"Expanding the Human Economy through Off-Planet Resources"

Moon Miners' Manifesto - Pleiades

MMM Classics
The First Fifteen Years

Year 15: MMM #s141-150
December 2000 - November 2001

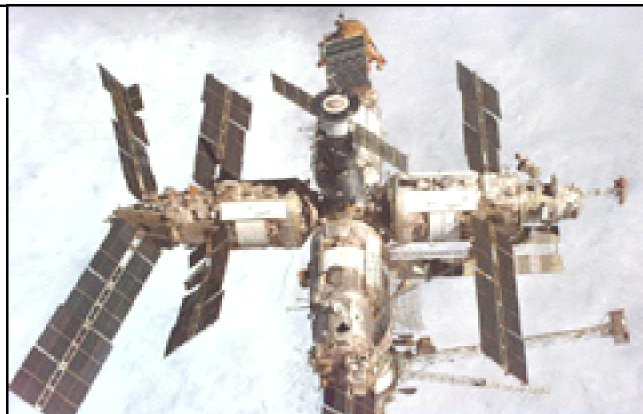
The year began with the fate of the Russian Mir Space Station still in doubt, but with the writing on the wall. Despite a concerted space enthusiast effort to save the venerable ragtag complex, NASA needed to be sure that the attention of the Russians was undivided. Down it would come.

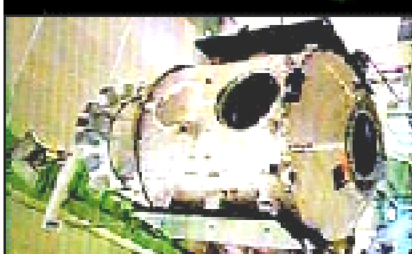
We brought up again the fascinating topic of sports in space, looking for opportunities for special sports modules as well as for EVA sports at ISS, and someday at orbital tourist hotels. This led to a spirited discussion of the use of legs in space.

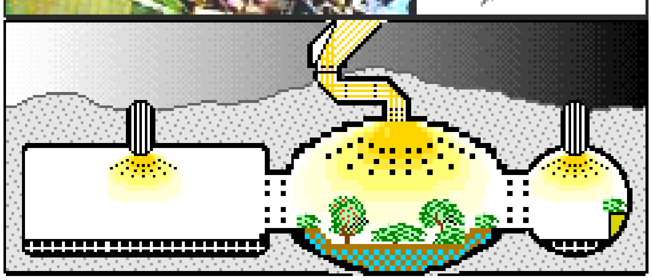
Our annual Mars theme issue concentrated on the role of Mars mini-moons, in particular on the role Deimos could play, both in the era of robust robotic exploration of Mars, as well as after human crews were on the surface, hopefully to stay. The successful NEAR mission to Eros could be repeated with clone craft to both Phobos and Deimos.

Does the Moon have trapped pockets of gas under the surface, and if so. could these be of economic value? We don't know the answers but the possibilities are exciting enough to call for a well-thought out plan to find the answers.

The value of shadow settlers, staying at home, but attempting to solve problems faced by pioneers on the Moon was thoroughly discussed. The options are many.







This year saw the first orbit flight of China's Shenzhou "taikonaut"-rated capsule.

Meanwhile, we revisited the ever interesting topic of how future Lunans would live: what their homes might be like. Multi-function spaces (Murphy Beds?) and clues from current Loft style living demonstrate options.

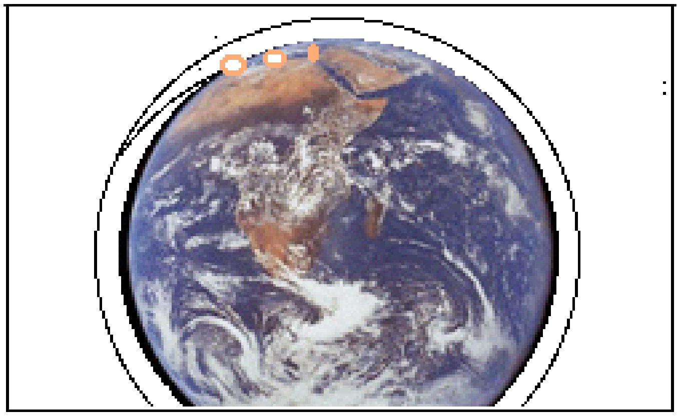
In a follow-on article, we show how the homestead garden, or Earthpatch, could anchor the home as the hearth had done on Earth in times past.

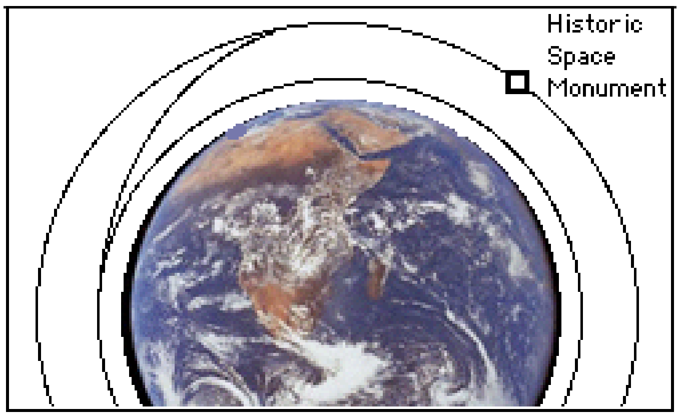
And following suite, we talked about the various kinds of cottage industries, and services catering to them, that could take off from homestead gardening.

On September 11th, this year, we had a real life hard lesson on the dangers of ignoring vulnerabilities. In a two installment essay, we tried to examine possible vulnerabilities in lunar outposts and settlements and draw lessons from what had happened in New York and in Washington, DC.

Finally, drawing from many past articles on relevant topics, we tried to show what the pioneers must do to reach that stage where they truly feel "at home" on the Moon. They would have to learn to not fear the long lunar night, how to domesticate and tame the troublesome moon dust, and to embrace the Moon's natural rhythms to give cadence and regular change of pace to their busy, productive lives.

MMM #141 - DEC 2000





What to do with MIR?

• There would seem to be two ways to remove **MIR** from service: L) a cheap but dirty deorbit mission with unknown damage to property and people on the surface. R) a more expensive major boost to a significantly higher parking orbit, as a Space Historical Monument. => p.3

The MIR Station World Space Monument
A Better Option for Decommissioning

by Peter Kokh

How many times have we heard "if your only tool is a hammer, every problem looks like a nail!" NASA is committed to seeing the MiR Station *removed from service*. But need removal from service necessarily mean removal from orbit?

To be sure, MIR will not stay in orbit by itself. At its altitude range, there is still enough wisps of atmosphere to continually drag down Mir's orbit to the point where it will eventually, controlled or not controlled, partially incinerate in the atmosphere, its remnants crashing into the ocean -- or onto land. It takes money to keep boosting up Mir's orbit periodically. So it would seem that to decommission Mir must mean either to allow its orbit to decay in uncontrolled fashion, or to deliberately accelerate the process in a way we can control it. A "controlled deorbit" has two costs:

- a Progress freighter bringing the fuel for the deorbit burn
- the impossible to estimate costs of the crash landing in inhabited areas of the many fragments too heavy and dense to burn up in the atmosphere

This second cost is the sleeper, as no one can estimate it in advance. If we take a median of optimistic and pessimistic assessments of the damage to property and citizens, and add it to the costs of the Progress freighter deorbit refueling mission, we come up with a *higher dollar figure* which should send us looking for alternatives.

We propose instead, that a more expensive refueling mission boost Mir's orbit up to an altitude where it would remain safe for generations. It can then be given the status of a world Space Historical Site, or Monument. At some future date -- no need to determine that now -- ac orbiting Visitor's Center could be built for students of space history and tourists to visit under careful guidance.

Mir should be seen as a priceless treasure of technology and achievement. That as long as it remains in service, it will be a thorn in NASA's side should not leave a destructive solution as the only option. It is not to the credit of NASA, or the agency's leash holders, let alone to the Russia authorities, not to seriously pursue this other option.

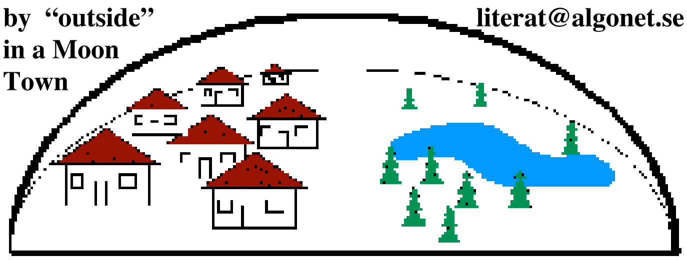
Those Russians who object to scuttling Mir are being dismissed as ultra-nationalists and communists. Alas, having lived through McCarthyism once, it is distressing to see it arise anew this way.

We call on all parties to take the time to look at this new option. Especially considering the potentially high cost of the inevitable rain of Mir-debris on property and people, we owe it to ourselves and future generations to take another look.

PK

What do you mean by "outside" in a Moon Town

by Niklas Jarvstrat
literat@algonet.se



Creating the "feel" of "nature" and the outdoors" within a lunar settlement is a challenge we can meet.

The traditional view of a lunar colony with a number of transparent domes with people in spacesuits walking "outside" between them poses severe technical problems, as demonstrated in a recent paper by Gregory Bennett in the Autumn 2000 issue of *Artemis* magazine. However, old concepts die hard, as evidenced by a suggestion in MMM to use double glazed domes with water in between to shield against radiation [a concept put forward by Marshall T. Savage in his book "The Millennial Project: Colonizing the Galaxy in Eight Easy Steps."]. High cost and technical issues - which would probably be prohibitive - are not the only problems with the glassed dome concept. Another problem with clear glass domes is that they will not remain clear for long. Even if not hit by meteorites big enough to shatter the glass, the outer surface would soon become milky and opaque from micrometeorite hits creating microcracking and/or minute impact craters" in the glass surface.*

However, what I'd like to emphasize here is that the feeling of freedom obtained from being outdoors does not necessarily mean that there is a blue (or black) sky above, but that there are other more realistic solutions for the outdoor feeling in a Moon colony. Consider a sizable settlement buried sufficiently deep below the lunar surface regolith blanket to be protected against radiation and meteorite impacts.

In order to make such a colony realistic, it would have to create most, if not all its food, energy, water and air supply. Air recycling and food supply requires green plants with current technology for really longterm use. (There are mechanical-chemical alternatives, but some dangerous residues tend to slowly accumulate in those.) Now, green plants could be efficiently grown and harvested in small, closed containers. The machines would probably require some human maintenance from time to time, but you would not have to touch the dirt. Then, when you have your free month of the year, you could buy an extremely expensive ticket to Earth, enjoy Nature and perhaps even get the opportunity to help out in the private garden of a friend. The Moon is a sterile place, too bad... **

But hang on, *we do need plants, so why hide them?* True, you could save some space. But humans need space for their well-being,. So why not use the farming sections to an artistic and recreational effect? The plants need a lot of light - and people tend to enjoy relaxing in the sunshine of a green oasis. Let's not hide the green plants in a far away corner of the colony! On the contrary, let us organize the colony so that everyone passes through a beautiful piece of landscape each day on the way to work. Thinking about my own situation here on Earth, the "outside" I see is the daily trip to my job, occasional work in my small garden, and sometimes a weekend out.

Going to work, I ride my bike for twenty minutes through a beautifully green par of my little town. The equivalent on the Moon could be to jog or walk a meandering path through a part of the agricultural fields designed for this purpose. I guess that would be a much nicer start of the working day than most city-dwellers' car rides. In your private garden on the Moon, mowing the lawn and growing flowers would be less of a luxury and more of a contribution to society -- part of the household need for vegetables and oxygen would be covered by this recreational activity.

The most difficult "outdoor" experience to duplicate on the Moon is the weekend or holiday trip into the big unknown -- fishing, hiking, sailing or camping in the woods. At least, that is, when there is only one, small isolated settlement. If there are more than one "city", you could always visit another city on your day off, and admire their solutions to landscaping.

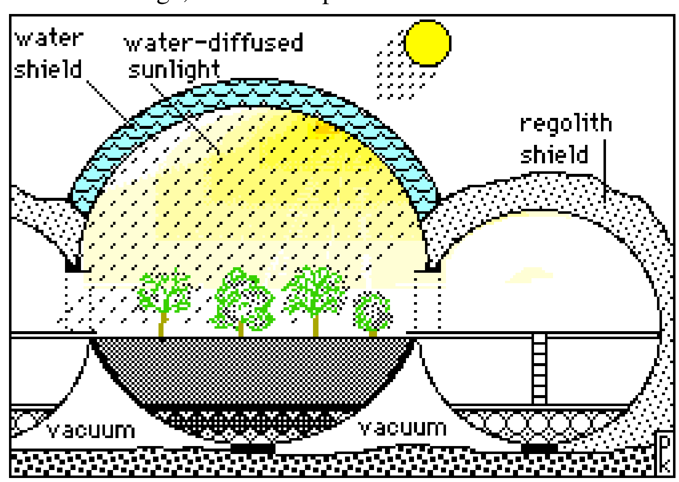
Camping may not be such a far off idea after all. (If you don't like rain, you could avoid the hours of irrigation.) Unless the indications of hydrogen at the poles are altogether misleading, there will be plenty of water, and fish is a reasonably efficient complement to the vegetable diet. Thus, "going fishing" could well be an option for the "day off." There would be no true wilderness, but by compact gardening, the feeling could be created, perhaps in Japanese style gardens. Reorganizing the landscape for variation could become a subject for a yearly landscape and garden design contest.

