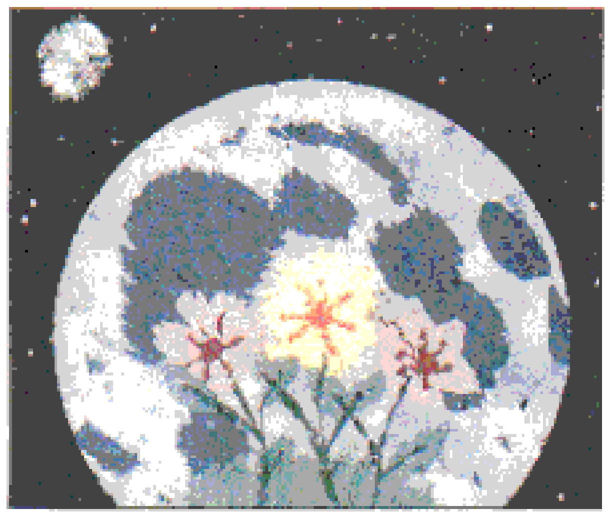
The "Middoors"as key Biosphere Component - In a modular settlement, allowed to grow as need be (not a fixed size megastructure based on someone's guesstimate of future needs), modular habitats and other structures are connected to pressurized residential/commercial "streets." These "commons" will contain the bulk of the settlement's biomass and biosphere. See "Being able to go Outside" pp. 5-6, MMM # 152 FEB '02

We have to stop thinking about living in tin cans hosting a few house plants and instead thinking of lunar habitats as ecosystems of vegetation hosting people. If we build in "full" modular fashion, expanding the biosphere along with the pressurized maze, erring in favoring plants over people rather than the other way around, we will create vibrant ecospaces, not a sterile engineering ones. And such spaces will support many of the hobbies, pastimes, and activities we feared we would be leaving behind forever.

Of course, we must forget about sailing boundless seas stretching from horizon to horizon, of flying from anywhere to anywhere, of climbing tall snow-capped mountains, of hacking trails through tropical rain forests, of doing a lot of things, to tell the truth. Yet, in smaller, restricted confines, some of our favored hobbies, pastimes and activities will find exuberant expression on the Moon.

The inevitable depression and sadness that comes from the initial experience of loss, only to be eventually replaced with the newfound joy of meeting an old long lost friend, has occurred countless times through human history as peoples have migrated from location to location, changing niches and climes as they adopted unfamiliar settings. Much of what they thought they must leave behind forever, they would eventually find a way to transpose, to translate, to reexpress in the new territory. Carpenters and builders might have left their favorite woods behind, but found new trees with woods almost as good, or even better, with new exciting grain. Potters, gardeners, weavers, all sorts of artists and craftsmen and tradesmen and hunters and fisherman will have had similar experiences. It takes time, of course, and having the right positive attitude surely helps. And so will it be when we migrate from "The Green Hills of Earth" to the sterile gray hills of the Moon.

Arts & crafts media (paints, ceramics, metals, fibers)



"**Moon Garden #1**" was reverse painted on an 8"x10" piece of glass, by MMM Editor Peter Kokh in September 1994.. The "paints" were not solvent based and incorporated no organic additives. Instead an inorganic adhesive (the only one known), sodium silicate, was used to suspend either raw regolith powder or colored metal oxide powders. The palette is still limited and the art form undeveloped.

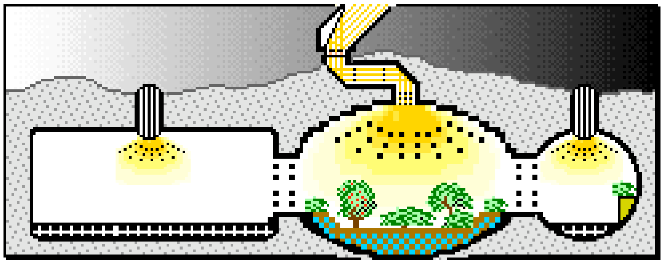
The media familiar to our artists may not be the same, but in time, we will develop paints and clays, alloys, and waste biomass fibers out of which lunar pioneers with a creative artistic bent will do wonders, filling homes and public places with beautiful objects, made on the Moon, of moon-stuffs. To some extent, we can pioneer those media, or at least analogs of them, here and now while we are waiting. Any activity along those lines would give frontier artists and craftsmen a helpful head start. See:

http://www.lunar-reclamation.org/art/

Gardening, flower craft, canning

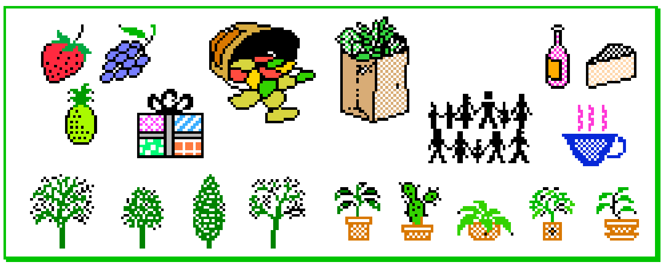
While at first, there may be very few crops, all staples, and only a few species of biosphere support plants, this will change, and quickly, if attainment of biospheric self-sustainability is a goal. And home gardeners will be a major part of this, and cottage canning industries as well.

Garden stuffs will support arts & crafts, especially among children, as they do today, here on Earth, everywhere.



The Heart of a Lunar Home: An "Earthpatch"

On Earth, if there is a feature that is consi-dered the "heart of the home" it is the "hearth." Real fireplaces are a highly unlikely feature for Lunar homesteads. But pioneer homes will have a "heart" nonetheless, the interior Garden, a veritable "Patch of Old Earth." The "Earthpatch" will be important for much more than strong morale! See pp. 3-7, MMM # 148 p. # — SEP 2001



Goodies from Homestead Gardens - What do fruit jellies and preserves, deserts with special ingredients, herbal teas, specialty wines, organic dye stuffs, specialty house plants, craft papers, gift items, and family morale have in common? They are all possible products of pioneer homestead garden cottage industry enterprises.

We have written much and often about the role of homestead gardening in the frontier settlements:

- MMM #2 FEB '87 "Moon Garden" republished in MMM Classics #1 at http://www.lunar-reclamation.org/mmm_classics/
- MMM #109 OCT. '97, pp 3-11. Luna City Streets
- MMM #149 OCT. '01, p 5. Homestead Gardens & Early Cottage Industry
- MMM # 65 MAY '03, p 3. Settlement Garden Tours, a Favorite Pastime

Sculpting & carving & carpentry

No marble, no soapstone, no sandstone, no ivory, no whalebone, no wood. No copper, brass, or pewter. What's the frontier sculptor, carver, and carpenter to do to express what's inside himself by exposing it in a material? We will have to explore new media, probably less easy to work with. The stable of lunar-formable alloys is not yet clear. metallurgists will definitely need to be on the lookout for alloys that are "workable." There is every reason to start the search now. We know what alloy ingredients are eco-nomically available on the Moon. Let's experiment!

Are any types of moon rock carvable? Probably not, but we can cast basalt. As to wood carving, the wood from many fruit trees, especially apple, cherry, and pear, is hard enough to make beautiful adornment items. Wood will be an accent item, not a main "stuff." For example, we will see metal cabinets with wood handles, the opposite of what we are used to. The carver can work with AAC, autoclaved aerated cement. We ordered samples, and you can nail it, drill it, saw it, and carve it. The sculpting and carving stuffs will differ, the inspiration and creativity will not.

Fishing, boating, nature walks, flying

The corridors and streets of the settlement must support the bulk of the biosphere mass. There is every reason to believe streams, ponds and waterfalls will be integral parts of the water recycling system. Ponds and streams will be stocked with game fish as well as ornamental varieties. Canoes and paddle boats will be common. There will be nature paths, pointing out the various plants and other features. Chains of such walkways could be a proud and much used feature.

Eventually, if the nitrogen which will be by far the most expensive component of air can be found in ample enough supply to support open spaces with high ceilings, human powered flight should be possible in the light gravity. This will not be a satisfying substitute for seasoned pilots. But the young, growing up on the Moon, will hardly complain.

For rockhounds

Those into rock collecting, cutting, and polishing may miss their familiar favorite rock types. There are no sedimentary rocks on the Moon, no marble or granite, and probably no geodes. But there are types of rock on the Moon not found on Earth and rocksmiths will soon figure out how to reveal their "hidden essence and beauty," and make objects of art and decoration, even jewelry with them.

Japanese style sand and rock gardening should be an early favorite using larger surface rocks well placed in a regolith "pond" well-ripple-raked.

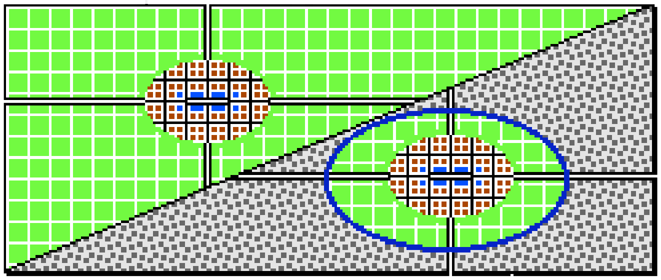
Ceramics and pottery will have to begin by making clay from scratch. Then mixing in various types of natural regolith and lots of experimenting. With cast basalt pieces, these media will be the source of much that is special and unique to tourist shops stocked with made on Luna items.

Sports - Terrestrial sports for the most part would make poor imports. With one sixth the weight and traction but full standard momentum, any familiar game could be but a caricature of the original, when imported to the Moon.

The pioneers will develop their own games, sports events, rules, playing fields etc. Some of them might make for good telecasting to fascinated watchers on Earth. {ABC's "Wide Worlds of Sports") The same goes for popular artistic dancing (e.g. lunar ballet, lunar ice skating) In short, those of us who enjoy athletics and energetic exercises, as such, or in the form of sport or dance, will still enjoy them on the Moon, though the forms may be different.

In short, no matter what kind of hobby, sport, or pastime activity you are into, there will be something for you on the Moon. It may not what you are used to, but it will tap the same energies, th'e same free spirit, the same creativity. Lunan pioneers, with the right spirit, will find many outlets for their energies. **<MMM>**

MMM #187 - AUG 2005



Cities (on Earth) vs. Xities (beyond)

In this issue, we explore the significant and definitive differences between human cities on Earth and the kind of human settlements that alone can survive beyond our biosphere. Settlements on the Space Frontier will not endure if they do not include within their limits what Earth cities can conveniently keep outside. There is a great difference between Outpost Mindset and Settlement Mindset. *Below*

Cities *"Out There"* Bringing Home the Difference

by Peter Kokh

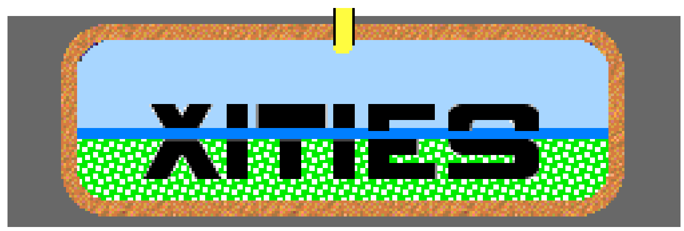
In MMM's 6th year, issues #s 51-60, December 1991 - November 1992 [just reedited, reillustrated and republished in MMM Classics #6 available as a PDF file download from www.lunar-reclamation.org/mmm_classics/] one theme dominated the year: the vast and rather radical (root-deep) difference between cities as we know them, all within Earth's biosphere and taking that biosphere for granted, and cities out there -- anywhere out there (other than planets around other suns, if those planets have a breathable atmosphere.)

> MMMC #6 begins: .... "**defining how different city life would be beyond Earth's cradling Biosphere. Cities out there, whether in free space as Gerald K. O'Neill envisioned, or on the surface of the Moon or other on worlds would be radically different. They would have to establish their own mini-biospheres, no longer something to be taken for granted, then learn to sustain them and live within them.** ***This will change everything!***
>
> **"**So radical will be the way cities out there will be built and run, that we cannot appropriately use the same word for them as we do for our familiar cities on Earth: whether they be primitive prehistoric towns, third world megacities or the affluent cities in prosperous countries. *They all get to take the biosphere for granted.*
>
> "Out there, our settlements will have to reprioritize everything. We need a different word for this different species of urban entity. **We call it the Xity:** X for "exo-terrestrial, not just beyond Earth, but beyond Biosphere I, Gaia.
>
> "We pronounce it not EXity (it's not ex- anything) but KSity, city preceded by a hard K, for the hard hull/shell that contains the manmade biosphere that pioneers now must nourish and care for as if their lives depended on it. *for indeed, their lives will!"*

We encourage readers online to download this volume of the MMM Classics and read it. Those not online may be able to access it at to a local library.