To conclude, I believe the Moon settlement will consist of large domes,*** with houses spread out similar to a nice Earth suburb. The dome will not be clear with a view of the lunar surface outside. On the contrary, the dome roof will be solid rock, perhaps painted sky blue, with scattered lamps providing ample illumination. [Such an urban environment could conceivably be created and sustained inside one of the Moon's many large lavatubes.] Connecting the houses will be walking paths instead of driveways, because cars will not be needed due to the short distances within the compact community. There will be a lot of green plants, but in contrast to the Earthly suburb, most of the plants will be edible.

For redundancy and pest and blight control, there should be at least three such domes, connected by airlocks, or within reach of a short suited walk. Some agriculture facilities will perhaps be sealed off completely form the human habitat areas. The houses are somewhat scattered, but concentrated towards one end of the dome. Toward the other end, there is a small lake or pond, with selected fish species. The pond area is popular for sleeping out, fishing and hiking. Our of necessity, the settlement will be ecologically sustainable and lean on resources. But, although the total volume available per inhabitant will be much less than the theoretical value on Earth, creative solutions and a participation in the environmental design will create a feeling of green, friendly wilderness. **<NJ>**

Editor's Comments: We thank the author for this fine article and share his belief of the importance of recreating a "natural" feel to our settlements on the Moon. We would like to append the following observations, however.

* The article about "hydrodomes" was not a proposal that we go that route, but how this suggestion, which came from Marshall Savage, could be improved.



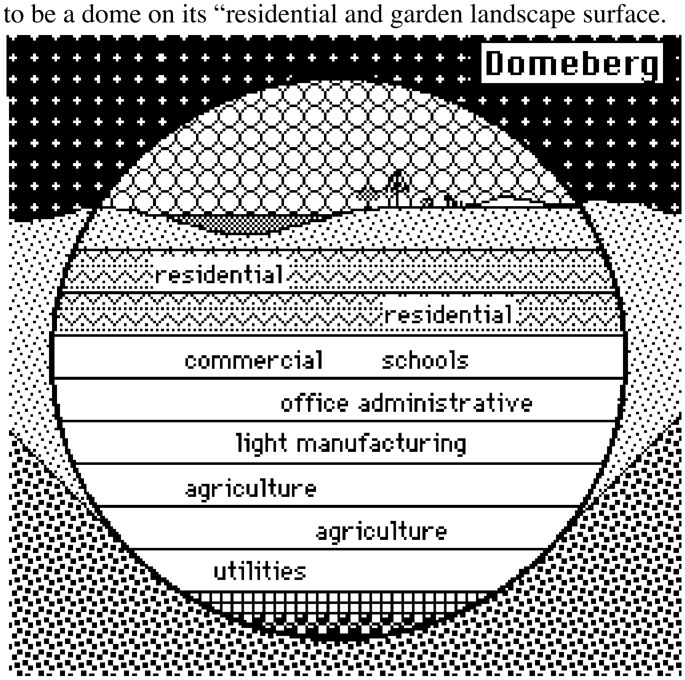
We did not point to transparency as an advantage of this concept, only to its translucency. We also suggested that a third, outermost layer of "sacrificial" glass panes take the hits of micrometeorite bombardment. But, not being part of the pressurization system, these panes could be easily replaced as needed. The chances of a meteorite hit large enough to break through are significant over geological time, but insignificant over shorter periods, say a hundred years or so. We did indeed point to the serious technological problems of such a design, especially to the plumbing and thermal challenges. While these problems may seem insurmountable, we continue unapologetic in our philosophy of pushing all the options as far as they will go, rather than make a premature choice.

** Experiments with returned Apollo moondust show that while it is sterile, it is "fertile" with many of the nutrients needed to support plant growth. With the additions of composted waste biomass and sterilized human manure, with prior sifting out of finer powder particles that could clog drainage, and with other measures, lunar regolith should make a fine soil for gardening and agriculture alike.

We would (as the author suggests) want all plants and crops to grow in "containers', planters, if you will, of all sizes, in order to manage drainage and contain the soil. But the amount of planting needed to cleanse the air and to provide all the food and fiber needed by the settlement would be quite substantial, much more than the average city dweller on Earth enjoys without a trip into the countryside.

As we have pointed out before, off-Earth settlements must not be conceived as "cities with a few house plants" but as agricultural areas "hosting" a human village. In other words, just as on Earth, in space we can survive only as the respectful guests of a biosphere. Task one in constructing a settlement is to install a biosphere. Now we have also suggested that this can be done, at least in part, in a modular fashion, with each homestead and place of human activity contributing more gardens and onsite primary treatment of wastes.

*** In some areas ot the Moon, we'd have to hollow out and fuse the fractured bedrock in order to supply such "domes." Constructing them on the surface and then covering them with regolith, poses the problem of severe stress: we must think of spheres, cylinders, toruses, etc., not "flat-floor" domes. Now a spherical megastructure could have its lower half filled with factories, environment maintenance equipment (water and air recycling) warehouses, etc. So that the structure still "appears" to be a dome on its "residential and garden landscape surface.



In some areas of the Moon especially in the maria, the lava plain seas, we will find ready made shielded volumes, the lavatubes. However, it will quite be a trick to pressurize them. -PK

CNN Sports Cosmodrome

Media-Paid Sport/Exercise Tank
for ISS Crews and Visitors

by Peter Kokh

It may seem an off-the-wall idea -- that TV-Cable Sports Broadcasting contracts could provide enough of a down payment to justify design, construction, and deployment of a facility to be attached* to the International Space Station, reserved exclusively for various kinds of athletic activities. But consider:

- Outside of freeform gymnastic play, no kind of structured athletics, individual or team, have been designed and tested for use in space.
- Even if one could concoct some space "sports", there is no guarantee that they would be sufficiently exciting for the armchair-bound to watch to justify advertisers to foot the bill, even on a long-term amortization basis.

Zero-G Sports Design Competition

That would seem, however, to be a self-defeating assessment of the prospects. There is no need to wait for the realization of such a facility to begin experimenting. It should be possible to write computer software for the designing of Zero-G sports and other activities that would take into account not just microgravity, but unreduced Earth-normal momentum, the ability to rebound and spring off surfaces, action-reaction consequences, the availability of traction only during rebound, and other factors that would come into play.

With such software, and given the size and shape of the proposed facility, designers could experiment with one-on-one and small team sports designed to be fun to play and watch with the outcome sufficiently up to acquired skill to engross potential viewers. Design of such sports events could be opened up to well-advertised competition with audience reaction to computer simulations being the basis for awards and continued work.

If, and we admit that it is an "if", the results prove sufficiently exciting for test audiences, the would-be-owner of such a facility could start feeling out various cable and television networks. Is there a market for sports broadcasts from ISS, say on the ABC Sunday Afternoon Wide World*s* of Sports? All it takes is one big contract. And given that there are multiple markets, multiple contracts are possible.

* In order to isolate vibration-sensitive microgravity work, such a facility would probably float nearby, or be attached to ISS by sa flexible tube.

Some of the Many Possibilities

What indeed are the possibilities? Consider zero-G analogs to:

- Synchronized swimming
- Ballet

- Skate-dancing has become extremely popular and a major beneficiary of advertising cash. So synchronized air-swiming could have promise.
- Freefall wrestling? You would not have gravity to help you "pin" your opponent, but you could hurl him into a bulk-head! (One move is to secure a hand or foot anchor as the other approaches and spin the opponent around, pushing him into an uncontrolled rebound) (target zones - e.g. more points for end-zone hurls) (zones not to touch, or not to be thrown into.)
- Track and field events are also spectator favorites, even if only seasonally, and over time, we could devise a growing list of events."

But we did use the "sports" word. In a space facility, even one so spacious as a retrofitted shuttle external (H2) tank, any kind of "team" sports game would be limited in team size. So forget about the many-player favorites: baseball, football, soccer, etc. That does not rule out versions of:

- Space soccer with two-person teams
- Space handball
- Space volleyball (possible rebound plates to pas ball for spiking, a centered round net, possible color-graduated wall zones for points)Space Tennis
- Space Jai Alai, a fast-paced exciting sport already played off walls as well as off the floor

Integrating Sports into ISS Operations

The addition of game and sport elements, turning exercise into friendly competition and even rivalry, can only be beneficial for individual and group morale. Humans are not robots, and they work better when they are afforded the opportunity to play, and play hard.

Some will object that there is no place at ISS for this kind of facility and the activities it would support Balderdash! Get rid of the stuffed shirts. People in space for appreciable periods need structured exercise activity. Astro/cosmo/spacio-] nauts [in the name of all that's holy, let's please find a better *international* word!} already have time set aside in their sche-dules for gymnastics and other exercises.

As for the regular presence of the media in space, this is already guaranteed. Energiya, the largest Russian space contractor (and builder of Mir) and SpaceHab, the only entre-preneurial builder of habitable space structures, entered into a joint venture in 1999 to build the Enterprise module to be attached to the Russian side of ISS. As a part of this venture, Space Media has been established to create proprietary content from and about space for television broadcast and internet distribution via the Enterprise module when it is deployed in a couple of years! Target audiences range fro students and space enthusiasts to major corporations. Regular commercial broad-casting from space is on its way.

broadcast operations from the Enterprise module will pave the way for sportscasters from a dedicated sports facility, commercially paid for an operated, and also part of a growing ISS complex. This concept is not far-fetched at all.

A humble but potent first step

What we are talking about is a humble start to orbital sports. There would be no dedicated sports players. Just working people, and possibly, occasional visitors, getting healthy diversion in off-hours -- amateurs of the purest kind. There would have to be a very considerable growth in the in-orbit population for us to think of anything else!

Yet, the fact that our proposal is designed to create high public interest, first in the open design competition of prospective sporting activities, then in the telecasting of such events -- once players get good enough at them to play with confidence, zest, and obvious skill -- at least on occasion, if only monthly, later weekly -- could work to grab the attention of a considerable fraction of the stay-at-home public, including many breadwinners and taxpayers who will see these things;

- Sports would be advertised as experimental: viewers would first see the original computer simulations, then watch real exercises ad be able to appreciate the learning curves of the individual payers, suggest changes in rules, equipment, arena zoning, etc.
- They will see space sporting activities that are not paid for by tax moneys but by free enterprise. Viewers are hardly likely to be resentful or to be sympathetic with those who would cut ISS support.
- Hey, this looks like fun! More and more people would see space as an attractive tourist destination once prices fall sufficiently. This very interest, if it builds high enough, will work to bring costs to orbit down, by strengthening the "market" in the eyes of potential investors in the necessary affordable transportation systems and their components.
- While males are more likely to enjoy watching "sports." the inclusion of space ballet and free form or even "ballroom" space dancing and synchronized space swimming, should attract an appreciable female audience as well. The wider the variety of spectator offerings from this facility, the greater the percentage of the population will sit up and take notice.
- Teams chosen to represent different national groupings of the ISS partner crews will work to spread this interest to international audiences. The pairings (USA+Canada vs. Russia+ESA) could be changed form season to season (e.g. USA+ESA vs. Canada+Russia etc.) so as not to promote unhealthy ingrained rivalries.

Facility Design Options

What kind of shape and structure would/should such a facility have? The options, all bounded by cost to build and maintain as well as by practicality of deployment, are several. Structurally, we could use a hard body tank, either a shuttle hydrogen external tank, or something smaller that would fit into the shuttle payload bay or of intermediate size, launched in place of the shuttle orbiter.

We could also use an inflatable structure: a sphere, a cylinder, or even a torus. The considerable advantages oft he inflatable option are these:

- More usable volume per shipping weight
- More usable volume still shippable in the shuttle payload bay

- More design options: an original cylindrical facility could be followed with other shapes that would permit a greater variety of sports design, as the "population" in orbit grows to supply a pool of "players." For example, a torus would allow continuous-pat foot-races, running on the outer wall to create one's own gravity.
- The opportunity to space-test an inflatable hull structure and prove it out for more widespread application. Choosing an inflatable could thus have the financial advantage of being subsidized, as a test, by the manufacturer interested in more business.

Whatever the design, not all of the volume can be given to play or sport. The whole idea is to also allow satisfactory, many-angle viewing by remote spectators. A way to build in an array of remote, non-protruding videocams is a paramount design constraint. How events will be judged or refereed is also critical. But these challenges seem meetable.

Investment Prospectus Summary

- Sponsors pay for computer simulations to create good combos of rules, players, arenas, equipment
- The Contractor subsidizes any experimental or test features, e.g. inflatable hulls
- Facility Naming Rights
- Cable-TV Network Contracts pay operating and maintenance costs plus amortization costs
- Legalized gambling on space sports might chip in a share of the profits.
- Lotteries to win trips to join in the games

So, *Let the Games Begin!* <MMM>

Recreational EVA at ISS?

by Peter Kokh

Currently, EVA in space is regarded as a high risk, fatiguing exercise to be avoided where possible. Competing Space Station designs have been evaluated on the basis of how far they go to minimize the need for EVA hours in construction and deployment. This in mind, it is still not to unreasonable to ask if this necessarily be so.

Suits vs. Hardsuits

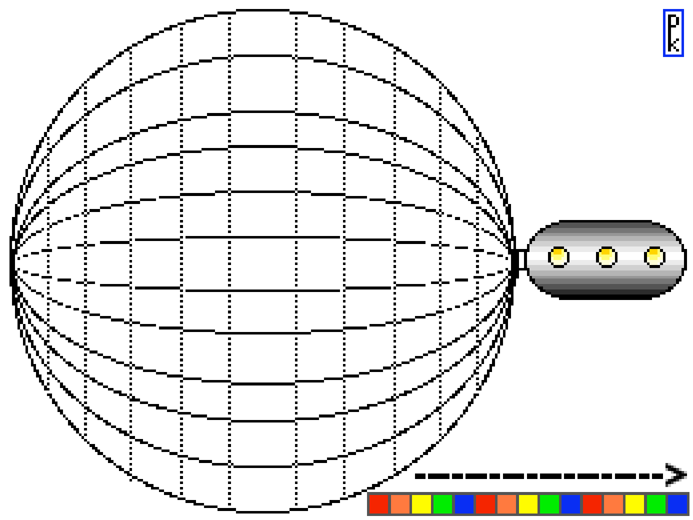
We currently use soft spacesuits that require under-pressurization with special atmospheres and that demand a lot of extra time spent pre-breathing." Fixed volume hard space suits that could be fully pressurized at shuttle or station standards -- and yet be flexible for easy operation -- have been toyed with by design groups, but NASA has chosen not to fully fund such research. This is a dead-end policy. Design and debugging of an improved spacesuit is an absolute necessity if we are truly going to become at home, not just in orbit, but on the surface to the Moon, Mars, and the asteroids. A suit that does not require pre=breathing would greatly reduce the burden someness of EVA activities and demands a priority slot in the NASA budget.

Look Ma! no Tether!

The tether is a safe, time-tested way of constraining EVA activity. But when several people are involved, the possibility of entanglement becomes very real. We think that this whole question needs to be rethought.

The simplest way to remove the need for tethers would be to "cage in" the activity area. We do not actually suggest this be done for construction zones (though it could be.) Rather, we would like to suggest that a "caged" area be erected in an "outside" area of bay strictly for the purpose of recreational EVA - with *no-pre-breathe suits*, of course!

By use of lightweight ribbing to which a lightweight netting is attached, an appropriately "spacious" volume can be set aside for tether-free exercise without danger of anyone "floating off". Below is a sketch of the idea.



CAGE FEATURES: The netting and ribs could be matte black so as to visually disappear into the background of space. Perhaps not all essaying out into such a safe harbor would successfully overcome their fears on "faith" that the cage/net is there. If panic ensues, the individual could press a panic button which would send a remote signal that would light up the cage ribs (or at least the nearest ones) in a color sequence that would cue the direction back to the EVA port -- e.g. repeat sequences of red-orange-yellow-green-blue or just homeward sequencing lights all of one noticeable but unobtrusive color. Those in distress could thrust towards the ribs and haul themselves back to the port, hand over hand.

For those uneasy but not in full panic, a "reassurance" button could prompt the grid to light up or pulse for a second or two before going dark. These buttons would be on the suit, probably on one of the wrists, in easy reach. They could also be voice activated for those in deeper distress. Finally, the suit itself, on sensing sustained "paralysis" could trigger the panic button, even gently thrusting towards the nearest cage rib. As with space sickness in general, this type of vertigo may be hard to predict accurately.

Meanwhile, those who conquer their fear, would have a *spacious* safe harbor in which to play with their suit-thrusters and learn to master them. Then various sorts of group activity could be attempted, form space suit waltzing to choreographed synchronized exercises, to races, even games of tag.

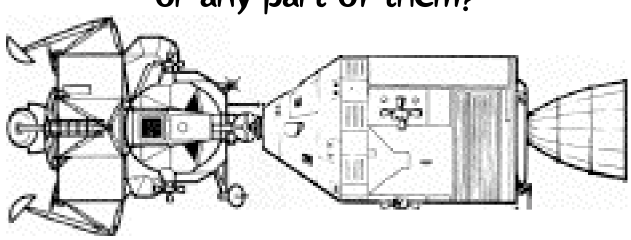
CAGE SIZE: 50 meters/yards? 100 meters? The size may be limited by weight constraints of the cage and netting which increase with the square of the diameter. The cage does not have to be very large to enable the experiences described.

As in the case of the Zero-G Sports Facility sketched in the preceding article, the first beneficiaries of a tether-free safe outside EVA recreational area would be the ISS crew and regular visitors. This provides another option for exercise and recreation. More importantly, it would help relieve pent up cabin fever, serve as a substitute for sorely missed outdoor activity, and provide safety valve change-of-scenery getaways from fellow crew members, as well as, for some, a special opportunity to commune with the universe at large.

But let's not forget the view! A chance to look at Earth speeding by below, not just out a porthole, but out one's helmet visor, could provide treasured moments. If the experience is sustained for a whole orbit, they would have the spectacle of urban lights to behold. Of course, these experiences depend on the cage being earthside of the ISS structure. If or when the cage is spaceward of the ISS structure, those inside could behold the splendor of the heavens with Earth's nightside at their backs.

All in all, we thing such an EVA Cage could become a very popular ISS feature, all for surprisingly little money -- once, of course, a proper EVA suits available. Meanwhile, videocasts of such unfettered fun in "free" space would whet public appetite of would-be tourists, helping beef up demand for cheap access and lodging in space. It should come as no surprise that "doing ISS right" will help pave the way for tourist resorts in orbit. **<MMM>**

Could we have reused the Apollo Capsules, or any part of them?



An exchange on artemis-list@asi.org November 22, 2000

Gregory R. Bennett <grb@asi.org>

"We did not reuse the Apollo capsules, or any part of them. But, could we have?

I was just wondering if there were anything inherent in the design of the Apollo capsule that precluded reusing it. It was a tiny part of the spacecraft, but it did contain a lot of expensive equipment.

I often wonder whether flying a whole new spacecraft is really more safe than using one that has been proven in flight. Perhaps the fact that each capsule went through extensive testing made up for lack of operational experience with the spacecraft, Apollo 13 notwithstanding.

Greg Bennett

Wallace A. McClure <Wallace.McClure@West.Boeing.com>

The short answer is yet to part of them, or at least some of them could have been refurbished to fly again. I also assume you are using a new Service Module with them. In particular, those used for Earth orbital missions could probably have been reused for Earth orbital missions.

- Structure -- Could have been reused, but you would have to inspect to ensure no sea water intrusion or corrosion (e.g. *don't get salt water in the structure, particularly inside the pressure vessel.)*
- Thermal Protection System -- This was sized for a direct return reentry from the Moon. Run the numbers and you see the heat load from an Earth orbital reentry was less than 50% of that of a lunar return. The heat shield was not replaceable in sections, but you could have theoretically remachined down the uneven remaining unablated honeycomb and reused it for an Earth orbital mission. (With inspections, of course!) Theoretically, you could replace the entire ablative reentry shield. *But that was never considered.*
- Avionics -- Reusable, yes, with replacement and testing of batteries, etc.
- ECLSS -- Most of the ECLSS was in the service module. You would have to renew the ECLSS LiOH [lithium hydroxide] and it was reusable. You would have to replace the connections to the service module.
- ACS -- The CM ACS was really only used post SM separation (and primarily for roll control). At a minimum, you would have to clean and replace all the burst disks, etc. But from a first look, you could probably reuse the tanks, valves, engines etc.
- Parachutes, etc. --Definitely replace them. They were ram-packed and certified for only one use. Also the pyros, etc. would need to be replaced.
- Soft Goods -- Inspect and replace seals, rubber gaskets, etc. You do need to look at them.
- Of course, if any vehicle was used outside of the expected operational conditions, reuse might not be possible -- land landing, hot-hot reentry, sea water sloshing around inside for weeks, etc. But for a run-of-the-mill Earth orbital mission -- probably most of it could have been refurbished and reused.

Dale Gray <dalegray@micron.net>

As I understand, the capsules evolved over time even after Apollo 8. Reusing an old capsule would be to take a step backward in safety, performance, mass. The returned capsules were far more valuable as national treasures, complete and untouched than any conceived salvage part or in whole.

Andrew Newstead <A.Newstead@pop3.appleonline.net>

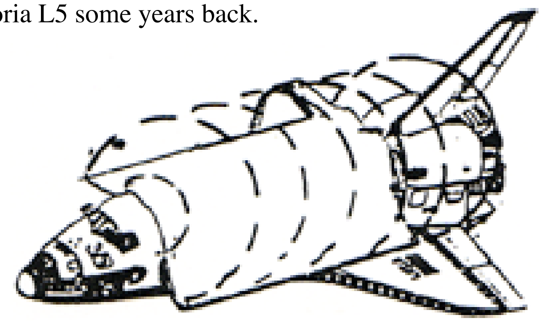
I believe the Apollo 14 docking probe was reused with one of the Skylab Apollos or the ASTP Apollo. Because of the difficulties with it during the flight of Apollo 14, it was brought back for engineering analysis, which found nothing wrong with it and it was reused as an economy measure. It gave trouble again when reflown, so go figure!

Ben Huset <benhusset@skyling.net" Todate, all the Soyuz capsules have been used only once.

Shuttle Connestoga,
SpaceHab, & Artemis Moonbase™: a Mission Design Dialog

by Peter Kokh
From MMM #51, December 1991,
"**Hybrid Rigid-Inflatables in Space**"

At the 1990 Space Development Conference in Anaheim, California, then deputy NASA Administrator, J.R. Thompson, shared with us some of his surprisingly unfettered thoughts about real near-term possibilities. Thompson felt there was no reason why the Shuttle orbiter, refueled in orbit, couldn't make a non-landing round trip out to the Moon and back. He imagined the Payload Bay outfitted with a folded inflatable structure. Once in cruise mode, the payload bay doors would open, the inflatable would be filled with air, and the Shuttle would take on a distinctively connestoga-like appearance, reminiscent of a bumper sticker design produced by Peoria L5 some years back.



Such a mission could be flown in low Earth orbit, but would be riskier (to the inflatable envelope) owing to the high concentration of accumulating space debris. Whether in orbit, or solely on the portion of the circumlunar cruise that lay safely beyond the debris zone, such an inflated orbiter mission would be enhanced if the bed of the payload bay were packed with space-lab type modules to structure the use of the volume supplied by the inflatable volume.

Advantages & Drawbacks of this Scenario

There seem to be three advantages:

- those making the Lunar Overflight Loop would not have to transfer vehicles at any part of the flight
- the tourist cabin in the Shuttle Bay can borrow communications and life support from the shuttle
- having the winged Shuttle as a carrier allows direct return to Earth with atmospheric braking and without a depot stop in low Earth orbit.

The drawbacks seem to be more considerable:

- Lugging along the entire 80 ton shuttle greatly multiplies the amount of fuel needed to make the translunar orbit injection even if there is to be a direct high-velocity return to Earth with atmospheric braking.
- To bring along this much fuel requires bringing an External Tank to orbit and perhaps a number of dedicated fuel shipments, along with in-orbit cryogenic refueling, something we have never tried (there is a first time for everything!)

A more sensible proposal

If the passenger cabin has to make both the ride up from Earth, and the return to the Earth's surface in a Shuttle payload bay, it could still be made self-sufficient in communications and life-support. If so, it could be removed from the payload bay in orbit by the Shuttle's manipulator arm. Then it can be mated with a much smaller 2 stage booster for the lunar loop trip, the second stage responsible for braking the cabin back in a low Earth orbit where it can be recaptured by the Shuttle.

This proposal would require only off-the-shelf components and is basically identical with the Artemis Project™ LTV stack. That is, we can make such a passenger cabin out of a specially designed gang of Space Hab modules.

At the time that J.R. Thompson made his proposal, Spacehab, a pressurized module that rides in the Shuttle payload bay, was itself just a dream on paper. SpaceHab is now a reality and has made many shuttle flights. There are even "ganged" versions with double (and potentially triple or more) the interior space.