In these articles we discussed a lot of things: new departments of xity government tasked with maintaining the integrity and livability of the manmade mini-biosphere and pressure hull complex; with short-cylce air and water recycling; with education to help citizens do their part: how xity-architecture and urban planning will play key roles . We discussed Xities on the Moon, then on Mars, on Europa and elsewhere in the Outer Solar System, even aerial (aerostat) Xities high in the clouds of Venus.

We tried to illustrate the difference between city and xity from many points of view. Having just reedited these 13-14 year old articles, however, new ideas for bringing home to the reader the crucial and definitive city/xity differences have occurred to us. *Read on!*



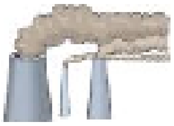
> *Xities beyond Earth's Biosphere will be be founded on a new contract between Man & Nature, a reintegration of urban and rural, of residential and agricultural, in which both humans and nature are much more immediately interdependent for survival. There is no more "downwind" and "downstream." There is no more "somebody else's backyard." There is no more putting problems off to future generations. In contrast, "Responsibility" and immediate "self interest" will be one, not two in conflict. Making it work will be everyone's job, not just the community fathers. There will be no room for "politics." Survival will always be problematic. Alert status: maximum.*

By Peter Kokh

Here on Earth, we have since time immemorial taken the global atmosphere, hydrosphere, and biosphere for granted. While destructive weather and locally catastrophic geological burps are problems, by and large, earth is a human-friendly place to live with lot's of shoulder room, although through our rabbit-like reproductive instincts, this last feature is rapidly coming to a close.

When we invented agriculture and started domesticating edible plant species and animals, our farms and hamlets were close-coupled. In time cities arose populated by those engaged in other pursuits than agriculture. Farm and settlement entered a period of evolving disengagement, with many urban dwellers never experiencing farm life and food production activities. Cities became places where nature was present only as a landscaping token. Urban "parks" while helpful, are nonetheless still token. Citizens of denizens of cities grow up with a vastly distorted view of how much plant biomass is necessary to sustain fresh air, much less the food supply. Cities became places in which people kept houseplants.

Symbols of Disengagement:

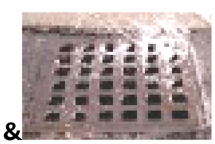
chimneys  **&**  **smokestacks**

Earth's atmosphere is vast: global and seemingly topless. Before the scientific age, most people imagined (some still do) that the atmosphere pervades all of space. That it is a finite blanket in which only so much can be dumped is just starting to be taken seriously, by some. Whether we are just heating our homes, or using heat in manufacturing, the nasty residue can just conveniently be dumped "downwind." Curbs on this practice are recent.

In Xities that contain and maintain a very finite atmosphere, there is no downwind. Everyone lives downwind of themselves. If you use a chimney or other exhaust device, what it pumps out you must inhale. Oops, we better do something drastically different. We can no longer count on the winds, the rain, the seas, and the forests to gradually cleanse our smoke and other dirty exhausts by the time the global winds bring it back around to us weeks later.

In xities, the long term recycling provided by nature on earth will not be available. We will have to use smoke-free, gas-free heating and manufacturing processes or find ways to scrub the exhaust before it leaves the confines of its generation. This will make xities out there radically different from cities down here.

Symbols of Disengagement:

gutters  **&**  **drains**

It was way back about 2,500 B.C. in the Indus River valley (now Pakistan) in the settlement we call Mohenjo-Daro that urban sewage systems were first built. That made an immense difference. People were not wallowing in their own body wastes. What we have today is but a more sophisti-cated elaboration of this ancient prototype, a means of transporting the undesirable to somewhere else. Now, of course, we are mandated by law to treat sewage before it is allowed to enter nature's waterways. But Earth's hydro-sphere being so massive and vast, "clean enough" is still far from clean. We rely on nature to finish the job.

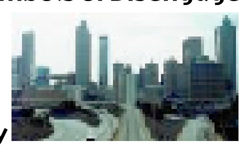
In settlements out there, settlements that contain mini-biospheres that they rely on totally, there is not enough biomass and water reserves to "finish the job" of sewage treatment. We must devise more comprehensive systems. The water we flush will be the water we drink, much sooner than we think. There no "downstream" out there. Unlike citizens, xitizens will live immediately down-stream of themselves.

It seems to us that treatment must begin imme-diately, with in-home treatment of toilet wastes. The Wolverton graywater system, in which wastes are flushed into tanks inoculated with microbes to breakdown the pathogens as well as the solids, and which feed successive tanks and beds of first swamp plants, then marsh plants, bog plants and soil plants, continuously cleansing the water while the plants cleanse the air, is the way to go. Check out:

http://www.wolvertonenvironmental.com/

Every unit or module that has a toilet, be it residential, office, school, workplace, recreation area, etc. should be so equipped. That will greatly reduce the burden the xity waste treatment facilities must handle in order to produce water for agriculture, industry, hygiene, and drinking. It will also increase the amount of biomass able to keep the air fresh and sweet. Water in advanced stages or treatment can do double duty for landscaping, park streams and waterfalls, boating, etc.

Symbols of Disengagement:

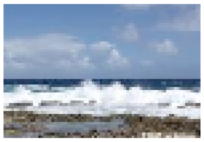
city  **&**  **farm**

Not long after the dawn of agriculture, cooperative farming began. People lived in farming villages, surrounded by their farms. Village and farm were separate but fully integrated. As cities developed to support marketing and trade, their integration with agriculture was less direct. As manufacturing arose, including the manufacturing of farming implements, the separation intensified. Nowadays it is common for city people to have never spent time on a farm, to have only a foggy and distorted idea of what is involved in bringing food to their table.

Because on the space frontier, xities and their farms must share the same contained atmosphere and mini-biosphere -- it will be the farm areas that keep the xity's air fresh and sweet -- this separation will end. Unlike the aloof and separate city, the xity will be fully integrated with the farms that support it. We will have come full-circle, back to the days of farming villages surrounded by their village-owned farmlands.

Forests and other natural planted areas will also be part of the xity. The amount of vegetation mass needed to clean the xity's are naturally is great. We can opt for chem-ical means, but that puts us at the mercy of engineered sys-tems prone to breakdown. No xity biosphere will ever have the guarnteed flywheel recycling system that Earth/Gaia enjoys, but the further we advance in that direction, the greater will be the Xity-Biosphere viability and security.

Symbols of Disengagement:

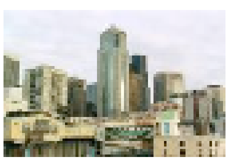
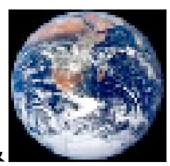
land  &  sea

City dwellers simply have no concept at all of how great the support ratio is of hydrosphere to vegetation mass to people mass is. Not only cannot we live with the help of a few potted plants, we cannot live without the analog of an ocean. In a hull-limited biosphere volume, we cannot, of course have anything like an ocean. On the other hand, the "ocean" of Biosphere II, while at the time a bold step in the right direction, was pitifully inadequate and symbolic.

Having ample water reserves will provide security, greatly ease water recycling system engineering, support recreation, and provide a thermal flywheel to help even out internal dayspan-nightspan temperature variations.

Rain which helps cleanse and sweeten the air as well as water vegetation and clean paved surfaces, is unlikely to occur naturally in a mini-biosphere. It may need to be provided by ceiling sprinklers, or at best coaxed out of air that has become to humid -- not a comfortable prospect. Fountains and mists may be a workable substitute.

Symbols of Disengagement:

city  &  world

The ultimate disengagement here on today's Earth is that between the city and the living world at large, aka the global biosphere, personified as Gaia. On the space frontier, xity and biosphere must be one and the same, united against the barren and inhospitable surroundings. Unlike citizens, xitizens have no global biosphere to take for granted. They must create, nourish, and sustain one inside their own urban space. World, as livable, as nourishing, as enabling and supporting must be one with the xity.

Consequences

We talk these days about "permanent outposts" on the Moon and Mars, about putting down roots and staying. No small outpost can have a sustainable biosphere. We will not be on the Moon, or Mars "to stay," all intentions, declarations and legislation to do so notwithstanding, until we build xities with a genetically diverse population of settlers, with a rich and diverse biota, with systems in place that will allow us to live immediately downwind and downstream of ourselves. That expertise will be a licensed export to Earth.

More simply said, humans can not settle the space frontier -- not alone, not without taking Earth-life along to reencradle themselves. In the process our civilization which now is a mess of disengagements of things that must naturally thrive together, will becomw whole again. Like a symbiote, we cannot live without our partner life system. Humanity and Gaia together will establish joint pockets beyond Earth. In contrast, "men bearing houseplants will go nowhere." except to lay the foundations of future ruins.

We will, of course, have outposts, rural boondocks towns supporting mines, tourism, and other "parts" of global economies on new worlds. But long term, those smaller exclaves of humanity will not survive without supporting xities within practical reach. The same goes for spaceships spending long times "at space" between ports. Their food growing areas will be token and fragile. Without ports of call with established biospheres, they can probably not ply the space lanes for long. It follows that for rural outposts and spaceships alike, the bigger the better, because needed plant life requires acreage and volume. Think grand! "Larger" will be much less expensive in the long run. But we can expect that to be a hard sell to budget-minded myopic officials and administrators.

Our goal must not be to establish a "permanent outpost" on the Moon, or Mars, or anywhere else. It must be to establish Xities, not exo-cities, but miniature encapsu-lated Earths, viable *populated biosphere systems*.

Our cry is "Ad Astra!" Well, Xities come first. So let's build Xities then. **<MMM>**

Outpost **vs. XITY**

Two Very Different Games and Mindsets
The Implications for Agriculture

by Peter Kokh

When the technologies needed for the Moon are discussed, it is almost always in the context of a starter outpost. After all, we do have to start somewhere, so it is only natural that everyone is focused on "the gambit game."

> A lot of the conventional wisdom about what we will need, and what we will do on the Moon turns out to hold only in this startup context. Once we begin to expand in determined fashion, *everything changes*.

In this brief article, I'd like to touch on a few of those things, to get the point across. For long term, we need to start looking at things from a totally opposite vantage point. Indeed, unless we can switch perspectives and gears, there will be no "long term."

Outpost Goals

Some may want to prioritize Science & Exploration as the principal goals of the Outpost. *Patience!* Far more sand much better science, and far more thorough exploration will get done, the sooner we transition from Outpost to Settlement. ***Preparing to lay the foundations for Settlement must be Outpost Job #1.*** If this is not the name of the game, then we are fooling everyone, including ourselves, and spending taxpayer money for trivial pursuits. In this light, here are the priorities, all in the form "test & prove"

- various methods of regolith shielding emplacement
- methods of excess dayspan power generation and storage for nightspan use
- methods for processing regolith for oxygen, iron, other metals and elements needed to for building materials
- modular architecture concepts using locally produced building materials

Notice that "test & prove" agriculture methods and concepts is not in this list. This is not an oversight. As we transition to settlement, the context of operations will change so radically, that little of what we learn in outpost agriculture exercises will continue to apply.

Out of the Sardine Can

The first lunar outpost will be constructed from modules and other elements manufactured on Earth: hard modules such as we have been using to date in space station construction, and inflatable and rigid-inflatable-hybrids. The inflatables will give us more elbow room per mass delivered to the Moon's surface and per number of flights. While this is a significant improvement on both counts over previous all rigid module outpost concepts, it will still put a premium on working and living space. We will always need more than we have. It will still be the Sardine Can, just the larger size. Priority in pressurized space allocation must be given for processing, manufacturing, and fabrication experiments. Any other prioritization will lead to inevitable failure of the Outpost as to its main goal: not to keep a token presence on the Moon indefinitely, but to lead expidi-tiously to real permanent human presence in the form of the first settlement.

(The Settlement will be unsuccessful if it is not sited to have access to all the suites of materials it will need to produce the bulk of its needs locally. That's why this writer so strongly opposes a lunar polar outpost. It's in the wrong place for industry.)

In sharp and definitive contrast to the Outpost, the Settlement Xity-in-the-making will be built all but completely from modules manufactured locally from local materials. Suddenly the cost per cubic foot per person will drop so dramatically, that we can begin to be more generous in per person allotments. The Settlement will be the beginning of the end of Sardine Can living on the Moon.

Now as we expand human presence across the lunar globe, their will always be small starter outposts. However they too will be built of modules made on the Moon. The cost if not the per person space allotment will be much improved over the first government or commercial outpost.