Modifications would have to be made to both the interior and exterior of the SpaceHab modules, of course. An ASI Design Team is looking into this. The SpaceHab mission would do three things:

- prime the pump for Lunar Overflight tour enthusiasm
- loosen the purse strings for needed additional capital for space module entrepreneurs like Bigelow Aerospace
- shed advance light on redesign needs

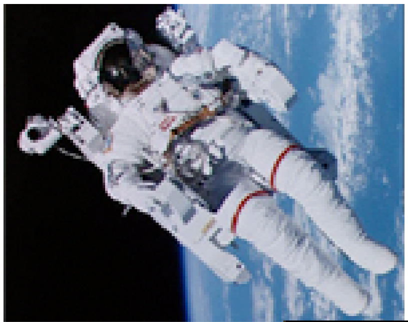
It would seem to be highly advantageous to the Artemis Project™ to plan the initial test flight of its Moonbase "stack" as a paying tourist venture.

- Tourist dollars as well as a contract from Bigelow to test various items, features, and services would help defray the cost of such a test flight.
- Public stay-at-home armchair enthusiasm of the pioneer lunar overflight passenger excursion will:
- spill over into enthusiasm for the Moonbase project itself
- build momentum for sales of "edu-tainment" products both from this initial overflight tour and from the ensuing moonbase mission.

Thus for the Lunar Resources Company (TLRC, the owner of the Artemis Project™ and Artemis Moonbase@ trademarks and conductor of the Projects) to conduct the test flight of the Moonbase stack *as a tourist offering* would seem to be a win-win situation with few drawbacks. **<MMM>**

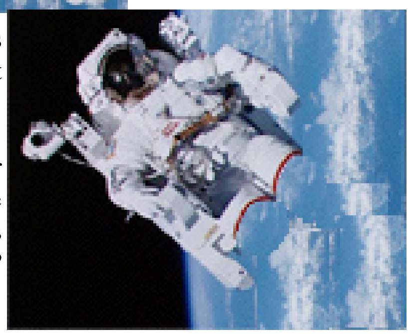
MMM #142 - FEB 2001

Legs in Space - Liability or Asset?



In the first of a pair of articles, Kenneth M. Skinner points out some advantages of being legless in Zero-G.

In the following piece, the editor lists a host of ways other than "walking" by which legs prove themselves most useful in space.



So should one bound for a lifetime stint in space amputate his or her legs or not?

=> read below!

Equal Footing

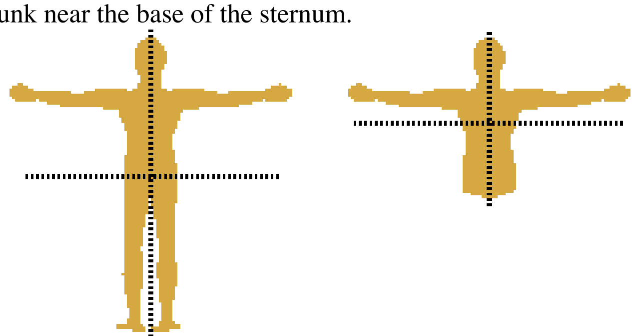
in a Weightless Environment

"What use are legs in zero-G"

by Kenneth M. Skinner

In the November 2000 issue of MMM #140, Richard Richardson presented some thoughts on "who is best fit to work on the space frontier." The discussion was based on a quote by Leo Frankowski that posed the question: *are physically superior highly trained test pilots really the best choice for all the jobs on the new frontier?* Richardson discusses at some length the psychological profile of individuals who may be better qualified for long duration space flight and early settlement. As a corollary to his discussion, the physical characteristics of certain individuals might also be considered.

The question is, of what use are legs in a weightless environment? Legs comprise an estimated 20 percent of the total body mass. Individuals with legs have a center of mass located in the lower trunk area near the navel. Individuals without legs have a center of mass located slightly higher in the trunk near the base of the sternum.



In a zero-G environment, the location of the center of mass affects the mobility of the individual and the action/reaction effects that result in performing work with the arms. When an individual with a low center of mass pushes or pulls with the arms in a zero-G environment, the force tends to initiate rotation around the center of mass. A legless individual wearing a backpack (air supply) would have a center of mass located nearly between the arms in the central chest area and experience a much reduced rotational moment when working with the arms.

Legless individuals who are self-sufficient on Earth have learned to move their bodies using their arms and upper torso muscles. These individuals are practiced at controlling their movements in a way similar to what is required in a zero-G environment.

Observing the posture of astronauts on the shuttle and on the space station, they tend to move in head-up manner looking parallel to their direction of movement and using their arms and hands for mobility. The legs appear to float behind out of the line of sight or in a tucked position when at rest. Legs appear to be of little advantage and may in fact be a handicap in a weightless environment.

Legless individuals have several other advantages that should help to qualify them for consideration for work in the LEO Zero-G environment. They have a lower average body mass, they would require less exercise time since they need only work their upper extremities and would probably have shorter rehabilitation times upon their return to Earth.

Individuals who should be considered for zero-G work should include those who, have no, or only minimal lower extremities, well developed upper body strength and control, above average IQ, good manual dexterity and mechanical aptitude and an acceptable psychological profile. They should be considered at least on an equal footing with their legged colleagues, and may have some distinct advantages over them on Zero-G frontier of the space station, orbital factories and other LEO facilities of the near future. **<KMS>**

* This should include "dwarfs" who are short mainly in the extremities, less so in the torso. **PK**

[Another Viewpoint]

Headed for a New Life in Zero-G? Don't Amputate Your Legs Just Yet!

Those who have legs will find ways to put them to good use

by Peter Kokh

One might come to the conclusion that legs, which we Earth-bound humans use for walking, would be just useless baggage in weightless space, and that those living permanently in a gravity-free environment, would be better off without them. Certainly, it would appear, that those with legs would function at a disadvantage in comparison to amputees or to those born without them. This proposition is not a new one, and has surfaced several times both in science fiction and in serious articles over the past three decades.

I'd like to offer a spirited rebuttal (I like my short legs just fine.) While legs may seem to be less important in weightless space environments than on Earth, those with them will find ways to put them to good use. Consider these points:

- Legs and/or feet can be essential springs for breaking or redirecting one's momentum. A look at any video of cosmonauts "swimming" gracefully through the mazes of Mir illustrates that. Those who have spent long periods aboard Mir have learned to use their legs as stabilizers as they move about. It is quite clear that in air-swimming, legs are an asset, not a handicap.
- Legs can anchor a person at a work station or elsewhere, by using rungs or Velcro boot pads.
- Legs in zero-G will be essential in most types of zero-G sports activities: rebounding, grasping, kicking, and dance.
- Bare feet can be taught prehensile tricks - just look at what some armless people have learned to do with their feet! Freed of the need to "walk," individuals who practice latent prehensile foot abilities could find themselves equipped with a second primitive pair of hands!
- Without at least leg stumps to form a sheltering "bay" male genitals would be exposed to frequent impact and occasional injury. Of course, padding, like the shoulder pads of a [U.S. style] football player could be used.
- I can think of at least three distinct ways in which legs would be useful in zero-G sexual activity (at least two of these should be obvious)
- Shifting the center of gravity higher up into the torso by amputating the legs would effectively shorten the extended "reach" of one's arms.

I'll grant that the legless, with less average total body weight, will require less food and other consumables. They will also need smaller private quarters, work stations, etc. These advantages are not inconsiderable and deserve much more attention than they have been getting. We have previously* pointed out these very pluses as reasons to give dwarfs and pygmies a major role in space, for example on pioneering expeditions to Mars.

* MMM #64 APR '93 World News Watch, A.F.D. News Service (2nd item) - and - MMM #113 MAR '98 "More to Mars: sending 12 men to Mars for the price of 4, 24 for the price of 8" [republished in MMM Classics #12]

But as to maintenance of muscle tone and overall health, and ease of readjustment to full Earth-gravity, not having *any* legs for sport and exercise and heart-conditioning would just put that much more burden on the hands and arms.

In sum, as legs are useful for so many things other than walking, it would seem a strong advantage to retain them even in a permanent zero-G situation. One might suggest that amputees or those born without legs would be at less of a disadvantage in zero-G than on Earth. But given all the non-walking utility of legs suggested above, I think such people would still be disadvantaged and "disabled" in comparison to those with *retrained* legs, though perhaps less critically.

But in space, as currently on Earth, we will find ourselves rewarded by whatever efforts we can make to integrate the physically challenged into everyday life and work. There is room for all of us to live up to our full potential.**<PK>**

Physical Activities in Zero-G Continued

In the December 2000 MMM #141 issue, we printed tow articles on sports activities in LEO, both applicable to zero-G environments in general:

- "Media-Paid Sports Exercise Tank for ISS Crew and Visitors"
- "Recreational EVA at ISS"

In both articles, that personnel would have legs was taken for granted. Leg-amputees in such locations, if there are enough of them, will require specially designed sports activities which may or may not be analogous to those that fully intact persons enjoy. The following article expands upon the theme of recreational zero-G excursions out the airlock. **<MMM>**

"Deadman's" Spacesuit Thruster Pack with Fail-Safe "Homing" Capabilities

EVA Assured Safety without Tethers

by Peter Kokh

Astronauts in space suits gliding off into oblivion and certain death is a standby of science fiction film melodramas. The tether breaks - or is "cut" - or a hero-martyr disconnects the tether to retrieve something just out of reach. The umbilical tether has been part of Extra-Vehicular Activity [EVA] ever since Alexei Leonov took the first plunge out the airlock in March of 1965 (Voshkod 2), beating Edward White's solo (Gemini 4) by six weeks.

While eventually, NASA would test the MMU "floating free" Manned Maneuvering Unit backpack in nine untethered EVAs in 1984 (seven of them from the ill-fated *Challenger* orbiter), the umbilical safety of the tether has been a hard cord to cut. With the MMU, there was always the danger of an accidental overthrust, putting the wearer on a trajectory from which there was no recovery or return.

That was seventeen years ago, *already!* Computers have come a long way since then. There would seem to be no reason why smart "override" controls could not be built in, keeping tabs of changes in momentum and vector and distance as well as remaining thruster fuel, the suit would automatically override manual controls whenever the delta V needed to return to the airlock approached the limits of remaining fuel. The suit could also have a "deadman's" control feature that activated automatic return if sensors detected any decrease in suit pressure or prolonged inactivity. Homing beacons on in-range airlocks would be part of the system.

Such a "smart" MMU would enable safe and worry-free EVA by more than one person without the risk of mutual entanglement. *The annoying problem of entangled cords is precisely what has made "cordless" power tools so popular in the work place!*

While useful for construction and inspections and other work duties, our point is that such a suit would allow "frolicking" in space for the very first time! Frolicking, and unleashed sports. Perhaps even "Extreme" Space Sports.

At first, there might be only one model, especially for construction, repair, and industrial purposes. But once there are enough people working and living in space to increase the demand for a variety of challenging sport activities, manufacturers could start producing “sport MMUs” with special “handling” and “maneuvering” capabilities. Range, in terms of Delta-V units, along with acceleration, will be as important to space athletes as megahertz and gigabytes are to computer buyers.

But as long as “all there is to do” is to go for an aimless joyride through landmark-free empty space, “free-thrusting” will be little more than a short-lived fad. Development of a real and growing market will go hand in hand with the parallel development of EVA team sports and games, even “track & field” type individual events in which one goes for a new “record.”

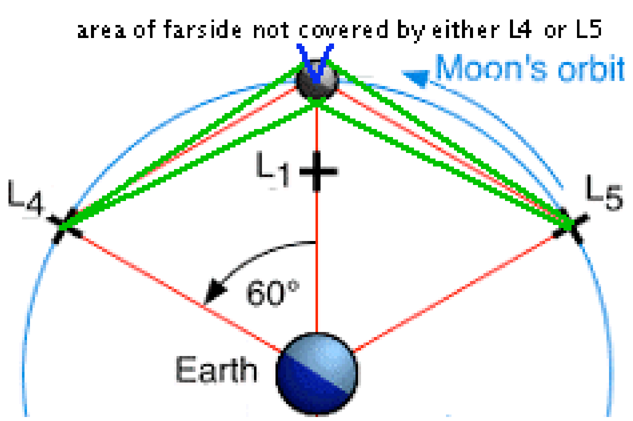
The start could be something simple like a rally around an ISS management sanctioned course around the periphery of the station with its many modules, struts, solar panels -- in and out of plane. To minimize accidents, the smart suit would have to have proximity sensors that would override manual controls in time to take evasive action. The idea. of course, would be to get as close as one could to a rally point without triggering the override as that might revector you out of the competition in a direction not of your choosing! If a game, sport, or event does not challenge one’s skills, what good is it?

An alternative would be a co-orbiting rally “course” with a set of station-keeping market buoys. Their mutual positions could even be randomized from one event to another, the proper sequence indicated by beacon color perhaps.

Space suit “team sports” could come in time. Touch Spaceball? Make the suits light enough, agile enough, and smart enough, and all fetters to the imagination will face away.

How far away is such a day? Perhaps a generation, to be conservative, not much more. Certainly, a risk-averse NASA will never allow such frivolities. *We will see the rise of such activities with the appearance of orbital tourist resorts.*

There is more to space than rockets and modules. The space suit has equal power to make or break the future. Present NASA suits are cumbersome and motion-restrictive and require hours pre-breathing and special atmospheres. Efforts to develop better suits -- and thruster packs -- have fallen victim to low-priorities and mis-budgeting. *It will be up to the space tourist economy to give birth to less restrictive and more comfortable and more agile suits.* **<MMM>**



Peeping Around the Edges of the Moon

Amateur Space Telescopes at L4 and L5 Could Study the Moon’s Farside Flanks

by Peter Kokh

It would be a very interesting project, and one bound to be endlessly productive, to send a pair of remotely operated space telescopes to the two gravitationally stable areas flanking the Moon in its orbit where Earth’s and the Moon’s gravities neutralize each other. In those two locations, known as L4 and L5 [see illustration below] these telescopes would keep their station without the need for fuel.

Built to be operated by amateurs and students, these telescopes would see 60 ° around the Farside of what appears to the Earthbound as the right and left edges, or limbs, of the Moon. This would give observers a chance to chart and explore and familiarize themselves with about 67% of the back side of the Moon forever (otherwise) invisible from Earth.

Professional astronomers are much too preoccupied with the stars and galaxies, and the Moon has long been abandoned to amateurs. Amateurs able to observe much of the Farside on a regular basis, under a full range of lighting conditions, something no orbiter has done, would be sure to bring to light many features that have so far escaped notice.

The telescopes could be small. In a previous effort in the early 80s which unfortunately failed, a group at Rensalaer Polytechnic Institute in upstate New York tried to design, build, and fly as a “getaway special,” a compact 18” telescope with a Ritchey-Chretien type of Cassegrain configuration.

Such a telescope, much smaller and lighter than the Hubble, would be more than adequate to serve amateur needs and appetites for decades. The telescopes could telephotograph using various filters, and extend the scope of TLP, Transient Lunar Phenomena studies. And there could be fringe benefits in the form of very useful piggyback payloads, asteroid/comet parallax program at “New Moon” phase.

The proposed sites, the L4 and L5 Lagrange areas, have been proposed as locations for future space settlements, homes for many thousands of pioneers. But the very fact that they are gravitationally stable makes it likely that both areas are also “Sargasso Seas” of trapped dust and other cosmic debris. Both telescopes could be equipped with dust counters so that we would know, instead of being forced to guess, how dusty these areas are.

They could also serve as ComSat relays for future probes, and someday astronauts, exploring the covered sections of the Moon’s Farside. Only 33% of Farside would not be covered by their line of sight. Usable full time, 24/7/365 - untouched by Earth surface weather of clouds, haze, fog, and sunlight,. the telescopes would peer down on Mare Orientalis, the great crater Tsiolkovsky, and many other “hidden” spectacles. A University center would coordinate use among observers submitting observation plans. Sponsors could help defray the cost. The American Lunar Society, and the Lunar Section of the Association of Lunar and Planetary Observers might be very interested in such a project. **<MMM>**

MMM #143 - MAR 2001

Manned Deimos Outpost is the Key to Timely Opening of Mars

• Sometimes an apparent "detour" is the key to reaching the finish line first (fable of *The Tortoise and the Hare!*) An as soon-as-possible manned outpost on Mars little outermost moon, Deimos could:

- Deploy various probes as soon *as ready*, not just every 26 months
- Teleoperate probes on Mars in "real time"
- Serve as a Quarantine Lab for a whole series of Mars Sample Returns
- Provide up front backup support for manned landing missions.

How it would all work => below

In Focus: ⌖ Mars' Moonlets Phobos & Deimos Ripe for NEAR Clone Sequels

The ***NEAR-Shoemaker*** mission to Eros has concluded as a resounding success, returning vastly more information than planners had expected. As a Discovery Mission, the first approved, it was all accomplished on a shoestring budget.

We cannot but wonder if this successful survey of a small low-gravity world could be replicated, for even less money, this time targeted at the two small moons of Mars, Phobos and Deimos. Even less money, we say, because the engineering is already done. Al we have to do is put two more NEAR-clone craft together and send them on their way, hopefully at the 2003 mission opportunity.

The Russians sent two probes that way in 1988-89, ***Fobos 1*** was sent astray by a controller's human error. ***Fobos 2*** was mysteriously lost after arriving on the scene and taking a distant picture or two. The only "PhD" mission proposed since has been ***Aladdin***, which was not approved for a Discovery slot. *See box at right.*

Given the unqualified success of a mission to a similar lightweight destination (Eros), the time is ripe to demand that those planning the robotic investigatory attack on Mars over the next decade or so, integrate such a mission to Phobos and Deimos into their plans.

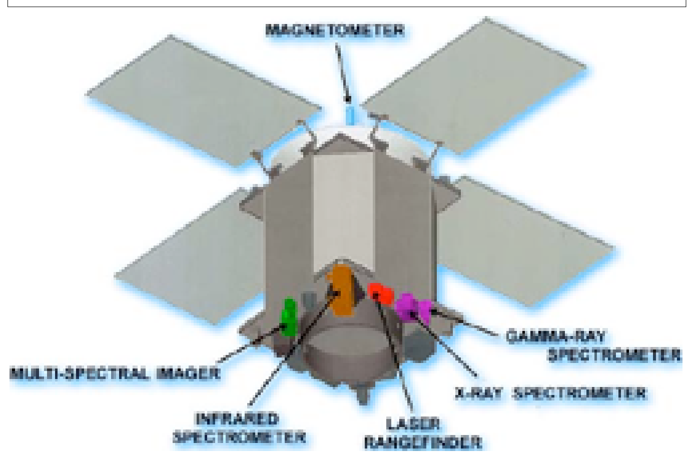
Aladdin, pegged at $248 M including launch vehicle, was a Discovery mission proposal to gather samples from Phobos and Deimos in early 2003 by firing 4 projectiles into their surfaces, then collecting the ejecta during slow flybys, returning the samples to Earth for study.

Aladdin was one of 5 semifinalists in the round won by *Messenger* (to Mercury) and *Deep Impact*.

The same repertoire of instruments carried to *NEAR* (see box below) would provide a wealth of desperately needed information about Mars' two moons. Adding or switching instruments would only add cost and delay with questionable reward. We have a winner. Just send in the Clones!

NEAR-Eros Mapper Instrument Package

- X-Ray/Gamma-Ray Spectrometer [XGRS] The X-Ray Spectrometer detects X-ray fluorescence from surface elements excited by solar X-rays. The Gamma-Ray Spectrometer detects gamma rays from specific elements on the surface, excited by cosmic rays or by natural radioactive decay.
- Magnetometer [MAG] Searches for and maps any intrinsic magnetic field.
- Coherent X-band transponder measures radial velocities of the spacecraft relative to Earth, helping to map the gravitational field of the visited body(ies).
- Multi-Spectral Imager [MSI] images target in multiple spectral bands to determine its shape, surface features, and mineral distributions.
- Infrared Spectrometer [NIS] Measures the near-infrared spectrum to determine distribution and abundance of surface minerals olivine and pyroxene.
- Laser Rangefinder [NLR] A laser altimeter that measures the range to the surface to build up high resolution topographic profiles. This data will give a global shape model of the target.



For more on NEAR, visit: http://near.jhuapl.edu/

NOTE: The Deimos Base Proposal in the following pages, bears some similarities to that of Dr. Fred R. Singer (See the References that follow our proposal) but has essential differences and was developed independently by the author. - ***PK***

Deimos Now vs. Mars Someday

The "Case for" a Forward Staging Base

by Peter Kokh

When it comes to on-the-surface exploration, there can be no question that it is much less expensive to mount a robotic mission to Mars than a human one. But a problem both approaches have in common is that the surface area covered is very small, even with rover-supported sorties into the "neighborhood" within reach from the touchdown point.

Now imagine how big a land mass we'd have if all seven of Earth's continents were recombined into one super-continent, as there is evidence was once the case some 600 million years ago. Mars is that vast! The pathetic futility of trying to explore the surface with one or even a few touchdown missions should be obvious.

All we can do is select a site that we hope offers a well-chosen sample of terrain. Imagine yourself an alien captain having to pick just one small area of Earth to explore. Which site would you choose? How representative would it be. - I'd be tempted to go with New Zealand as far and away the single most variegated compact area on Earth, but even there you'd miss so much.

"any kind of serial mission approach to the exploration of Mars will span many decades.

A whole series of missions would certainly be needed to provide a reasonably complete picture. But the problem with serial missions is twofold:

(1) The **synodic period between Earth and Mars** orbital lineups is 780 Earth days long -- 25 5/8 months, 759 Mars days That is the average time between launch windows, either going or returning, the average wait for *any kind of follow-up*. Even if the time to prepare a new mission were minimized, we'd still have to wait for a launch date. That puts enormous pressure on planners to design a follow-up mission that will address as many of the analyzed shortfalls of the current mission as possible. In effect, any kind of serial approach to the exploration of Mars, whether manned or unmanned robotic precursor missions such as those we have been conducting, becomes an effort that spans decades.

"the serial approach is a throwaway one"

(2) There are **repetitive costs** to the serial mission approach:

- Transportation out from Earth to Mars (and in the case of human crews, transportation back home.)
- No part of a lander or orbiter, even if it still works, is retrievable for reuse, however reusable. The serial approach is a throwaway approach.

The serial approach to either unmanned or human-crewed exploration of Mars has the solitary advantage of requiring no commitment. Committing to any one mission does not require commitment to follow-on missions, however desirable they should be. In the absence of more than temporary political consensus, that seems to be the only way to do things.

Each mission is designed and launched as a stand alone project out of political expediency. Each new class of leaders with short-term vision confined to reelection effort advantages, demands the right to veto or confirm all programs supported by the previous set of leaders afraid to lead. Inefficiency and mediocrity are two of the tradeoffs we habitually pay for democracy. Consensus and long-term commitment require full national discussion, an effort unlikely to ever be made. Indifference and short-term vision along with attention to innumerable vested interests conspire to make productive consensus and long term commitment unlikely.

A Manned Forward Base Meta-Mission Strategy

Perhaps it is fantasy to believe that we could do things in a more sensible manner. We won't try to touch that one. Our purpose here is not to propose a better way to "do politics," but to identify a better way to "do Mars," with a "meta-mission" strategy that:

- Telescopes the time involved
- Fractionalizes the total cost

What makes serial missions "necessary" is simply the unexamined assumption that Earth must continue to be our staging base. That mind set locks us into the stretched out timetable that the Earth-Mars synodic period between similar orbital lineups demands. And, it locks us into "throwaway" cost multiplication.

Recall the fable of "the Tortoise and the Hare." We are an impatient species. Taking the tortoise approach does not come easy. It demands an act of faith. Moving the Mars mission staging base off Earth will require such a leap of faith. At first glance, the delay of setting up such a forward base will seem to be a detour. And humans have been impatient with detours from time-immemorial. I have a plaque on my bedroom wall that says: "the contented man is one who enjoys the scenery along the detours." That is a virtue that does not come easily. Faith that the detour will get us to our ultimate goal *more quickly in the end,* is hard to assent to. We are anxious to see early milestones. Impatience comes pretty close to identifying the all-crippling "original sin."

Most Mars buffs are thus naturally suspicious of any proposal to use the Moon as a staging base for the opening of Mars. But that is not at all what we have in mind. Whether the Moon should be developed before, or in synch with Mars is not the question.

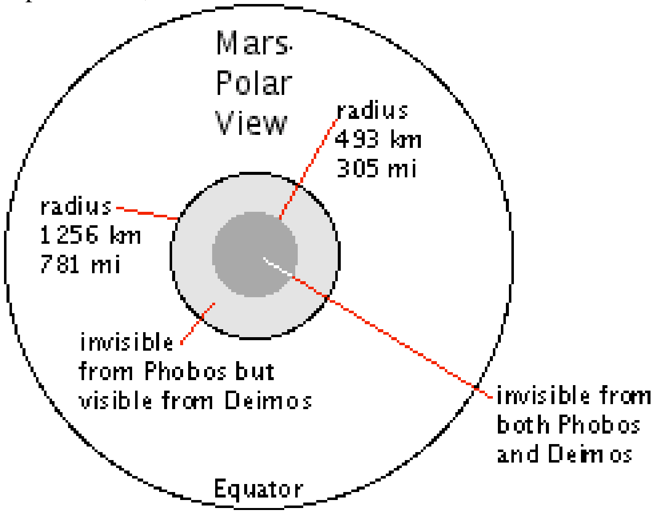
Rather, we are suggesting -- and this idea is hardly new! -- that in the long run it makes much more sense to make our number one Mars Program priority *a manned forward base* on the outer of the two Martian moonlets, ***Deimos.***

Why Deimos?

Though Deimos is smaller than Phobos (less than a third the surface area and only half the feeble gravity) and 2.5 times as far from (the center of) Mars, it would seem to provide the better perch for teleoperations on Mars.