Beyond Hydroponics

With significantly cheaper and more spacious units produced on location, agriculture will be one of the first beneficiaries. This new elbow room will allow us to move past hydroponics to a mixture of hydroponics and geoponics. Why? Two very simple and cogent reasons:

- Some plants do better in soil than in nutrient solutions. For more variety on the table, we have to give up the silly adoration of hydroponics as "the" modern method.

Far more importantly, *all hydroponic nutrients must be imported.* That represents a cost target for reduction. The simple fact is that the greater mass by weight of the nutrients needed per mass of plant are found in the regolith. So it is simple economics that once pressurized "space" is not a bottleneck, we transition to systems that are more locally supportable. Regolith can be processed into good agricultural soil *in the process of moving it* from out on the surface into an agricultural module.

Beyond Agriculture

"Man does not live by bread alone!" or food alone. We also need fresh air, and frankly, just growing all our food will not provide the biomass needed to support a true biosphere, a biosphere which naturally cycles air and water. Now we will never get to the stage we enjoy here on Earth where nature takes care of itself. Our biosphere operates as a flywheel, always maintaining itself, *given sunshine*. Our mini-biospheres will need some mechanical assist, and at times, some chemical tweaking. But to the extent that we can get it to run "on automatic" the more truly viable and sustainable our presence on the Moon, or anywhere else, will be. For that we need more than food and fiber plants.

But before we elaborate on that, consider fiber. No man-made fabric is as comfortable as cotton, all claims to the contrary notwithstanding. Yet most writers insist that cotton will have no place on the space frontier because too great a percent of the plant is inedible and/or unusable for any other purpose. "We simply can not devote that much acreage for that little fiber output." This may be true in an Outpost situation. *Once we see the Outpost as "a temporary construction shack for the Settlement,"* all those points go out the window. Indeed:

- The "waste" biomass can, in fact, be run through a bio-digester (such as one manufactured by a biotech firm in Wisconsin) to produce a tofu like food with only 2% stubborn residue
- The "waste" biomass is helping produce oxygen from waste carbon dioxide, and thus supporting the biosphere
- The argument from "efficiency" is thus quite invalid

Other desirable crops which have been put on the embargoed list prematurely by the Outpost-mindset, can now likewise be reviewed for their biosphere contribution value. Even more significant. given that no amount of plant biomass is too much, and that from a biosphere point of view that more is definitely better, those with a Settlement-mindset need to think beyond food, fiber, and pharma-ceuticals, indeed, *beyond agriculture.*

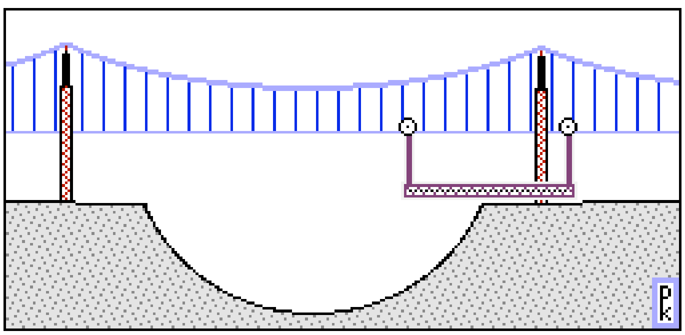
Think of a diversified flora, groves of trees and nature parks with ornamental and other species. Think of flower gardens, not just vegetable gardens. They all will help the biosphere engine run more smoothly on automatic.

Generous water to biomass to human mass ratios

Consider the enormous mass of Earth's hydrosphere (oceans, ice sheets, lakes, rivers, clouds) in comparison to the mass of living plants. The ratio is quite high. Consider the enormous mass of living plants (forests, grasslands, crops, etc.) to that of the Earth's human population. While not as great as it once was, that ratio is still quite high. The point is Earth's biosphere can only support certain minimum ratios if its going to continue to be self-maintaining.

We may never reach such a state in our minibiospheres beyond Earth, perhaps not even on a terraformed Mars. But the more generous a ratio of water to plant life to human population, the better. This means abandoning the Outpost mindset which thinks in terms of *just enough* water just in time, *just enough* food just in time. Any "monkey wrench" at all in such a fragile setup will lead to crises.

We have to have generous water reserves, and extensive vegetation. The Outpost can think house plants. The Settlement must think Nature. Again, we have to re-integrate human community with life at large. Our Xity must include what cities do not: the farms and the forests and prairies and seas. *They must be mini-Earths.* **<MMM>**

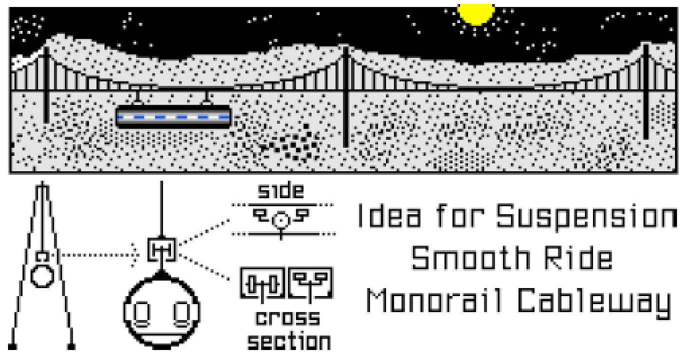


A way to "bridge" rille valley chasms
before traffic warrants building a bridge

by Peter Kokh

While the Moon has no water-filled rivers, it does have river-like valleys and chasms that present potential obstacles to road builders wanting to take the most direct route. Someday, we may find ourselves building bridges on the Moon, and Mars too, for the same reasons and in very similar situations.

While the maria are lava plains, much more easily traversed than crater-saturated highlands, they frequently incorporate lavatubes as part of the process by which the lava sheets spread across the basin. And lavatubes not sufficiently deep below the surface will have ceilings thin enough to have failed and collapsed resulting in a chain of pits or even continuous rille valleys. These valleys could lay astride otherwise logical transportation routes, presenting an obstacle. Detouring around the shortest section of the tube might detour involve extra drives from tens of miles to a few hundred, all out of the way: a lot of time and fuel would be wasted. At first there will be little choice. But as "traffic" develops, the incentive for some way to "bridge" or "ford" the gap will gain enough priority to trigger action.



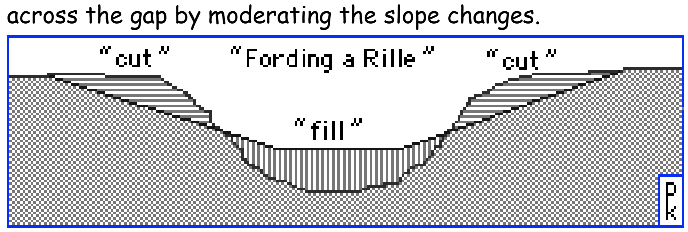
[MMM #169, October 2003, "Early Frontier Highways on the Moon" pp. 4-7] "Lighter, crater-pocked highlands surround darker and flatter lava flood plains, the 'maria'. But a mare may have several deep rille valleys (left) and flow front escarpments (top) and a few younger craters.

Road building solutions

Switchback roads, carefully zigzagging down one valley wall to the bottom, then carefully winding its way back the other side might seem the simplest solution, involving not much more than one heck of a lot of grading. But in soil that is poorly consolidated, and prone to slides, this would be dangerous work for human-crewed road building equipment. Teleoperating such equipment would be safer for the pioneers, but involve no risk reduction for expensive equipment. It is not an ideal solution, the more so the steeper the valley slopes.

Of course, on the Moon where rights of way are of little concern, one could engineer a single long **ramp** down one side and another single ramp up the other, avoiding switchbacks which are accidents waiting to happen.

"**Cut & fill**" is a more ambitious and elegant solution is to do a procedure to build a direct and straight road across the gap by moderating the slope changes.



[Ibid. p.6] "It may be some time before bridges and tunnels are built. 'Cut & Fill' is easier, less expensive, low-tech: ideal for a small population with limited industry. The lunar surface is bulldozable down to a depth of 2-5 meters (6-16 feet). Below that lies fractured bedrock. So major 'cuts' will need the assistance of dynamite or other explosives."

Lighter Touch Solutions

It may well be much more expensive and require more materials and man-hours of labor to build a bridge than to cut & fill a landfill causeway. Yet there may be reasons why we want to, *or decide to,* tread with a lighter foot on the lunar landscapes, preserving them as integrally as we can in their natural state.

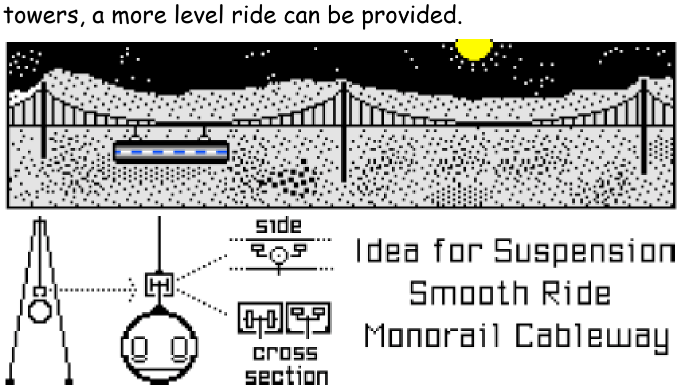
The problem is the cost. Does the foreseen growth in traffic warrant that expense? That a bridge is more convenient is not the point. Where the valley is deep and the slopes steep and treacherous, making traditional road-building approaches more difficult and dangerous, the bridge will loom more attractive.

Yet the expense of building a bridge could be a lot for the young frontier government to handle. We'd like to suggest a step-at-a-time bridge building approach by which key elements are built first, other elements phased in as the growth of traffic warrants.

The Proto Bridge

There are a growing number of types of bridge architectures. While the earliest bridgings may have been fallen logs over small streams and brooks, or carefully placed steppig stones in a shallow river bed, the early true bridges were supported from below by a masonry arch, or if needed, by a series of arches: this method was elaborated further to build aqueducts and their close cousin, the elevated canalways of Britain. The wooden trestle bridges of the early railroading days also are supported from below. But this is as much an incursion on the valleyscape as a cut & fill causeway, even if more appealing to the eye.

The **suspension bridge** and its more recent take-off, the cable-stay bridge, are products of the industrial revolution with the heavy use of iron and steel. We think that the suspension approach is ideally suited for the Moon. Once the towers are in place and the cables strung, traffic can hover above the otherwise undisturbed moonscapes allowing them to remain more natural and rustic. We have already talked about using cableways for tourists in especially scenic areas, along valley shoulders, crater rims, and mountain ridges. By having the cable car ride a second cable -- *or a box beam* -- below the support cable sagging between towers, a more level ride can be provided.



A "Ferry Crossing"

While we may well see cableways continue over rille valleys, the idea here is to build a "ferry crossing" using elements of the above-described suspension cableway system. Two towers and two anchor points are needed, one of each on each rille valley shoulder. A single suspension cable is slung from anchor to tower top to tower top to anchor. From it is suspended a box beam in which a pair of trolley boogies can ride, holding up a flatbed car, built to carry land vehicles from side to side.

The ferry parks on one side, the destination side of its most recent traverse, waiting for customer traffic. It is fully automated, so that it does not matter if the wait is minutes, hours, or days. If a vehicle approaches from the side on which the ferry waits, it drives on and uses the appropriate radio frequency to activate the controls. Once on the other side, the vehicle driver tells the flatbed ferry to wait in park mode, and drives off the other end to continue its journey. If a vehicle approaches from the side opposite to that on which the flatbed ferry is parked, the driver signals the ferry to cross so that it can be boarded.

From single to double suspension ferry to full bridge

Such a system postpones the erection of a second twin cable and suspended box beam as well as of a roadway supported between them. As traffic becomes more frequent the second suspension cable/box beam pair can be built so that two flatbed ferries can cross in the same or opposite directions at the same time. Now the stage is set for building a true bridge roadbed when traffic becomes so frequent as to warrant it.

If traffic never grows beyond the capacity of the first phase, nothing is wasted. And that is the beauty of the Suspension Ferry system. It is self-sufficient, but can be the start of a full-fledged roadway bridge.

The role of Bridges in the history of civilizations on Earth

Many major cities have grown up around the junctions of roads and rivers. Bridges were built were rivers were narrowest and most easily spanned. Bridges have united communities that had sprung up on both sides (Buda + Pest => Budapest being but one example) and have allowed other cities to expand to the "other side."