- Deimos revolves about Mars more slowly, in 30.3 hours, but as the surface of Mars is rotating a bit faster underneath in 24.7 hours, any point on Mars is in sight from Deimos continuously for <u>40 hours at a time</u>. That would allow, for example, a telescope on Deimos to produce continuous video records of individual intriguing objects on Mars through the whole range of lighting conditions from dawn to dusk so that they can be better interpreted.

- At that greater distance, Deimos overlooks much more of Mars' near polar areas than does Phobos, some 4 million square. kilometers or 1.5 M square miles total in the two polar areas, north and south.



- Important both for using solar energy to maintain a base and for minimizing periods in which the base is out of communications with Earth, the seasonal periods in which Deimos traverses Mars' shadow cone and is in solar eclipse are proportionately shorter in length and fewer in number than is the case for Phobos.
- As tiny as it would seem to be, Deimos is sizable enough to host a base with considerable expansion potential.
  Diameter: 15x12.2X11 km (9.3x7.6x6.8 miles)
  Circumference: 42 km (26 miles)
  Surface Area: 542 km2 (210 sq. miles)
- The pulverized rock powder blanket (regolith) on Deimos seems to be substantially thicker, an estimated 5-10 meters (16-32 ft.) than that on Phobos, judging from the way crater rims on Deimos are "muted" or softened. This will make burrowing into the surface relatively easy.
- Deimos is more richly endowed with hydrates and other volatiles, an invaluable resource. These can be used for air and water, fuel production, food production, agricultural byproducts, synthetics and other essential needs. This would make for a more self-sufficient base than Phobos could support, as well as potential trade items.

Why not just a Mars Orbiting Space Station?

Okay, so Deimos has advantages over larger and closer-in Phobos as a perch. Why not just put a Space Station in orbit around Mars? Why not in synchronous orbit where it can overlook an entire hemisphere permanently? Well, we could do that. Three such stations would give u s permanent full-time global coverage. But using either Deimos or Phobos has these advantages:

- Shielding mass, from the local regolith or blanket of impact pulverized rock, would be available on Deimos or Phobos. The base could even be built in a tunnel. Shielding is very important, for there is no Martian equivalent of Earth's Van Allen belts to protect personnel in Mars orbit from solar flares and cosmic rays.
- Probes, orbital and lander, might be designed so that less sophisticated replacement parts could be fabricated on Deimos in base shops.
- We expect that rocket fuels could be processed from Deimos' regolith as well as outpost atmosphere and water needs.
- Using regolith, the base could be expanded more liberally by local fabrication of big dumb shelter units (of steel and other alloy, concrete, or glass composites) than by expensive and infrequent shipment of additional space station type modules from Earth. Imports would be reduced to compact work stations, etc.

Major Synergies with lunar Development

Regolith-based technologies needed to develop a Deimos forward staging base will be broadly analogous to those we need to open and develop the Moon.

If both these frontiers developed simultaneously, the cost of the needed R&D could be charged to, or born by both frontiers. If one preceded the other, sale of technology and equipment to the other could be a source of supporting revenue. If these technologies were field-tested and became operational first on the Moon, then the Moon could possibly support the forward Deimos Mars Staging Base by providing some of the *initial* equipment and supplies:

- Regolith-handling , processing, and manufacturing equip-ment; crude but workable solar panels
- Regolith-based replacement parts and nonvolatile regolith-based fuels for Mars orbiters and landers and on site generators, equipment, and vehicles
- Regolith-based outpost expansion modules

Deimos is comparatively will endowed in the volatiles the Moon lacks. A "pipeline" shipment plan for supplying lunar settlements with liquid methane and liquid ammonia in trade for manufactures listed above at a fuel-cost advantage for both locations over Earth-sourcing will create a natural two-way trade to the benefit of both Moon and "Mars PhD."

Advantages over Earth staging for Manned Mars Crews

We can go for a quick, cheap, and dirty human expedition to the surface. Far and away the most popular course, it has these major disadvantages:

- Even if the technologies for a human landing mission were online, the mission would be politically "postponable" until "further information" is gleaned from a stretched out series of robotic missions mounted every 26 months.
- Follow up crewed missions would be subject to the inconstant vagaries of political illogic, and could easily be delayed beyond "next" opportunities
- Deimos is easier to reach, fuel-wise, than Mars with more cargo throwweight (no aerobrake shields needed, etc.)
- It takes less fuel and less preparation and equipment to return to Earth from Deimos than from any other location in the Mars system.
- New surface missions can be flown as soon as the equipment is ready, and teleoperated in real time instead of by limited intelligence robotic AI programs.

In contrast, as the first order of business of a forward base would be to do a much more extensive robotic exploration of Mars in a greatly shortened time, the forward staging base strategy would see a permanent human encampment on the threshold of Mars years before the common wisdom strategy could hope to result in a first *temporary* visit to Mars' surface.

What it will Take

For a Deimos Forward Base we'll need the same basic equipment as for a Mars surface b ase with these differences:

- Equipment to produce volatiles (carbon, oxygen, nitrogen, hydrogen) from the regolith instead of the ISRU sabatier reactor intend for Mars surface use.
- The crew quarters should be designed as a low profile horizontal than vertical cylinder for ease of covering with regolith shielding
- Shop facilities for integrating instruments shipped from Earth into new orbiter, lander, rover, and penetrator packages for Mars.
- Capacity to retrieve orbiters at the end of their mission and salvage reusable parts
- Mission control facilities ot deploy orbiters and surface probes and to take over final guidance of incoming flights of cargo from Earth.
- Phase II: regolith processing, building materials, production, and some manufacturing facilities to enable self-expansion of pressurized volume.

The Thoroughness Argument *Our goal should be nothing less than the uncancelable opening of the Mars Frontier.*

We now are forced to make painful choices in selecting landing sites for rover probes. If a more promising site is found, we have no choice but to wait for another launch opportunity window. A Deimos base with a supply of programmable landers, would be able to dispatch them to fresh target areas in relatively quick succession.

Further, surface probes and rovers could be teleoperated from Deimos in almost "real time." The 1/6th to 1/7th second Deimos-to-Mars-surface-and-back radio signal delay is only half as much as we routinely accept in terrestrial newscast interviews via geosynchronous communications satellites.

Consider the case for Mars Sample Return. Not only would Deimos provide ideal biological and chemical isolation, and, if need be, quarantine, but we would not be stuck with sampling just one site chosen as a political compromise between geologists and Mars exobiologists. Not having to send samples all the way back to Earth,a whole series of sample return-to-Deimos-lab missions could be flown for the same cost as a single return-to-Earth mission. In a relatively short time we could do fairly representative sampling of many heterogeneous areas of Mars. As frosting on the cake, in the unlikely (as it seems to us) event that the samples contain biological agents that could prove harmful to Earth life, a quarantine lab on Deimos would be infinitely safer than on on Earth, or even in Earth orbit.

And that would mean a much better "economic geography of Mars, a much better idea of where the starter settlement should be -- not just for science purposes -- but to support industries needed for settlement self-sufficiency. After all, just ot concern ourselves with getting there is rather short-sighted. Our goal should be nothing less than the uncancelable opening of the Mars frontier.

In short, the time of preparation for a manned Mars landing, the wait before we can say the time for a manned landing is truly "ripe," will be shortened. The present "Hare" mentality promises a shorter wait but will instead either result in indefinite postponement or in a premature "flags and footprints" Apollo type "Kilroy was here" (and gone) one time program of pride and achievement, followed by ... er, nothing!

A political commitment to even a one time manned Mars landing sortie may prove out of reach. But a commitment to a long-term manned forward base on sterile Deimos can be made now. Will Mars advocates find the wisdom to switch gears? We must take the Tortoise Faith step first. **<MMM>**

Phobos - Deimos Trivia

Both of these mini-moons were discovered after a prolonged search by Asaph Hall in 1877, who was encouraged not to give up by his wife Angeline, née Stickney. Her role has been recognized by naming Phobos' largest crater after her.

Phobos (Greek φοβοσ Fear) and Deimos (δειμοσ Terror) were the attendants of the Greek god of war, Ares (Αρεσ), identified with the Roman god of war, Mars. Deimos is *Cluros* in Barsoomian (Edgar Rice Burroughs' John Carter on Mars series of novels.)

Mars looms huge in Phobos' sky, spanning 42°, 21 times the apparent diameter of the Earth seen from the Moon and covering 400 times as much of the sky. Mars spans 16° of arc in Deimos' sky, still an awesome sight.

Full Mars to Full Mars, 30.3 hours on Deimos, may dominate practical scheduling, if not timekeeping, for a manned base (35 Demos Full Mars to Full Mars periods very nearly equal 43 Mars days.) Personnel may experiment with special clocks and calendars and work schedules.

Phobos laps Deimos in a synodic period of 10.24 hours, about 3 times per Deimos day.

As late as 1960, it was possible to suggest that these might be hollow artificial worlds. Iosif Shkovskii's intriguing suggestion has since been ruled out by Viking measurements of the two moons' masses and densities. (as well as by their irregular shapes.)

How Mars came to have or acquire these moonlets is still a puzzle as the mechanics of capture (of approaching asteroids) into their present orbits seem unlikely.

The surfaces of both moonlets date from the last period of heavy impacting from solar system debris 3 billion years ago.

Both are dark (low albedo or light reflectivity) and seem similar to carbonaceous chondrite asteroids, denser than ice, less dense than rock debris. Phobos is the denser, having lost much of its original water ice or hydrates in the heat of the impact that created Stickney crater.

Tethers have been proposed to capture incoming freight and dispatch outgoing cargoes from Deimos, to further reduce Delta V needed for imports and exports.

Unmanned solar sail freighters could be used to keep shipments between Deimos and the Earth-Moon system "in the pipeline."

Life at a Deimos Forward Staging Base

Minimal Gravity or "Mini-G"

it takes ta speed of 25,000 mph to escape the grip of Earth's gravity; 5,300 mph to escape from the Moon; and only 18 mph to escape from the "gravity dimple" of little Deimos. Popular assertions to the contrary, human muscle power would not be up to the task. No one can jump with that much force (without a series of accelerating bounces of a trampoline), and with near zero traction, it would seem impossible to build up enough speed by "running."

Feeble as it is, Deimos gravity is enough to hold undisturbed items in place. "Undisturbed." That means furniture and furnishings must be securely fastened to floors and walls less a casual touch or brush send them flying. People will need velcro soles to "walk" or maintain position within the habitats, handrails attached to walls and ceiling will be useful in pulling oneself along, feet tending to drift towards the floor and drag a bit. Out-vac, on the surface, a railing system will allow personnel to zip along regular traffic routes. Pogosticks with landing pads may, with practice, become popular, but a bounce off uneven terrain could be dangerously uncontrollable. Pogosticks could help in reconnoitering unfamiliar terrain or getting one's bearings when "lost." They might also lead to out-vac sports activities: races and rallies, even slaloms.

Those who wanted to maintain muscle tone for eligibility for a hoped for trip to Mars' surface or a return home to Earth, could exercise in a centrifuge.

Other Free-time Recreation

Watching the gradually changing phases of the slowly rotating globe of Mars above will be especially interesting when dust clouds are astir. Mars viewing will be more comfortable, but also more distracting, if the Base is located so that Mars hovers over the horizon. Live surface videocams could feed electronic Marsscape photomurals in the lounge.

Getting Away From it All

To get away from thing from time to time for relief from the stress of work and interpersonal irritations, there could be a pressurized retreat "cottage" on the "farside" of Deimos where Mars will be "out-of-sight-out-of-mind; there, the Earth-Moon bi-planet, Jupiter, and the Milky Way will rule the heavens.

Tours of Duty

The Forward Base strategy will work best if crew replacement frequencies can be minimized. One perk for tour extension may be earning points for selection to the crew that will make the first Mars landing. Will it be better to pick married couples? free swingles? or monastic types? One shouldn't discount the power of faith, ideals, and dedication in allowing one to cope with extreme assignments. **<MMM>**

Phase II: A Quarantine Facility on Deimos

The initial task of a Deimos Forward base will be to deploy and teleoperate a growing fleet of rovers, landers, penetrators, balloon-borne and flying Mars probes. But long term, its ultimate *raison d'etre* or flagship capacity will be to serve as a Quarantine Facility for Mars sample returns.

The Quarantine Facility will be equipped for physical, chemical, biochemical, and biological analysis of sampled materials. A Terrarium with a wide variety of Earth life forms will be needed to test the interactivity of any discovered life forms or remains.

> It is only with such a facility, and only if it is situated on Deimos or elsewhere in orbit around Mars, that a convincingly thorough bioanalysis of Mars life forms or remains can be made.

It is nothing less than mass self-deception for Mars advocates to think that a tabloid-reading public, led by rabble-rousing fringe scientists, could ever settle for anything else.

Mainstream thought, which has been wrong before, is that we will not find surviving lifeforms on Mars. And if we do, the odds are that *they will not find us nutritious or tasty, and vice versa*. But say the worst case scenario holds true. The public would demand that an infected Quarantine Facility in Earth orbit [as called for in NASA's Antaeus Report] be destroyed, along with all its occupants, including human ones. A facility in the Mars system would be sufficiently remote. We just wouldn't ever send any replacement crew personnel. The inability to "rescue" "infected" persons on Deimos in any timely fashion, thanks to the long period between launch windows and the long travel times en route, would ease consciences. Analysis of any Mars life forms or remains on remote Deimos would "threaten" no one.

Putting the Mars Sample Return Quarantine Facility on Deimos is our only option if we want to our money's worth.

While discovery of surviving life forms on Mars may be exciting, it could very well doom all public support for human Mars exploration and settlement. One must never underestimate the capacity of the public to be irrational.

A Mars sample return facility on the Moon might be just as safe, but could not economically support a thorough series of sample returns. A lunar location, though "safer" than Earth orbit, makes no sense. To analyze one sample return or many, the cost of the facilities will be the same.

Phase III: Support for Mars Surface Operations

The Forward Staging Base on Deimos would not become obsolete with the start of manned Mars surface operations. Most importantly, it might enable rescue and recovery from potential disasters where the only other assistance was many months, or years, and millions of miles away on Earth.

- The ISRU Sabatier reactor automated fuel production plant to be landed on Mars two years before the first crew arrives could fall short in its production quota or fail entirely. The forward Base could send some of its own locally produced fuel (methane) reserves to the surface on very short notice.
- The Deimos Base fabrication facilities would be a source of some (not all) critical replacement parts for surface missions
- Its "Mission Control" could guide unmanned freight and cargo pods to on-target landings.
- Deimos Mission Control could also assist and guide manned exploratory surface rover excursions.

- The Deimos Base could provide rescue personnel (medical, systems, engineering, etc.) in short order (assuming a personnel shuttle craft was at their disposal)
- Given such a shuttle, Deimos could provide R&R (Rest and Recreation) for surface crews along with the possibility of trading crew members if needed.

In Summary

A Deimos Forward Base has " **the potential to reduce costs, accelerate schedules, and reduce risks**" for a combined robotic-human program of *comprehensive* Mars Exploration. **<MMM>**

Relevant Reading from Back Issues of MMM

◇ MMM #6, JUN '87, "Mars, as I see it"; "Mars, PHOBOS, Deimos"; "M is for Methane & 'Momonia"
republished in MMM Classic #1

◇ MMM #18, SEP '88, "The M.U.S./c.l.e. Plan for Lunar Industrialization: ¶ The Contribution of a Phobos-Deimos M.U.S./c.l.e. Plan to Mars"

◇ MMM #19, OCT '88, "Mars Option to Stay: Scenario 1: Timeline 2010: A Complete Phobos Base"
both #18 & #19 articles republished in MMM Classic #2

◇ MMM #25 MAY -89, "Podokinetics"
republished in MMM Classic #3

◇ MMM #42 FEB '91 "Locomotion: Mobility in Very Low Gravity Environments," Michael Thomas

◇ MMM #45 MAY '91 "VLG Regolith Tractors, Michael Thomas

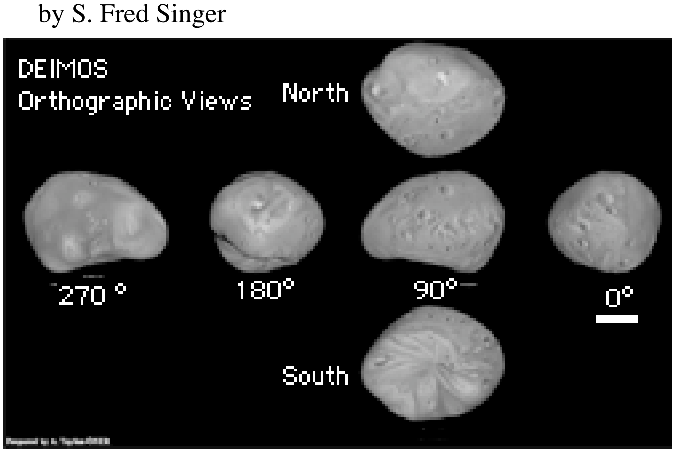
◇ MMM #46 JUN '91 "Footloose Among the Asteroids"
#42, #45, #46 articles republished in MMM Classic #5

◇ MMM #110 NOV '97 "Lunar Quarantine Facility for Mars Sample Returns, Bob Bialecki, P. Kokh
republished in MMM Classic #11

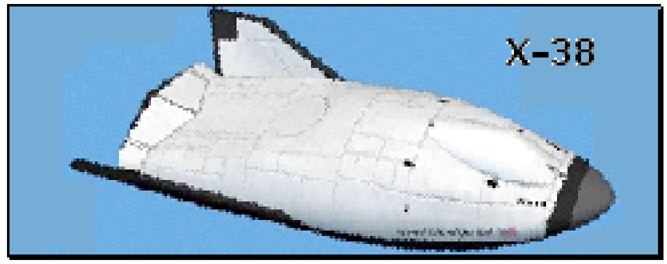
Other Readings

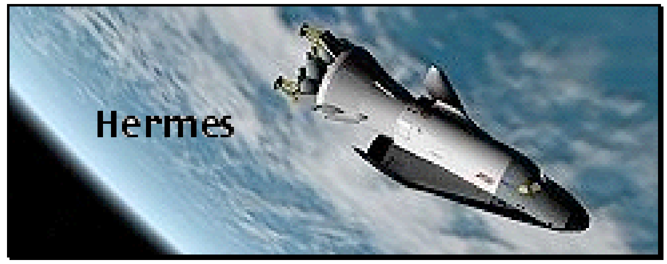
◇ "An Orbital Quarantine Facility for Analysis of Returned Samples" [abstract only. John R. Bagby, AAS 84-194 p. 701, The Case for Mars II (proceedings), Ed., Christopher P. McKay, Vol 62 Science & Technology Series, American Astronautical Society, 1985.]

◇ <http://www.scientificamerican.com/2000/0300issue/0300singer.html> "To Mars by Way of its Moons: Phobos and Deimos would make ideal staging areas," by S. Fred Singer



MMM #144 - APR 2001





Can Someone Rescue one of these "almost-made-its"?

Coastal Ocean Beaches
as Analogue Mars Topography

by Robert McGown <mcgown@teleport.com>

The blowing and shifting sand over the wet, compact underlying sands on an ocean beach may represent a good analogue for a Martian landscape. At the Mars Instrument and Science Team Meeting, MIST, Oregon L5 Society, Bryce Walden made a video that resembled an analogue of Martian topography. Many ideas came out of the discussion of the unique footage.

The ideal situation may be the winds from a North-South orientation blowing sand over semi-permanent landscape objects. This shifting sand may be an analogue of the sand and strata over the Martian permafrost represented by the undulating layers of wet sand. The sand is deposited due to a variety of factors: wind currents, mounds, obstructions, dampness, angle of deposition, humidity, grain mass, size, and shape.

Concentric rings, terracing off, may represent a Martian ice cap. T he scene resembles permafrost evaporating as each season passes. Terraced sand plateaus are scoured out, and layered ridges carved by water and sublimation. This may represent a scale of up to 1/50,000 meters for the northern ice cap in the Martian winter.

Another analogue of Mars represented by the dry valleys of Antarctica* and the ocean wet sand underlying beach sand would be as follows:

> Tongues of sand cross wet sand in a Martian mockup of permafrost and springs with overlying strata. On the sides of their steep ridges, processes take place such as mass wasting as the sand peels off the hillside and slumps.

Blowing sand moves along the surface at different rates according to grain size and weight. The black Hawaiian sand will layer differently than the fine windblown sand. On Mars, the black sand streaks across the grooved ridges display sand stratification. On Earth, from the terraced low point to high point there might be a two foot difference in elevation on the contoured coastal beachhead with some 40 terraces. This observation was made by observing coastal sand terraces on the southern Oregon coast.

Grooved channels and tributaries represent an analogue model on Earth, of the great Valles Marineris carved by slumping, wind, and water. Although the present Martian canyon building process is unknown, there are similar land form models that may be created by these processes. When water reacts with dry beach sand, it is capable of carving our escarpments, possibly similar to the escarpments and channels seen on Mars.

The wind blowing past an object is like a Martian volcano creating its own weather. Water mixed with sand washes layers upon the shore as if it were flood basalts of an ancient volcano. Sand guilds up on the flanks as the wind wraps around the obstruction in the sand. A similar process takes place on its flank and lee sides; sand particles build up as the seasonal dust storms shape erosional processes on Mars, leaving the uplifted hills and formations to be sculpted by blowing sand.

As a final thought on the exploration of Mars, The Planetary Society proposed a Mars Balloon to be carried adrift by the Martian winds, dragging an umbilical cord "snake" with scientific instruments. In the blowing dust of Mars, perhaps nanoprobes spread by the wind -- Smart Dust" -- would further the future exploration of Mars.

References:

Smart Dust ref V+Cheryl Lynn York
Oregon L5, Mars Instrument & Science Team
Gus Frederick Chair, Tom Billings, Robert Mcgown, Bryce Walden, Cheryl Lynn York

The Rivers of Mars, Aurum Press, 1977 Piers Bizony

Uncovering the Secrets of the Red Planet - Mars,
National Geographic Society, Paul Raeburn, Matt Golumbek

• **<RMG>**

Stay-at-home Shadow Settlers

Forging a "Critical Mass" of Brains & Skills by TP - "Tele-Participation"

by Peter Kokh

From time immemorial, those who would set out to pioneer new territory were very much on their own. If they found that they needed something that they had not thought to bring with them, they either had to provide it from scratch where they were, or do without. They were also limited by their own skills. It was a rougher world, and only the most resourceful became established in their new homelands.

Gradually trade arose and neighbor peoples could share tools, goods, resources, knowledge and skills. Trade burgeoned, leading to a widely shared and richer material and cultural civilization base.

Today we have the telegraph, telephone, radio, television, and the Internet. Undersea cables, microwave towers, and communications satellites make the shunting of information flow easy and virtually immediate. The space pioneers of tomorrow, at least those who pioneer within reach of this overmind, will have a leg up on their predecessors.

Settlers bound for the space frontier will not be able to succeed with the much simpler tools and skills that allowed earlier generations of pioneers to prevail. The shores across the space ocean are alien by any standard of common human experience.

Yet the pioneers will be few, their settlements small. How can a few people -- a dozen, a hundred, or even a thousand -- possibly possess the critical mass of skills needed to accomplish their phase b phase goals in any reasonable amount of time? The solution is simple. The people on the front lines, actually at the outpost location, can benefit from virtually real-time teleparticipation of many more talented people on Earth -- "shadow settlers" if you will.

Two preview cases in point

You have probably seen the very successful 1995 Ron Howard film *Apollo 13* staring Tom Hanks, Kevin Bacon, and Gary Sinese. Two days before the launch, Ken Mattingly (Sinese) was forced to stay behind on Earth because of possible exposure ot measles (which he never got). This proves fortunate for all as Ken saves the day when the *Apollo 13* crew faces almost certain reentry disaster. Ken works in the simulator until he finds a way for the crew to pull off the reentry sequence with the 16 amps of power available in the crippled Command Module.

Prior to that, the *Apollo 13* crew is saved from suffocation in their own carbon dioxide when a surface team figures out how they can mate the more powerful square scrubbers in the Command Module with the round ones in the LEM, using only stuff they are known to have on board.

ot just for crises -- the ongoing struggle

But as important as a ground team with real time access is in crisis situations or repair and rescue, there is much, much more to be gained from a shadow team than that. The frontier is a place where almost everything we knew how to do back home does not work in the new setting. We have to find new ways to do almost everything. We have to learn to do without many of the things which we have always taken for granted. We have to learn how to confront new dangers and risks and to respond to them as if by second nature. Here are some of the areas in which the two few people on the frontier will need backup:

- power systems dayspan & nightspan
- pressurization problems & emergencies
- dust control
- field equipment maintenance
- inventory management
- biosphere management
- water and air recycling systems & quality
- thermal management & humidity control
- agriculture, food production, crop health
- waste processing, management, recycling
- sound/acoustical management
- exploration & field science
- prospecting & mining

- processing & chemical engineering
- manufacturing
- operations scheduling dayspan/nightspan
- construction & expansion
- engineering & automotive challenges
- fabrication of new items & repairs
- paperwork & bureaucratic necessities
- social interaction problems
- stress problems
- medical situations: illness & trauma diagnoses
- arts & crafts media development
- documentary production & broadcasting
- continuing education

On the frontier, despite the complexity of the problems and challenges we face, we will always be in short supply of people to throw at them. It would seem a hopeless task. To meet an unprecedented flood of new challenges with way too few people.

We cannot afford to put a critical mass of skills and talent on location in the near term. So how are we going to meet the challenges "anyway?"

The answer is that we only need a few people on the front line, in direct contact with the situation, so long as they have immediate and continuous access which can be anywhere that the means of "live" real time communication can support. For those trying to establish a lunar frontier settlement, shadow teams on Earth will do just fine.