... and on the Moon (and Mars)

More importantly, bridges are logical pinch points for transportation. Traffic funnels from various angles on both sides to the Bridge crossing, and thus into and through the city built around the bridge. This is true even where, in advance of a bridge being built, a regular service ferry crossing is established. River cities have become major gateways to virgin lands beyond (e.g. St. Louis) The pinch point inevitably becomes a major regional center of trade, commerce, culture, and recreation.

Cities grow up around other seeds, of course, such as where river meets shore or at entrances to mountain passes. We discussed how the lay of the land and transportation routes would determine where thriving settlements would spring up on the Moon in MMM #140 November 2000.

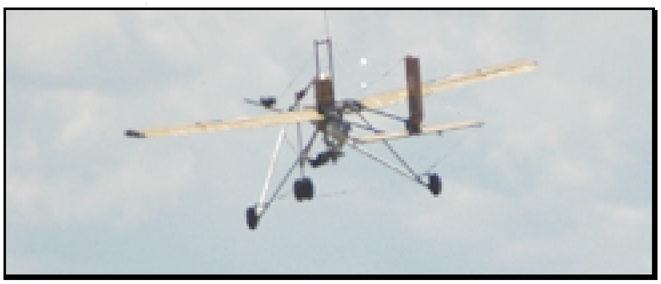
Suspension Ferry Crossings that provide shortcuts across mare rilles and similar obstacles will attract convenience travel centers, and possibly settlements. Thus, erection of a cable suspension ferry crossing will appeal to entrepreneurs who want to get in on the ground floor of a potential successful new settlement and market center. It could well be an enterprise that builds the first such system rather than a frontier government. Of course, a frontier government led by forward thinking leaders might well start the ball rolling by seeking suitable enterprise partners. After all, what's good for business is good for taxes!

Not all river crossing, river-spanning cities have names that reflect that fact. But some do: Harper's Ferry, Bridgeport, Rockford, Sioux Falls, Grand Rapids, etc. It is possible that some future lunar towns will be named in part for there valley spanning function.

The Moon is more than a gray, monotonous rubble pile

The more one gets familiar with the lunar globe and maps, the more the nuances which make *this* gray rubble spot different from *that* one begin to suggest a world of possibilities - indeed, a human world of possibilities! The idea of suspension ferry crossings that span rille valleys is just one example. The more really familiar with the Moon you become., the more concrete the potential of settlement will loom. Take the first step through the Lunar Study and Observation Certificate Program cosponsored by the Moon Society at www.moonsociety.org/certificate/. **<MMM>**

MMM #188 - SEP 2005



Refueling "off the land," Mars Gashopper Flies

When the December 2004 flight over Mars' Grand Canyon by NASA's Mars Plane, the Kitty Hawk was canceled in the wake of recent probe failures, we mourned. But that would have been one short flight. Now Robert Zubrin's company has test flown a craft that can land, refuel itself from Mars' atmosphere, and take off again to explore other places, indefinitely! See the report *below*.

"XITIES" Continued

2 more analogies bring home the differences between terrestrial Cities and Xities out there

[Settlements beyond Earth will be radicallly different meta-institutions from cities on Earth because they must create, incorporate, and maintain a biosphere that city-dwellers and city-fathers take for granted on Earth. We use *a divergent term* to refer to them: Xities, pronounced *Ksih* ties]

For more, read the original series of articles on Xities, just republished in MMM Classics #6, a freee download from www.lunar-reclamation.org/mmm—classics

And refer to the articles on this topic in last month's issue.

Desert Oases & Xities "out there"

The Arid, Barren Desert as a metaphor for vacuum or unbreathable atmospheres

by Peter Kokh

Definitions:

Desert: 1 a: arid land with usually sparse vegetation
2 *archaic* **:** a wild uninhabited and uncultivated tract
3: a desolate or forbidding area
Oasis: 1: a fertile or green area in an arid region (desert)

Comparisons: 1. The Desert

By a "desert", we commonly mean a barren and arid expanse of land of rock and sand. But the term is also used to refer to ice sheets that experience negligible annual precipitation and similar ocean expanses where life is sparse.

For our purposes, a desert is an area in which the biosphere life support system is thinner than that in the areas where most people live. Aqueducts, canals, and irrigation may be needed, except along rivers and wadis and where underground aquifers are close to the surface, sporting springs around which life is more abundant: oases.

Thus the desert is a soft analog of the vacuum of space, washing airless worlds like the Moon. It is also an analog of thin and/or unbreathable atmospheres, such as exist on Mars, Titan, and Venus. In other words, the desert is a weak analog of the conditions space frontier settlements will face: a need to provide an oasis of life-support, where not provided by the host environment at large.

Other Similarities

On the Moon, as in the desert, temperature ranges between day and night are exaggerated. Passive technologies to cool living spaces during the day and warm them at night are useful. Structures are designed with shade in mind. Shade walls are more effective away from the equator. Active cooling and heating under these conditions is very energy-consuming, and called for only where energy sources are abundant, as will be the case on the Moon.

On Mars, there is also thermal exaggeration, as without thicker moist air and vegetation, what little heat is gained during the Martian day (and summer) is quickly lost during the night (and winter.) Conserving heat, and banking it for future use will be important technologies. Insulation from the cool, cold, bitter cold and beyond will be essential.

The Xity is better prepared to conserve and moderate thermal flow than smaller outposts and isolated structures or individuals out in mars suits. Mars thin air provides little of the UV protection that is afforded by Earth's atmosphere. A terraformed Mars with vegetation out in the open is unlikely unless a thicker atmosphere is also UV-blocking. But no free oxygen, no ozone.

Comparisons: 1. The Oasis

On Mars, we have the opportunity to place settlements near underground water reserves. Once (and if) ESA's Mars Express MARSIS instrument successfully maps subsurface water sources on the ocher planet, we will have a good idea where we can create Martian Oases.

On the Moon, hydrogen is everywhere in low but retrievable concentrations in the form of protons from the incessant solar wind adhering to the fine particles of the regolith rock-powder blanket. But some types of regolith may prove to have adsorbed more hydrogen (literally, the water maker) than others, the dark, iron-titanium rich ilmenite soils in particular. Some consider the lunar poles the ultimate lunar oases, but while Lunar Prospector findings do indicate these areas as richer in hydrogen (presumably water-ice particles), the abundance may be only three times the concentration as in areas farther from the poles. Given the engineering difficulties of harvesting and refining such resources, and accompanying dangers to personnel in hori-zontally-lit terrain with very long shadows, the gain is low.

The Xity as an Oasis in a Desert

On Earth, oases are to be found in many desert areas. Water is available through rivers on the surface, or just below. Oases come small and quite large, up to many tens of thousands of square miles, the largest being the Okavango Delta in Botswana, in South Africa.

T he oasis is alive and teeming with vegetation and people. The desert is *relatively* dead and empty. But while there is some resemblance to the Xity, a strange entity in a strange land, the partial wall between desert and oasis just dimly prefigures the complete containment-hull we will need on the Moon and elsewhere humans settle. Terrestrial oases and the surrounding deserts are both *within* our biosphere, sharing air, light, energy, and life along the margins. An Oasis may have a richer flora and fauna, but this is given, not something the oasis fathers had to provide.

Out there, the Oasis Effect will be total. Nonetheless, the comparisons are useful. It will be surprising if the pioneers do not borrow many names and terms to fit their situation. In so far as the oasis is fragile, and its environmental sensitivities need to be paid maximum respect, it remains a useful analog of the space frontier xity. **<MMM>**

Polders & the Space Frontier Xity

Farm & Village Polders "Reclaimed" from the Sea as a Metaphor for Xities beyond Earth's Biosphere

by Peter Kokh

Readings from Back Issues:

- MMM #38 SEP '90 pp. 10-13 "POLDERS: a space colony model" by Marcia Buxton, republished in MMM Classics #4, download: www.lunar-reclamation.org/mmm_classics
- MMM #110 NOV. '97, p 3. "RECLAMATION is a Xity's Charter Function" by P. Kokh

Definitions:

Reclamation: 1. The transformation of waste, desert, marshy or other barren and for agricultural or other life-supporting use. **2.** The process of deriving usable materials from apparent waste.

Polder: (Dutch): a tract of low land (in the Netherlands) reclaimed from a body of water (as the sea)

Map of the Netherlands, showing two polders created from the sea in the past century: 1 Northeast Polder, 2 Flevoland 3 Markerwaard (not built). These lands, as many other areas nearby, are below sea-level and protected by dikes, with rain water pumped out by windmills. The Netherlands is a densely populated country. The need for land is critical.

The Zuider Zee was a large body of water in northeastern Holland. It was originally a lake, but heavy flooding joined it to the North Sea. A dike created the southern part, called the Ijsselmeer, where reclaimed land is used for agriculture.

Precursor for the Space Frontier Xity

In several respects, the Polder may be the closest analog and precursor of future xities beyond Earth. They embody a containment wall, the dike, that keeps the life-hostile outer surface environment at bay. The dikes must be vigilantly maintained, lest the insistent sea spill in and flood the low-lying areas that have been reclaimed from the shallow seabed that was there before. In the case of the polder, the pressure is outside and to be resisted and controlled. In the Xity, the pressure is from within, the life-supporting air that would leak outside to be lost forever. In both cases, polder citizens and space frontier xitizens must maintain a high state of vigilance. Survival against what lied without is always at stake.

Inside both are farms and one or more farming villages. The dikes are not for cities, but for farming villages and their farms. In contrast with the sea of water, or the sea of vacuum or unbreathable air outside, both the polder and xity zealously guard their dike/hull protected island of life.

That other symbol of Holland (the area of the Netherlands between the Ijsselmeer and the sea) is the Windmill. This passive, wind-driven pump lifts pooled rainwater and leach-water up over the dike into the sea or sea-feeding streams and canals. The xity will have its radiators, which take excess solar input leaking inside, and dumps it back out into the void above the lunar surface. Airlocks will be designed to minimize oxygen and nitrogen losses through repeated cycling. Loses need to be made up with fresh reserves processed from the dust

Towns in the polders tend to be small. Almere is the biggest, nearing 200,000. The polders were built to increase farmland, not rural settlement. In that respect, too, they prefigure the space xity, which must maintain a high ratio of vegetation to human life in order to be viable long term.

Reclamation

The Dutch, however, have made "reclamation" a national pastime. Nowhere else has the reclamation of wastelands or areas lost to the sea been practiced on such a wide scale, in so determined a way. Keeping the sea out (vacuum or unbreathable atmosphere analog) and plants, animals and humans safe from inundation (analog of decompression) requires both vigilance and a matrix of good habits. The result is human living space where none had existed before. Terms and symbols from dike and polder lore will find there way to the Moon and beyond. **<MMM>**

Mail For MMM

Two much vegetation can be as bad as too little

From Larry J. Friesen 9/08/'05.

I have read your two articles "Xities" and "Outpost vs. Xity, Two Very Different Games and Mindsets, the Implications for Agriculture" in Issue # 187 of MMM. I would like to offer some comments for the correspondence section of MMM. Much of what you write is on target, but with respect, I would like to offer a different point of view on one aspect of the agricultural situation, and try to explain my reasons why.

The tone of both articles seems to be that more [plants] are always better. If that understanding is correct, I respectfully disagree. I believe that it is possible to have too much, even of a good thing.

When I consider mass balances, it seems to me that if you have too many plants, they will produce more oxygen than we and whatever animals we bring along can consume. Even if we find ways to dispose of the extra, and I'm sure we can, too many plants may require more carbon dioxide than we and the other animals in a settlement on the Moon or Mars or an asteroid can provide. Perhaps the deficit will not kill the plants, just slow down their metabolism, but that will negate whatever benefits might have come from having the extra plants on hand.

It is true, as you wrote, that the plant biomass on Earth is many times larger than the human biomass. But remember that on Earth, the plants support an entire ecosystem, with many kinds of organisms, especially animals and fungi, not just humans. Even with our overpopulation today, humans do not make up the majority of Earth's animal biomass.

Furthermore, on Earth, any surpluses of biologically produced chemicals, whether oxygen, carbon dioxide, methane, or whatever, will eventually be recycled by geochemical processes, even if not by biochemical processes, on a sufficiently long time scale. But geochemical processes will no more run by themselves in an extraterrestrial settlement than will the ecosystem.

In a system as large and diverse, and with as many buffer systems as Earth has, we dare to depend on geologic cycles that may take thousands or even millions of years to complete. I don't believe settlers of the Moon or Mars can wait that long.

I think what we want to strive for, in the long term, is a balance. We want to grow enough plants to produce enough oxygen and food for the human colonists and what-ever animals they bring, whether as livestock, as pets, as agricultural assistants (earthworms, for example, to help convert lunar regolith and recycled wastes into fertile soil), or to populate the "middoors" areas, plus supply oxygen for whatever useful fungi the settlers decide to bring. The idea is to produce the right amount of oxygen and consume the right amount of carbon dioxide, at least to first order, and at least over the long term.

As an aside, we may want to think carefully before turning loose too many animals into the "middoors". At least until we have figured out how to insure that, for instance, pigeon or squirrel droppings get recycled through the settlements ecosystem.

I would agree that an agricultural system for a long-term settlement needs to be larger, more diverse, and more robust than is often assumed. But more will not always be better, and it will be possible to have too much, even of green plants.

Sincerely,
Larry J. Friesen

EDITOR'S COMMENT: While it is true that by natural biological cycles, "too many plants may produce more oxygen than we and whatever animals we bring along can consume" and that "too many plants may require more carbon dioxide than we and the other animals in a settlement ... can provide," we are not obliged to rely on natural cycles alone.

Waste biomass can be processed in both biodigesters and compost piles to produce methane. Cf. our article, METHANE MMM #40, November 1990 Reedited and reprinted in MMM Classics #4 pp. 68-69, available in pdf format as a free download from http://www.lunar-reclamation.org/mmm_classics/

In this article, we noted that "Methane is comparatively clean-burning in air (79% N2) so far as Hydrocarbon emissions and Carbon Monoxide are concerned - Nitrogen oxides are still a problem. So if we burn it instead with pure Oxygen stored in a tank just like the Methane, this will give us a Nitrogen-free combustion environment, an engine that exhausts only water steam and Carbon Dioxide needed by vegetation. Nor will that mean too much CO2.

"By taking the pains to produce compost, we are left with a fuel which can be used to run agricultural equipment - at no extra expense - dumping its CO2 rich exhaust into the farm areas right where it is needed. As far as this writer knows, there are no existing engines that burn Methane with tanked Oxygen. However, we will be developing them anyway for Mars applications, as it is the ideal fuel for that environment.

"Such engines could run plowing, tilling, harvesting, processing and drying equipment etc. They could also be used to generate extra heat needed in nightspan. Why not be the first to develop such an engine in your garage?"

In short, we have the means to address any such surpluses that might occur from "too many plants." But my main point is that there is far more danger that we will grow too few plants to support the biosphere, not too many. **<PK>**

Zero-Mass Products & Services as a Major Part of a Lunar Frontier Economy

by Peter Kokh

At the Planetary & Terrestrial Mining Sciences Symposium in Sudbury, Ontario last June, we had the pleasure of meeting Klaus P. Heiss. Our initial misgivings based on his well-known support (on highfrontier.org) of Star Wars Space Defense initiatives, quickly gave way to respect and admiration for his clear brilliance and command of the issues involved in opening up the Moon.

Klaus correctly points out that the Lunar Settlements will not pay their bills (for imports) with material exports to Earth's surface. First, most anything that can be made on the Moon can be made here on Earth - with the rule-proving exception of Helium-3. Transportation costs will make "competing" lunar products anything but competitive, let alone an add on for amortizing the capital equipment needed for their manufacture on the Moon. The frontier will need to concentrate on "Zero-G" massless products. Among these he lists the following:

- **Information:** 40%+ of modern economies are based on information flow, not product flow.
- **Communications**
  C-Band, Ku-Band, LEO-HEO-GEO
  GPS, Navigation
- **Observations**
  Earth Resources, Environment, Weather, Climate
  Solar System, Milky Way, Galaxy
- **Energy: Enabling Resource**
  Solar: Lunar Solar Power Arrays, Solar Power Satellites constructed of lunar materials
  Nuclear: Fission, Fusion, He3

Non-terrestrial markets for lunar physical products

While the importance of massless products as a mainstay of the lunar economy is not disputed, Klaus (and others) overlook(s) the possibility that the main market for physical products made-on-the-Moon will be not current consumers on Earth's surface but those in other off planet markets that will arise during the same time frame as lunar settlements: In low Earth orbit space stations, orbiting manufacturing facilities and laboratories, in orbital tourist facilities and hotels; even the outfitting of space craft meant to ply the space lanes without ever landing on Earth; markets on Mars and its Moons, and out in the asteroids.

For these markets, anything the lunar settlements are able to produce for their own domestic consumption in place of expensive imports from Earth, can be competitively marketed to other concentrations of people in space at a transportation-cost advantage over similar products made on Earth's surface. Building materials, furniture, utility systems, even food products may come under this heading. We simply cannot and must not forget that the lunar settlements will not develop in a vacuum!

Additional Categories of Zero-Mass products & Services

In addition to those listed by Klaus, we feel the following product & service sectors will play a major role in the buildup of the lunar economy.

Virtual Tourism: Teleoperable rovers can provide backgrounds for movies, electronic games, racing, and plain tele-exploring. The user on Earth will pay for the use of the equipment on the Moon to pursue his/her interests and curiosities. There will be major advances in Virtual Reality technologies to support this.

Virtual Employment: Persons on Earth will take care of the many paperwork and bureaucratic tasks for lunar settlements, including tech support, analysis, and even teaching, freeing pioneers on the Moon for those duties that cannot be tele-outsourced and which more directly support the production of products for export.

Real Tourism: the first lunar tourists will simply swing around the Moon without landing. This will be followed by self-contained landing excursions. Next will come landers visiting modest surface facilities, supporting short overland excursions. As settlements arise, income from tourists from Earth will rise significantly, as costs fall.

Archiving: Lunar lavatubes, those intact have been intact for 3.8 billion years, are the most ideal locations in our solar system for archiving anything we want to outlast our own current civilization. The cost of archiving records and historical artifacts, genetic materials, samples of flora and fauna from around the world, paleontological fossils, and other "Ark" services, etc. will be worth it as there is no comparable alternative. The lavatubes provide vacuum, controlled low temperatures, dust-free environment, virtually no maintenance costs. Placement could be done robotically or tele-robotically, as could retrieval. In addition to public records, personal memories and memorabilia and time capsules could be so preserved for billions of years to come.

Technology Licenses: Lunar settlements will develop biospheric know-how and methods because they have to. This know how will not be developed on Earth because we are not "under a similar gun." But once created, this know how along with other technologies developed on the Moon, will be a zero-G export category of significance. Lunans will develop new materials (e.g. glass composites), new alloys (making do with alloy ingredients available on the Moon - along paths unexplored on Earth), new production methods, etc. - all because they must: many materials used on Earth cannot be produced on the Moon, and methods used on Earth cannot be used on the Moon.

In short, those who can see no economic future for lunar settlements exhibit a major lack of imagination. The opportunities for making money on the Moon are abundant, and I am sure that those listed above will be proven to have just scratched the surface. **<MMM>**

Carved Basalt

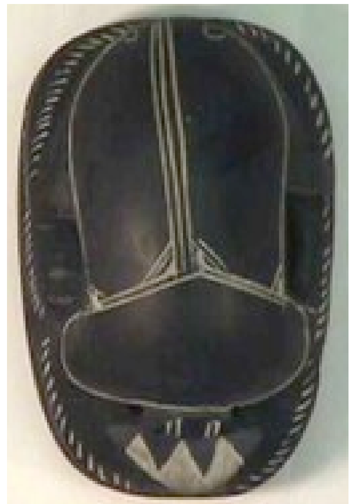
by Peter Kokh

In a number of past articles through the years, we have talked about art forms that might be available for Lunan Pioneers, supportable by materials processed locally on the Moon. The Moon will not be a source of granite, marble, soapstone, sandstone or other materials favored through the ages by sculptors on Earth. Without an economical source of copper, brass, bronze, and pewter will not be available media. But Lunan sculptors, we noted, could work with concrete, glass, and various metals. *Art du Jour* temporary sculptures could be created by children from various garden stuffs. More recently, we introduced AAC, autoclaved aerated concrete, as a possible medium.

All this time we were ignoring an obvious sculpting material abundant on the Moon: basalt. Basalt has been carved into objects small and large throughout the ages by many peoples. Basalt carving continues today, with newer tools such as titanium tipped chisels and various abrasives. Now we had indeed written about "cast basalt" as a hard durable material that could be shaped into all sorts of useful and decorative items. But casting and carving are two different things.

The lunar maria or seas consist of congealed lava flows: basalt. But all available surface basalt has been pre-pulverized to several meters down by repeated meteoritic bombardment. That is why the use of basalt as as a carving material never occurred to us; we thought only of casting it.

But significant quantities of non-pulverized, non-fragmented basalt should be available for quarrying from the walls of the numerous lava tubes to be found below the surfaces of the various maria. Lavatubes are a natural feature formed by the way the lava sheets flowed across the lunar surface, filling the major nearside impact basins



We did a Google search on carved basalt and on basalt carving methods and tools. This is indeed a promising medium for future pioneers, one that will yield many decorative objects for frontier homesteads.

Perhaps more importantly, carved lunar basalt items could become a significant source of export income for the settlements.

To see for ourselves what promise this material holds, we ordered a 3" Scarab of basalt carved in Egypt, for about $30 plus shipping. This item will be on display at the next Lunar Reclamation Society Meeting October 8th. **<•>**

MMM #189 - OCT 2005

Cooking on the Moon

This may seem to be a trivial topic at first. But to most of us, when the day is done, and we are tired out and in need of serious regeneration, "what's for dinner?" trumps "what happened on the stock market,today" anytime. And we also want to be assured that what's-for-dinner is flavorful, palate-pampering. Some pleasures are essential, after all! *See the Article Below!*

COOKING on the Moon

by Peter Kokh

We, all of us (or those of us who get beyond boiling water and making toast), have our preferred ways of food preparation and cooking, ways that suit our individual personalities and lifestyles. Some of us happily take hours to prepare great dishes from scratch, micromanaging every ingredient, patiently going through all the steps in proper sequence, mastering all the tricks of the trade. We are would be candidates for Iron Chef. Others, like myself, want our robust flavors the quick and easy way: just add a can of tomato or cream of mushroom soup, put it in the oven at 350° for an hour and a half, and viola!

Some like to simmer or smother. Others to bake or broil. And then there are those who insist on (egads!) frying as the only way to get that down home deep southern taste!

Will the lunar frontier be so forgiving an environment, letting each of us indulge our preferred cooking habits and methods? The short answer is "maybe someday, but not in the foreseeable future!"

In the beginning – ingredients and recipe starters

What the program managers for the first NASA lunar outpost will order to be shipped to the Moon is one thing. Waht makes sense, may or may not be something else. Here, we take the viewpoint of what practices are sustainable, that is, once we realize that we are back on the Moon indefinitely, with an open-ended future. Here are the premises from which we argue:

It costs much less to send dry and dehydrated food stuffs and ingredients (spices, herbs, recipe starters, etc.) than to send fresh, frozen, or canned items.

It makes sense to ship to the Moon, only those things that can eventually be provided from lunar gardens - why get the pioneers spoiled?

Variety if the spice of life. At whatever reasonable cost, lunar cooks and chefs need a staple of versatile ingredients with which to prepare a wide variety of tasty meals from a minimum of ingredients. So those spices and those plants that support the most diversified cuisines will have priority.

Shipping prepared items will probably be out. Most of them may not dehydrate well. That means no canned and bottled condiments, soups, broths, sauces, for cooking, no dressings for salads. And forget about TV dinners! Now dehydrated meals, of the kind available in camping supply stores, may be tapped for early missions, but are not likely to be selected as a regular import. When push comes to shove, the ingredients supporting the most versatile cuisines, are the likeliest to get a ticket.

Growing herb and spice plants in frontier gardens will have some deserved priority. Settlement self-sufficiency is the Holy Grail, after all. But clearly, priorities will be set: those plants easiest to grow *and supporting the most diversified use* will be the first to be cultivated. So if you, as a lunar chef or cook, want an herb or spice that is only of limited use and/or is hard to grow - forget it!

Homestead Gardens to the Rescue

Whatever strictures may apply to settlement-owned and operated farms and gardens, what individual lunar homesteaders choose to grow, produce, and pre-prepare in their own garden spaces (assuming that lunar homesteads are built to include these, a very wise policy) is pretty much up to them. Homegrown food item specialties not otherwise available will be a major wellspring of Cottage Industry. Settlement markets supplied by homestead gardeners, will offer prepared sauces, soups, jams, and special combinations of herbs and spices, prepared condiments, salad dressings, garden juices (á la V-8) and even wines are sure to appear.

The insatiable needs of the cook, as well as of the home furnisher will be primary fuel for private enterprises springing up, at first, as spare time, after work hours activities. Out of such beginnings will the first real businesses not devoted entirely to production of capital goods and export products develop.

What herbs and spices and other recipe starters are selected for import from Earth are most likely to come in bulk, and that is how the lunar cook/home shopper will find them available. No handy (and exorbitantly overpriced) small bottles and shakers! Just transport yourself back a century or so, to the days of the old General Store, and you will get the idea.

Salad Stuffs, vegetables,and fruit from the Garden

Our experimental space agriculture efforts to date have centered on a few staples: potatoes, wheat, rice, lettuce, etc. All of these go a long way to supporting many kinds of preparation and presentation, so they are apt choices to begin with. But fast forward to a decade after the first permanent outpost has begun in earnest to grow into a civilian pioneering hamlet. Those managing the commu-nity gardens will want to start with crops that are easily grown and versatile in their uses.

On the other hand, those preparing meals will be just as concerned with full flavor and gusto, with interest to the palate. They will have their wish list: onions, tomatoes, garlic, and on and on. Not to forget coffee, my personal drug of choice. "Easy to grow" be dammed! Again, the cottage gardener to the rescuer. The community gardens manager need not worry about coffee. Coffee will come!

Fortunately, many fruit trees have now been bred in fruit-laden dwarf varieties, just right for the tight, low indoor ceiling spaces of settlement gardens. A plus is that many fruit tree woods, notably apple, cherry, and pear, produce excellent hard woods, great for carving.

In the past two decades, we in America have been introduced to, and have begun to take for granted, a host of tropical fruits: kiwi, starfruit, etc. The settlement gardens may at first provide only a temperate climate suitable for growing traditional species. As the settlement expands, separate climate-controlled garden farms will be able to raise tropical varieties as well.

In short, we'll start with a few versatile staples. But in time, *as the population and total demand grows,* the specialty food items will appear. In the beginning there will be nutritious food - say your "grace" and "thanks." After all, what is a frontier if it does not start off *"rough."* But once a critical mass of industry can support accelerated growth and a steadier, larger influx of new settlers, the frontier, as all frontiers before it, will begin to show some "sophistication" and one place it will show up first is the dinner table.

Humans are Omnivores – grains & veggies *plus*

Some of us are vegetarians. We've either been raised that way or have chosen that as a lifestyle, whether because it suits our tongues or our philosophies.

The rest of us (most of us) are still meat eaters. Forgive me if I take what may seem to be a cheap shot here, but it occurs to me that in nature, it is the carnivores and omnivores that are the most intelligent, and the herbivores which are the most, well, *you pick the word.*

But this is not about philosophies. This is about what can and cannot be supported on the early frontier.

Raising "meat" for want of a better word, requires more acreage, devoted to forage and feed for livestock, than does growing vegetables and grains. It is a less efficient form of agriculture, if you will, and there have been, and will be, situations where that is *the* single most important consideration. The early decade(s) of the space settlement frontiers are likely to fit that mold. We won't be raising livestock.

Dehydrated meats anyone! There is always beef jerky and faux bacon bits. And don't forget soy-based veggie burgers. (Most of those commercially available are anything but tasty. However, I've found some that pass my taste buss.) Meat available in dehydrated form is likely to be available for a garnish, rather than as an entree - in casseroles and salads, if you will. Fortunately for myself, I like casseroles. Some refuse to try them (again.)

What about a decade or two down the line? Some livestock are more efficient to raise than others. Foremost amount these would seem to be the Cavy, a mainstay of Peruvian cuisine (known to us as the Guinea Pig); then the rabbit, then the chicken. Pigs (ham and pork) will beat out the cow (beef).

But don't forget fish! Some species, especially Talapia, grow very will in greenhouse-based water recycling systems, and that makes them a shoo-in for number one non-vegetarian food stuff item on the early frontier.

If and when we start mastering growing individual meat tissues in vats (meat "without the face") with far greater efficiencies than farm-raised animals, meat will begin to resume its customary place of honor on the settlement dinner plate.

And then man discovered fire ...

It is no secret that male cooks prefer gas stoves to electric ones - we want the instant gratification of real fire on demand. Unfortunately, fire produces byproducts. In the ordinary anything-but-airtight home, these gases are not a big problem (though children in homes with gas ranges suffer twice the incidence of respiratory problems). On the space frontier, with absolutely airtight spaces, combustion byproducts will be an absolute "no no."

But there are other culprits, which again is no problem in most leaky homes, but which could be most troublesome on the frontier: humidity (steam vapors) and grease/oil aerosols. We can't just turn on the range hood ventilator to dump these culprits "outside." That would throw out precious air with its contents, the baby with the bath water, as the saying goes.

What does that mean? It means that a lot os us, should we be so lucky as to have the chance to pioneer the Moon, are going to have to change our favored ways of cooking. *Here is the bad news, as we see it.*

- no open boiling (putting a lid on it won't do)
- no open flame cooking (forget about BBQs!)
- no frying *!!!*

Are there any perfect solutions? Not sure. Some people like microwaves: except for reheating leftovers, I personally hate them. Something old timers will remember may be a better choice: **the pressure cooker**. This device controls and minimizes steam and vapor escape, and by cooking the contents under pressure, is much faster and more flavor-enhancing than oves or stovetop methods, and *not that much slower* than a microwave.

Smothering is a better solution than frying, as is baking and broiling.

To be fair and honest, **this is all excellent material for a small group or chapter project:**

Study all forms of cooking and rank them according to least production of gasses, steam humidity, aerosol grease vapors, and nuissance odors.

For our assumptions above should not be repeated as gospel. They seem reasonable, but must be put to the test.

Ingenuity is not to be discouraged

Frontier entrepreneurs (read restauranteurs) will find a way. (And, yes, you "smell" a future Article)

Relevant Reads from MMM's Past

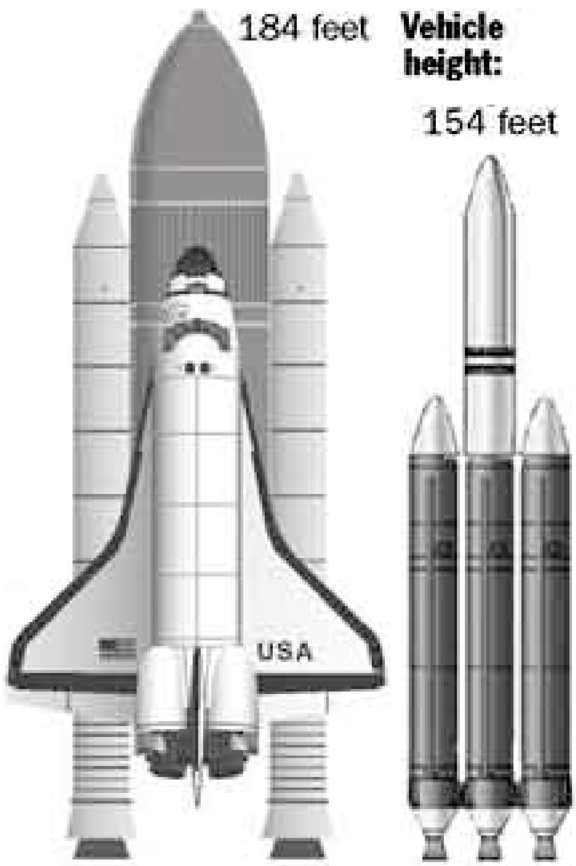
- #2 FEB '87 "**Moon Garden**" reprinted in MMM Classic #1* | * pdf file from www.lunar-reclamation.org/mmm_classics/
- #39 OCT '90, p3 "**Saving Money on Food in Space**"
- #148 SEPT. 2001 p 3. **EARTHPATCH: Anchoring Lunar & Martian Homesteads**
- #149 OCT. 2001 p 5. **Homestead Gardens & Early Cottage Industry**
- #165 MAY 03 p 3. **Settlement Garden Tours Favorite Pastime**

What Asteroids Look Like, *Really!*

The dream destination of many a space enthusiast is neither the Moon nor Mars, but some place out in the wild and woolly Asteroid Belt, the ultimate boondocks where indivduals can be who they want to be, or so goes the lore. We've all seen pictures of Gaspra and Ida and Eros and a few others, but the details of Itokawa blow the mind:

http://www.isas.jaxa.jp/e/snews/2005/1102.shtml

Industrializing the Moon with Delta 4s: Recasting the "High Frontier" Vision



By David A. Dietzler

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http://www.moonminer.com/Conquering-Moon-D4.html

The High Frontier Revisited

In 1976 Gerard K. O'Neill and others created The High Frontier and the prospect of space colonization to generate energy for Earth with solar power satellites. The original plan involved spending about $250 billion over ten years to place 3000 to 20,000 tons on the lunar surface with Shuttle derived heavy launchers that could place 80 or more tons in LEO. Today, such rockets do not exist, but the job can still be done. The Delta 4 is our most powerful ELV.

Imagine 100 Delta 4 heavy launches and 2500 tons of payload to LEO at 185 km. Or they might be launched from Korou, French Guiana to achieve a somewhat higher orbit that will not decay as fast that and which also has a more favorable orbital plane for launch from LEO to the Moon. If we have NEP {Nuclear Electric Power] tugs with 10,000 second specific impulse drives and vapor core+MHD power plants that generate at least 1 kWe/kg. that amass 20 tons we find that only 1.9 tons of propellant is needed to get to low lunar orbit with a 25 ton payload.

Exhaust velocity of ion tugs = 10,000*0.0098=98 kps

Since about 4 kps needed for Earth escape and braking into LLO, mass ratio = e(4/98) =1.04166 Propellant mass = 1.04166*45=46.8747 46.8747-45»1.9 tons

Since the tugs have to return to LEO we must factor in the reaction mass for this.

1.04166*20=20.8332»20.85 850 kg. of reaction mass for return to LEO. Less would be needed if aero braking is used. As this increases the Moon bound mass we find:

(25+20.85)*1.04166=47.76 A total of roughly 2.75 tons of reaction mass is needed per roundtrip. A total of 275 tons of reaction mass is needed.

If robotic ice miners and landers that use NTR and water in Kevlar bags for a high mass ratio are used no fuel for landers must be up-ported to the Moon. The O'Neill team did not know of this water resource on the Moon, although they suspected it. There is still some controversy regarding the ice, but let's be optimistic.

The ice miners might amass two tons each like a large automobile and the landers no more than 20 tons each. If we use five miners capable of pumping their water loads into the landers and two landers we have a total of 50 tons. To land this with NTR using water for reaction mass and an Isp of 400 seconds:

NTR exhaust velocity = 400*0.0098= 3.92 kps

Since 1.6 kps is needed to land from LLO, mass ratio = e(1.6/3.92) = 1.5

Propellant mass = 50*1.5=75 thus 25 tons of reaction mass needed

This must be sent to LEO and then by ion tug to lunar orbit. Water will not boil off during the multi-month voyage. Five ice miners + two landers + landing propellant = 75 tons. About nine tons of ion propellant brings us up to 84 tons. We might need some teleoperated orbital devices for transferring propellant and assembling the payloads, so let's estimate 125 tons for this ice mining 'bots and "nuclear steam" landers system to LEO.

We could land 2000 tons of industrial payload on the Moon, cannibalize cargo modules and Delta 4 upper stages, and even land the tugs to convert them to power plants on the lunar surface.

2500 (100 Delta 4 payloads to LEO) - 100(five tugs) -275(ion propellant) = 2125 tons payload lunar

2125 -125 (miners+landers, etc.) = 2000 tons to lunar surface .

The Costs

At $170 million (1999 dollars) per Delta 4 launch this would cost $17 billion, a drop in the bucket. The payload would consist largely of power supplies, stereo lithographic machines and metal extraction devices. This payload would multiply its own mass many, many times over as the years tick by. To get humans to the Moon we would use something like the Artemis Project system. Human crews would be minimal at first and robots will be primary.

Comparisons: Shuttle weighs almost 3 times as much as the SSME-powered Delta 4 but can lift only 18 tons to the Station in comparison to Delta 4's 24 , despite the Shuttle's greater thrust. Boeing's Delta 4, with aq 20 year history is now the workhorse of the U.S. fleet..

Since the tugs could be landed on the Moon and converted to power plants we get another 100 tons although it may be argued that the tugs might be putto better use if left in space for future cargo hauling. Occasional refueling with uranium or thorium would be required. The 50 tons of mining 'bots and landers should also be considered to be lunar cargo, so we've actually got 2050 tons to the Moon and some space transit infrastructure in the form of the NEP tugs. Also, we would get 100 Delta 4 upper stages amassing 3.5 metric tons each for a total of 350 tons of metal ready to be worked into various parts. These upper stages are 5m (16') wide and 12m (40') long. They would make excellent orbital fuel depot storage tanks for fueling up high thrust manned ships and habitat modules on the lunar surface. 2050 +100 (tugs)+350 (upper stages)=2500 tons of useful cargo (ignoring those teleoperated devices for transferring propellant to landers). That works out to about $3400 per pound. Not counting the tugs and upper stages, about $4150 per pound.

Astrodynamics Wizards Wanted

The Mark Maxwell ice tanker consists of a Kevlar bladder filled with water and a NTR engine. It would operate in conjunction with robotic ice miners to land payloads on the Moon that were lofted to LEO by Delta 4 rockets and transported too LLO by NEP tugs. It could also move water to L1 where it is loaded in aero braking modules and shot down to LEO depots when we have a station at L1 capable of splitting water into hydrogen and oxygen. This would be faster than using ion drives, and time is often money. It only takes 3150 m/s to go from LEO to L1. Locating a station at L1 should be more efficient than going from LEO to LLO. A minimum energy ellipse from L1 to the lunar surface and vice versa requires a delta V of about 2.3 kps and 70 hours. This would put payloads on the far side of the Moon. If we send payloads from L1 to LLO and then retro down from LLO to the near side surface about the same amount of energy is required. We could also travel directly to the near side from L1 in an almost straight line but this will require more energy. Since the Mark Maxwell ice tanker may have a very high mass ratio and 400 seconds or more specific impulse it might do the job. This gives mission designers and mathematicians plenty to think about if they are looking for something to work on!

Those who are knowledgeable might also point out that I have treated maneuvers with ion drives as if they were impulsive delta Vs and the actual astrodynamics are more complex. Perhaps twice as much propellant for ion drives or about 550 tons will be needed! I'm not asking anybody to clean up my mess, I'm just trying to spur some thought out there! I don't have the mathematical prowess or computer programs to make low thrust long duration trajectory calculations but one can estimate that twice as much delta V is needed as an impulsive thrust delta V and that roughly doubles propellant mass requirements with the mass ratios we are looking at here.

Then and Now

Many technologies exist today that did not exist in 1976. Computers and robotics have exceeded the expectations of the most optimistic speculators and they will continue their relentless progress so that by the time we actually commit to a space colonization program we will have some really capable AI [artificial intelligence] robots for work in space. By using AI robots we could avoid the expense of building Bernal Spheres for 10,000 people.

T.A. Heppenheimer thought that magazines would be faxed to high orbit and Xerox copies would be distributed amongst space colonists. He didn't foresee the internet, laptops, PDAs or DVD players, at least not publicly! In 1976 that was science fiction!

The relatively simple FFC process for extracting titanium for titanium dioxide did not exist back then. The early NASA studies looked at the laborious Kroll process for refining titanium in space.

The Delta 4, Atlas 5 and Titan 4 did not exist almost thirty years ago and everyone expected reusable Shuttles to be cheaper than evolved expendable rockets such as the previous three mentioned. The vapor core reactor with MHD which can get 1 kWe per kg. of system mass or better like that which is being developed at the University of Florida's Innovative Nuclear Space Power Institute did not exist either. In the seventies the best space nuclear power systems could get about 100 kWe from four tons of mass or about 1kWe per 40 kg. with almost 20 times as much power wasted as reject heat!

More technological breakthroughs are certain to come in time for a space colonization, industrialization and energy program. We might even see the use of

- artificial spider silk from GMOs which has five times the tensile strength of steel, and
- C60 nanofiber based materials, as well as
- AI computers with nanocircuitry.
- We might make use of gallium-indium-nitride solar panels that are 70% efficient and high temperature 77° K superconductors.
- Stereo lithography and laser additive manufacturing are far more advanced today and it will be possible to make molds from basalt for casting aluminum and magnesium as well as make
- parts directly from powdered titanium. In the free vacuum it should be easy to make powdered metals by evaporation of molten metals.

Build lunar mass drivers out of local materials

We will not ship mass drivers up to the Moon in finished parts. We will build them from local resources. The equipment sent to the Moon will consist mostly of

- power supplies,
- regolith refining devices like magma electrolysis furnaces,

fluidized beds that use hydrogen to reduce ilmenite,

- magnetic separators,
- centrifugal grinders that need no abrasive wheels or grit that wears down with heavy use,
- Sabatier reactors and related gear to recycle carbon from CO gas formed during smelting,
- sulfuric acid makers,
- robotic mining shovels,

s• tereo lithographic and

- laser additive manufacturing devices.

Integrated modules might receive Moon dust on one end while iron, titanium and ceramics come out the other end. Other modules will have inputs of metals and parts as output. We will make everything we can on the Moon from aluminum mass driver coils and titanium bracings, ceramic bricks for smelting furnaces, LOX tanks, molds and glass-glass composite materials to vehicles and volatiles/helium three mining machines.

Smart robots with teleoperated assistance from Earth and small crews on the Moon will assemble everything. We will even make habitat modules from local resources of iron and titanium. We will ship seeds to the Moon and grow crops in lunar soil fertilized with N, P and K mined on the Moon to create a food supply for future crews. The original 2000 tons of machinery will create more machinery and grow into a multimillion ton industrial base on the Moon like a tiny seed growing to become a mighty oak tree. This will take a lot of ingenuity, sophisticated software and human brainpower, but I am confident.

Justifying the Cost

Spending $17 billion to launch 100 Delta 4 rockets is not exorbitant. That's about the cost of eight new nuclear power plants. The actual cost of the program will be much higher when we include the cost of developing all the robots, ion tugs and ground support and operations centers. Operations centers will be located around the world and linked by cable and satellites. Sophisticated software will be needed to make everything work. We will also need remote control technicians to drive the robots on the Moon and operate the mining shovels. The young generation of video game enthusiasts will provide plenty of human talent for this. Global ground control centers will make it possible for daytime crews on Earth to operate the lunar machines 24 hours a day without forcing anyone to work the graveyard shift. The total cost of the program will be several hundred billion dollars with launch costs being a minor fraction, even at $3400 to $4150 a pound!

The cost is justified because the benefits will be clean solar energy from space and helium 3 fusion fuel with tourism and astronomical observatories coming later as icing on the cake. Let's consider the price of nuclear fission. Today it costs about $2 billion to build a nuclear power plant generating 1000 to 1500 MWe. In 2050 based on projected rates of growth we will need 53 TW of power. Even at this level of production half the world's people will have about as much energy as Mexicans do today and the other half about as much as Europeans. To generate 53 TW with fission we'd need about 50,000 power plants rated at 1 GWe each and this would cost $100 trillion! Even if we get about 20% of our power from winds, biomass, some fossil fuels, hydro and other sources we will still need 40,000 nuclear power plants.

If the efficiency of these plants is increased by co-generation (also called combined heat and power) from a typical 35% to 70% we will need 20,000 nukes at a price in today's dollars of $40 trillion! Add the costs of waste reprocessing, waste disposal, increased global security costs to prevent nuclear proliferation and nuclear terrorism and accidents to the picture and nuclear power becomes a costly way to defeat global warming and provide energy to the world. Space solar power will be much less expensive once we are tapping resources from the Moon instead of launching them from Earth. The program could be an international govern-ment-private corporate partnership. Preferably, the govern-ment role would be minimal or the project will become another pork barrel that politicians use to create jobs for their constituents and business for their corporate suppor-ters. Perhaps government should limit its role to tax credits, awards, subsidies and defense contracts.

Finally, it is apparent that nuclear fission is the only non-carbon emitting energy source today that can be used for large scale reliable power generation, but the cost is outrageous even compared to space travel. For a few hundred billion dollars we can industrialize the Moon, build some powersats and start selling electricity. Reinvestment of profits will pay for the construction of more powersats and the initial investment will grow. Stocks sold to finance the project will increase in value. The economics of space solar power are far superior to nuclear power, despite the cost of rocket launches which tends to scare people off. The hostility of the space environment is no great threat to robots. Putting humans in space is a challenge but we've learned how to do this with years of experience on the Russian Mir and now the ISS. Supplying humans in LEO, GEO and on the Moon will be far easier than keeping humans alive during three year missions to Mars. We might even develop LUNOX augmented nuclear thermal rockets that can reach the Moon in 24 hours.

These could be launched atop Delta 4s which have a five meter diameter payload capacity or made from converted Delta upper stages. Some nuclear power will be needed in space but the risks presented by this will be miniscule compared to 20,000 nuclear power plants on Earth. Unimaginative corporate and political leaders might scoff at space power and advocate nuclear fission. That could be the greatest obstacle to the development of the High Frontier•

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CO-OPs as Enterprise Accelerators:

Homestead Garden-based and other Cottage Industry Cooperatives will take Early Lunar Frontier Enterprise "Prime Time"

by Peter Kokh

The Early Frontier Situation:

How do we progress from an early frontier settlement in which all arrivals have been recruited for full time production work in mining, processing, manufacturing, and other essential industries aimed at maximizing exports and minimizing the need for imports? When, and how will the settlement reach that stage where the first self-employed pioneers can successfully launch their own businesses? How do we get from a company town, hopefully a multi-company town, to what looks like a normal civilian settlement with a truly diversified economy?

The situation in the early frontier will be that every able person has a regular "day job" as an employee. Will some just "quit their day jobs" and set out on their own to make a living serving the pioneer consumer market? That is possible, but daring without a heap of capital and a hefty savings cushion. A far more likely "fail-safe" route is that talented and motivated pioneers will take the first steps in their free time, after/before work and on weekends, in their own homes, not quitting their day jobs "just yet."

Built-in Launchpads for Cottage Industry Enterprises

If the launching and development of private enterprises is something to be desired, the settlement Fathers could guarantee a favorable climate by "engineering into" the settlement system and both its legal and physical infrastructure a number of critical built-in features that would encourage and nourish "Cottage Industry" activities of many types, creating a favorable climate. Our pick of these built-in features follows.

a) Enterprise Seeds: Overtime Exemptions

Company employees wanting to attempt launching a cottage industry activity would apply for a limited time exemption from any mandatory overtime requirements: say six months. Near the end of this term, if the entrepreneurial activity had not been abandoned and was showing promise, an extension could be requested and granted. A non-company review board would hear the request and approvals would be binding on the applicant's employer. Without some protection of an employees "free time," the entrepreneurial climate would be severely handicapped.

b) Enterprise Seeds: "Greathome" Spare Spaces

Most of us might expect pioneer homes to be small and cramped, a carryover from space station and early outpost *sardine can living.* Way back in MMM #75, May '94, we introduced the "Great Home" concept.

Size of Lunar Homes - the "Great Home" Concept

We must resolutely and brazenly set aside the notion that lunar settlers shall be forever condemned to endure life in cramped quarters. As long as pre-built shelter must be brought in from Earth, weight limits will work to keep pressurized space at a high premium. ....

But once simply and cheaply and easily manufactured housing modules have been designed that incorporate local lunar materials almost exclusively, valid reasons for pioneers to continue accepting constrictive personal quarters evaporate.

If it can be achieved within the labor and productivity budgets of the settlement, there is no reason why lunar settlers should not request and receive homes that are spacious by American standards. Indeed, *there are good reasons to err in the opposite direction.* First, considering that lunar shelter must be overburdened with 2-4 meters of radiation-absorbing soil, and that vacuum surrounds the home, expansion at a later date will be considerably more expensive and difficult than routine expansion of terrestrial homes. Better to start with "all the house a family might ever need", and grow into it slowly, than to start with initial needs and then add on repeatedly.

Extra rooms can, of course, be blocked off so as not to be a dark empty presence. But they can also be rented out to individuals and others not yet ready for their own home, or waiting for one to be built.

Even more sensible is the suggestion that the extra space will come in handy for cottage industry in its early stages, before the new enterprise is established, matured, and doing enough business to be moved into quarters of its own. At the outset, with every available hand employed in export production, the demand for consumer goods, furnishings, occasional wear, arts and crafts, etc. will *have to* be met in after-hours spare time at-home "cottage industry". The lunar "Great Home" could meet this need elegantly

c) Enterprise Seeds: Homestead Gardens

The Moon, outside the airlock, will always be a harsh, hostile, unforgiving environment. More to the point, it will always be barren of life as we are used to seeing it outdoors. We have to bring the green lawns and gardens inside, if we are to have them and enjoy them at all. Those of us who enjoy living in detached single family homes enjoy outdoor greenspaces as an integral part of our property. On the Moon, such a welcome benefit must be provided indoors with built in garden space. We've talked about this many times, most recently in the article "Earthpatch" in MMM #148, Sep. '01. We followed up in the next issue, #149, Oct. '01, p. 5, "Homestead Gardens & Early Cottage Industry."

Many Hurdles Facing Cottage Industries

To develop a home-based enterprise, one must find affordable sources for tools, equipment, and needed raw materials: seeds,seedlings, fertilizer for the gardener; clay for the potterer, etc. One must find appropriate packaging and labeling materials, and most importantly, markets. This all takes time and effort difficult to spare from the daily attention demands of the cottage industry activity itself. It becomes instantly clear that with out a supporting network of related industries, starting an enterprise becomes a losing proposition. Enter the co-op.

Co-ops Combine the Forces of Many Sparetimers

If our would-be home garden entrepreneur forms a cooperative association with others attempting to do the same thing, they can then combine purchasing power, and marketing resources. Taking our Home Garden example, the co-op can find seed and seedling sources, tools, fertilizers, pest control, and other business needs such as pots and other containers, labels, etc. Members can share advice and experience and tricks of the trade. Legal advice and insurance is another area best handled on a shared basis.

A Home Garden Co-op can find space to market the products of the individual members. Manning market outlets would be shared, with all members contributing a few hours. Coop markets could start as weekend enterprises, and expand hours as success and demand warrant. In this fashion, a number of spare-time entrepreneurs can launch a whole cottage industry sector even in a young settlement , without anyone involved on a full-time basis. With time-share management, minding the store and other duties become onerous to no one.

The Co-op can encourage friendly rivalry: development of improved and diversified products, more convenient packaging, and expansion of the consumer market.

In finding and developing a network of suppliers, the co-op encourages the rise of complementary industries. It all knits together. Support industries will include:

- containers
- labels
- canning supplies
- dehydration
- and more

Through home garden co-ops, pioneer consumers will find many new products:

- canned & foods: jams, jellies, soups & sauces, condiments
- seeds, seedlings
- cut flowers
- composting services
- fertilizers, mulch
- dyestuffs
- floral arrangements
- craft papers
- paper craft items
- wood items
- carved wood jewelry
- medicinals
- herbs & spices
- recipes, cookbooks
- cooking demonstrations

Online co-op markets are another way individual gardeners can work together to develop more business. For the individual consumer, the co-op market will make finding what they want so much easier - "one-stop shopping."

Streetside Garden Co-op markets could also host cafes & restaurants featuring their products and produce, as an unbeatable way to hook customers on their goods.

From Food to Fabrics: a Home Garment Industry Co-op

While it may be possible to grow cotton and other fiber producing plants in the home garden, the quantities needed render fiber production at home a most unlikely endeavor. However, using not the Earthpatch Garden space, but other spare space in the Great Home, individuals can get into the fabric and garment industry on a cottage industry basis. They can purchase bolts of fabric and/or standard issue garments for alterating from the settlement farm mill, as a basis for a number of Cottage Garment Industries.

The settlement fabric mill, a subsidiary of the settlement agricultural farms, in addition to production of a basic selection of fabrics available in bolts, will likely produce a line of basic standard issue products: underwear, shirts, blouses, pants and slacks, etc. In the interests of efficient productivity, a minimum of variety will be offered. both in garment designs and in fabric bolt colors and patterns. And that leaves the door wide open to follow-on entrepreneurs.

In addition to creating custom garments of their own design from available bolts, individuals can purchase standard garments in quantity at a discount for alteration either on request or on speculation re-tailoring them, dying them, adding appliqués and adornments, etc. A Co-op for home fashion creators would help improve output, profit, and variety. The co-op could purchase equipment and supplies at a discount for the benefit of its members. It could run Co-op consignment fashion outlets, both physical and online. Again, friendly rivalry would work to create more variety and better quality all for the consumer's benefit.

A Home garment industry co-op could run a fabric and garment dying operation much more efficiently, as it would do so on a full time basis, using equipment and raw materials more efficiently. A sewing machine repair person would be a complementary addition.

fabric and garment dyeing might well be one of a number of "controlled activities" because of the load it may place on the settlement water-recycling system. A co-op facility would be able to pretreat the effluent dye-containing drain water before dispensing it into the settlement's drainage network.

The Co-o's dying facility would purchase equipment sufficient to meet member demand, and work with members to schedule facility usage. It might also keep some equipment free for usage by individuals who need such services rarely and are not co-op members.

A Home Garden Co-op Consignment Outlet could, in addition to a variety of custom garments and apparel accessories, offer materials, equipment and patterns, for the fabric hobbyist wishing to make things for use around the home or as gifts, well short of plunging into a cottage industry business. Fabric and garment scraps would be for sale for turning into artifact creations from rag-rugs to rag-dolls and more.

A Woodworking Co-op

In general, it will be imperative for the settlement's success to recycle all biosphere-derived materials. All waste biomass will be recycled. Food, reprocessed by the digestive system will be further decomposed in the settle-ment sewage works back into water, carbon dioxide and soil amendments to reenter the biosphere food-growing cycle. Because wood incorporates rare hydrogen, carbon, and nitrogen, withdrawal of wood for use in construction, making of paper, and other uses for which substitutes can be found, will be discouraged by heavy "withdrawal" taxes.

This will make wood a precious item on a par with jewelry stuffs. In furniture, we are likely to see high end metal case goods (dressers, cabinets, etc.) sport wood handles - just he opposite of our common practice. Wood jewelry will be highly valued. And as it happens, common orchard fruit tree woods are hard, and make fine carving woods: apple, pear, and, of course, cherry.

So we are likely to see cottage industries based on premium wood use. A home-based wood adornment industry could benefit from a Co-op's purchasing power of equipment and supplies, as well as co-op maintained workshops outfitted with extra-expensive seldom used or needed equipment. It could maintain a wood craft and wood jewelry consignment store, both streetside and online.

A Custom Home Furnishings Co-op

In the section above about Home Garment cottage industries, we mentioned our expectation that the settlement fabric mills would of necessity concentrate on a bare minimum of standard issue garments, leaving to entrepreneurs their further customization as well as the creation from scratch of a great variety of apparel items and accessories. We expect that the same will be true of the settlement furniture factories. "You will be able to buy whatever you want so long as it is the one model and color we produce." "Issue" furniture, however, will be designed to be post-manufacture customization friendly. And that opens the door wide for individual designers and craftsmen getting start on a cottage industry basis. Cf. MMM # 77 July '94, p 4. Inside Mare Manor Pt. II: "Cinderella Style"; Furniture.

Homemakers want to express their own individual personalities in the way they furnish their "digs." The appetite for variety and distinctiveness and uniqueness is extremely strong. Those with appropriate talent will be much in demand. A furniture/furnishings cottage industry co-op could, in addition to bulk purchasing power applied to equipment and materials, maintain co-op workshops for less frequently needed and specially expensive woodworking and finishing equipment, leaving the home woodworker to concentrate on equipment to be used more frequently, etc. The co-op could also maintain streetside and online co-op consignment markets, leaving the member entrepreneur to concentrate on production.

Custom tables, dressers, cabinets, bed headboards, lamps, etc. will be in demand. Again, rid yourself of the expectation that wood will be a common furniture material. Think instead of metal alloys, ceramics, glass composites, even concrete. All of these will require special tools to shape, finish, and adorn. Unlike the situation here on our still well-forested planet, the furniture maker will not be a graduate carpenter.

Co-op Scavenging Industries

As here on Earth, scavenged materials have the very attractive quality of being free for the price of disassembly and cleanup. For craftsmen and other enterprising individuals operating, or beginning operations on a shoestring budget, scavenged items and materials present an attractive situation.

Such unwanted materials include not just consumer trash items, but also post-manufacturing seconds, scrap, and byproducts. To increase bottom line profits, manufacturers are always on the lookout for mass markets for these items for which they have no further use. Sales are sales. So what is available to the home entrepreneur is the trash leftover from this first skimming by other industries.

A Co-op could maintain an online inventory of available items and materials, sources for tools, and a place to post patterns for sale and use by others. And of course, both streetside and online consignment markets for trashure items whether they fall into the category of useful items or just interesting pieces of art and craft. A co-op would offer an environment wherein individual trashure artists can further inspire one another.

A Co-op for Rockhounds

To must of us earthlubbers and perhaps to many less discriminating settlers, a moon rock is a moon rock. "Once you've seen one, you've seen 'em all." A true rock hound knows better. A rockhound can appreciate subtle differences and will know about hidden assets. Rocks can be collected for arrangements in rock gardens, cut and polished to reveal distinctive hidden surfaces, to be incorporated into custom jewelry cabinet hardware. A rockhound co-op could accelerate the diversification of rock and regolith based products by bringing people passionate about rock and its hidden aspects together, purchasing tools and materials at a discount, and setting up streetside and online markets.

University of Luna Assistance

A settlement university should have a department that will encourage the transition from cottage industry through coop membership organizations and activities, to stand alone businesses that employ people full time. In this way the settlement's economy will expand from one consisting of a few basic industries designed to meet minimum consumer needs, to one serving the individual consumer and homemaker, an economy offering an every expanding variety of goods and service. Coops will be the "accelerant." **<MMM>**

[Book Announcement]

Halley's Quest:

A Selfless Genius ans His Troubled Paramore

www.halleysquest.com

by Julie Wakefield - www.juliewakefield.com

"I want to notify Moon Society members about my first book, Halley's Quest, released October 11 by the Joseph Henry Press. It's a biography of Edmond Halley of comet fame but it talks a lot about his contributions to moon research."

List Price: $27.95 - Amazon.com **Price: $18.45**
Hardcover: 261 pages
Publisher: Joseph Henry Press (October 11, 2005)
Language: English - **ISBN:** 0309095948
Dimensions: 8.8 x 5.9 x 1.0 inches

"Halley's Quest takes readers on a trilogy of sea voyages, each of which proved to be as novel and revealing as it was difficult and controversial. But more than a yarn of risk and adventure, the story at the core of the book is a deeply personal and intellectual tale that captures the science and the spirit of an almost forgotten episode in the history of navigation. This delightful book emphasizes the drama of Halley's mission and the passion of an era hungry for the stories science had to tell. - *Joseph Henry Press*

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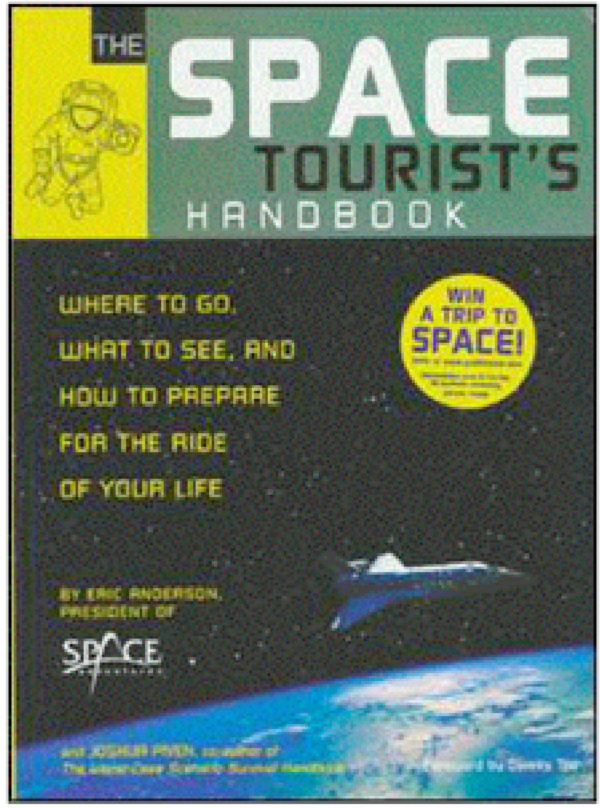

Space Tourist's Handbook:

Where to Go, What to See, And How to Prepare for the Ride of Your Life

by Eric C. Anderson and Joshua Piven

Eric Anderson - President/CEO of Space Adventures Ltd. Joshua Piven - coauthor The Worst-Case Scenario

Survival Handbook Series

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Paperback: 192 pages English - **ISBN:** 1594740666
7.3 x 5.6 x 0.7 inches; 12.8 ounces

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Classic Issues of L5 News now available in pdf format

http://www.l5news.org/index.html

The L5 Society was born in the mid-1970s out Gerard K. O'Neill's vision of Space Settlements and Solar Power Satellites built from Lunar Materials. The L5 News, edited by Carolyn Henson, was the monthly magazine that sketched out the vision and goals of the Society. Long available only in rare hardcopies, the first 34 issues are now available as free pdf downloads from the above site: the first four issues from 1975, twelve each from 1976 and '77, and the first six from 1978. More issues are being converted and preserved in pdf format.

On March 27th, the former L5 Society, and the former National Space Institute merged to become the National Space Society, at the 6th International Space Development Conference, in Pittsburgh, PA.