If all we need is your brains, not your hands, you can help from Earth, just 3 radio response seconds away from Lunar Nearside.

Brain and Hands -- *mente et manu* -- as it summed up in Latin. We need both in the real world, but not always in the same degree of immediacy. Many problems yield to real-time brainstorming by a team of experts. So long as they have all the particulars, so long as they know the special and peculiar circumstances that affect the situation on the Moon, so long as they can converse and gesture and draw with a virtually real-time interplay, they don't have to be physically present.

Of course, there comes a time to call an end to brainstroming and to make decisions among options. In the early phases, "Mission Control" on Earth will insist on having the last word. Eventually, those on the front line, whose fate lies in the balance, will prevail in the thumbs up/thumbs down decision. It is they who must make the solution work, they whose lives are on the line. As the settlement grows and with it a stable, permanent population, the move to "home rule" will be inexorable.

And for those extras necessary for morale

We have spoken before of the vital role development of frontier arts and crafts will play in getting the pioneers to "feel at home." Once they can express themselves creatively using local materials and resources, in however crude, amateurish, rustic, and experimental sort of way, that will make the frontier seem that much less alien. The support of a host of artists and craftsmen at home supplied with lunar materials to help identify by trial and error what will work will greatly speed up the rise of lunar art forms.

the thing to remember is that while in theory, the media stuffs with which to paint, make art glass, pottery and ceramics and sculpture exist on the Moon, they will take some tim to develop local sources of ready-to-use ingredients. Nor will these all come on line at the same time.

This means that we can expect "Periods" in each of these lunar art forms in which artist and craftsmen struggle with less than they would like to work with. It will take a great deal of patient experimenting, often without the rewards of success or the sense of progress before there are satisfying results. Now the pioneers will have limited free time for this.

If much greater numbers of artists and craftsmen on Earth can be turned loose on lunar simulant materials, even on some of the real stuff to lay with, they might be able to advance some primitive lunar-appropriate art forms suitable for each phase in the development of local sources.

This will free those on location to begin producing real art, however primitive, and to practice refining their personal styles instead of getting discouraged, spending too much time with experiments that could have been done beforehand.

This is essential. for the sooner outpost pioneers can produce creations from local materials, the sooner will the pioneers begin to feel "at home." In the long term scheme of things, the battle of morale is as important, if not more so, than any other.

Other artists could test our art forms the pioneers could try using waste biomass products from the planned agriculture unit. They might even recommend the inclusion of certain plants on the merits of especially useful products and extracts.

Still others could take a look at other waste and surplus materials accumulating in the outpost and suggest ways artists and craftsmen could use them creatively. These can include scrap metal, metal fittings from the machine shop, waste packaging stuffs and more. Waste not, want not. perennially, cash-poor artists have always been especially creative with materials that are laying around "free."

For inspiration, check out these pages online:

- http://www.lunar-reclamation.org/art/
- http://www.lunar-reclamation.org/laamp.htm
- http://www.asi.org/adb/06/09/03/02/091/waterglazing.html

Who goes to the Moon? Who stays on Earth?

The too easy answer is that those who are best with their hands are needed on location, while those who are best with their brains can provide adequate support from Earth. Of course we don't need a bunch of dolts or automatons on the frontier. In fact, those on Earth must be able to go through the motions of whatever it is that those on the Moon are trying to do. And those on the Moon need to accurately describe their problems. We need brains and hands in both locations!

Those with a lot of back-up knowledge and related hands-on expertise can coach form the rear. With high-definition television and with teleoperated controls equipped with sensors that provide tactile feedback, stay-at-home experts will have all the immediacy to the situation that they need to assist effectively.

The virtual shadow outpost.

Nor will all the shadow settlers have to be physically in one place. As long as they can videoconference, in most situations, that will work fine.

There will, of course, be need for Mission Control problem solving clusters of technicians provided with physical simulations of the problem areas at issue: equipment, controls, systems, etc. For example, in the *Apollo 13* example given above, where a team had to figure out how to connect A with incompatible B given the spare equipment and items and tools actually available on location.

Back on Earth, there will be an all but endless pool of people to throw at trial and error problem solving -- to free the few pioneers to try pretested methods and effect solutions. If all these people were actually on the frontier, it would be hard to keep them busy and earning their tickets. It is no problem to keep a pool of people on call, on Earth, without a situation of "too many cooks spoiling the broth."

Settler Recruit Training Camps

We can assume that there will be a settler recruit training camp, or if "settlement" is not yet the operative word, a training camp for those hoping for duty assignments in the lunar outpost(s). These men and women will be especially motivated to assist those already on location by simulation exercises, pioneering and debugging new ways of doing things, lunar appropriate art forms, lunar-style agriculture and horticulture, and ... the list goes on.

The recruits can tackle items that have not come up yet, to help prepare for when they do. They are likely to train in an Earthside near duplicate of the lunar outpost where simulations in realistic lunar situations can be run.

They can help with paperwork and bureaucratic duties, working on data and files emailed from the Moon, in order to free up those on the Moon for get-your-nails-dirty front-line tasks. They can be available for Internet chat or radio/TV jam sessions. They can do other remote support and service tasks. The important point is that in the recruits we will have an eager population that does not need to be paid in cash or credits for their work on behalf of the people already in the lunar trenches. Of course, their diligence will be duly noted when it comes to final selection time for the next transport out.

Spinning-Up

In previous articles and editorials [e.g. MMM #65, "Career Choices in "Spin-Up" Industries"] we have tried to push an important piece of space counterculture: "spin-up" as opposed to "spin-off." Instead of extremely expensive crash programs to develop technologies needed on the frontier, then justify the expense to the masses on the merits of alleged "spin-off" goodies, we could take an entirely opposite approach.

We look at the new technologies we will need on the frontier at various future stages. Next we brainstorm these technologies for possible profitable terrestrial applications, and develop business plans to develop them on that basis. The idea is to make money now with the frosting being that we will be putting "on the shelf", technologies that can be used as is. adapted to the frontier when we need them. Some examples:

- **glass-glass composite technologies** (possible Earthside markets: high end furniture; architectural elements; boat hulls, etc.
- **"poor-ore" mining technologie**s (would allow nations "poor in mineral resources" to stand on their own.
- **dry water-free or water-reduced processing technologies** (would help save the environment by reducing toxic runoff)
- **clay-free silicate ceramics**
- **water stingy concrete (steamed concrete)**
- **small, modular sustainable biospheric systems**

One could brainstorm endlessly, just looking at the challenges pioneers will face in trying to build a self-reliant industrial lunar settlement.

While this is certainly an important way that would-be entrepreneurs can help pave the way, it is a much more ambitious and long-term commitment than the kind of "shadow settler" activity we are trying to describe in this article.

The com link -- the most vital tool of all

The contribution of shadow settlers will only work via the "com link" which thus becomes the one most essential system, the backbone system needed for establishment of beachhead communities beyond Earth. Call the com-link the "umbilical cord." if you will. Call the stay-at-home BLM solving matrix of shadow teams the "placenta." Call the actual settlement in the process of becoming established on location the "fetus."

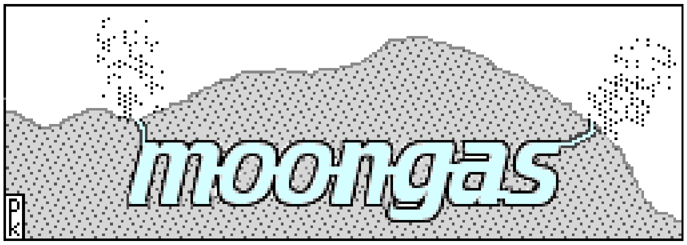
The settlement's weaning from this teleparticipation will be gradual, as it grows, becomes more confident, and successfully handles ever more of its problems and challenges on its own. To make a settlement self-reliant and viable, you need a large critical mass of skills and talents. In the period where it is just getting established, we can expect to have only a nucleus of such a critical mass on location with the bulk of the rest contributing from 3 radio response seconds away.

That works for the Moon. What about for Mars? The Martian pioneers will not be able to engage in "real-time" brainstorming sessions with their counterparts and expert support teams on Earth. Given the 6-40 minute response time that will never shorten, the best we can expect is the less intense level of brainstorming that goes on in email discussion groups. Earth-based and Mars teams can trade video monologues. It will be cumbersome. If there is a forward base on Deimos, the people stationed there can be of some limited real time assistance. Martian settlers will be operating at a distinct disadvantage in comparison with the Lunans.

Recognition

Certificates, awards, plaques, ribbons, and medals should all be considered for awarding to those who perform this yeoman support service on Earth. These people, whatever their field, will be vital parts of the settlement team as it attempts to establish a successful beachhead on an alien shore. That they remain physically on Earth does not lesson the importance of their work.

"Honorary Citizen of Luna City" -- "Pioneer at large" -- "Ancestor of Lunan Settlers" -- such titles might be awarded in recognition of outstanding service with suitable public ceremony and recognition. The names of those so honored should be inscribed in memorials within the settlement. As the old saying goes, "they also serve who only ...." **<MMM>**



or "As the Moon Burps"

by Peter Kokh -- Sources:
http://www.spacer.com/news/lunar-01b.html
http://www.spacer.com/news/lunar-01c.html

David Darling ALS TLP Project
<daviddarling@daviddarling.info>

MMM #31 DEC '90 "Moon Glow" [incl. in MMMC #4]
Alan Binder (personal conversations)

The Moon seems totally dead. However, Apollo mission scientists, suspecting that there might be some residual outgassing from the Moon, equipped the Apollo 15 and 16 Command Modules orbiting the Moon with alpha particle spectrometers to detect radioactive emissions from any traces of radon gas that might be coming from underground decay of uranium, and released through lunar surface vents as part of(comparatively) bigger flows of more orthodox gases such as carbon dioxide or argon.

Meanwhile, for decades, amateur observers have been reporting fleeting, non-permanent local changes in color (reddish) and shade from various areas, most notably around the craters Aristarchus and Alphonsus. These temporary changes they noted as "Transient Lunar Phenomena" -- TLP.

Lunar Prospector was equipped with an alpha-particle spectrometer to follow up on these earlier indications. After much work in the past two years sorting out the faint signals from the unexpected amount of noise coming from the very active Sun during the *Lunar Prospector* mission in 1998-9, scientists have identified the signatures of two radioactive gasses: radon and polonium. These gases are produced as byproducts of radioactive decay of uranium, an expected component of the lunar crust, as it is of Earth's crust.

Fractured Crust and Trapped Gas Pockets

The upper 10-20 km (6-13 miles) of the Moon's crust is fragmented and fractured, allowing trapped gasses to leak out over the eons. These leaks increase during moonquakes caused by continued settling of the lunar crust or by fresh impacts. At some deeper level in the crust there may be high pressure pockets of gas left behind as the solidification of the crust advanced downwards. This should include carbon dioxide, carbon monoxide, and other volcanic gasses.

Bear in mind, that lunar volcanic gasses will be dry, without water vapor, and given that the Moon is less oxidized than Earth (note that iron is present on the Moon mostly in ferrous rather than ferric form), we would not be surprised if carbon monoxide, rather than carbon dioxide, is the dominant gas. There could be sulfur and nitrogen compounds also.

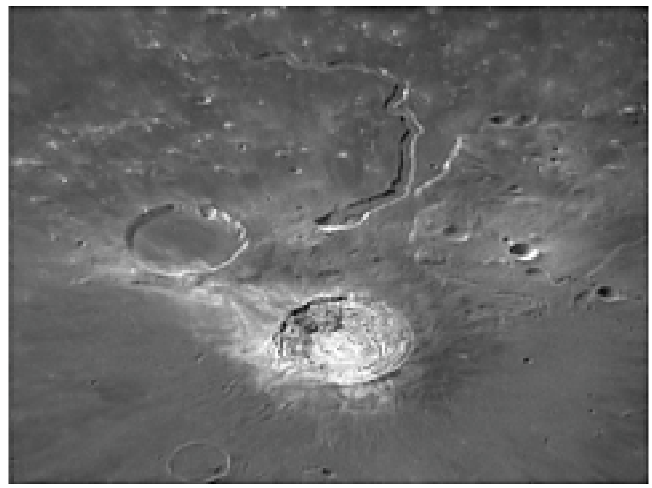
Scientific Significance: Uranium

Of course, lunar scientists are interested primarily in the "scientific" significance of the new readings: they confirm the expected presence of uranium in the crust. Another *Lunar Prospector* instrument, the gamma ray spectrometer, had traced abundances of another radioactive element: thorium.

Radon 222 and Polonium 210 each have distinctive signatures. As radon has a half-life of four days, while polonium has a half-life of 21 years, sniffing radon indicates very recent outgassing, while detecting polonium indicates activity within the past two decades. Based on *Lunar Prospector* findings, uranium deposits are more widespread, particularly below the Nearside maria, than had been thought.

Prime Locations:

The region around the crater Aristarchus seems to show the most activity, and this has been long suspected. Aristarchus looms as the prime destination for a future manned geological mission (before Nixon canceled it, Aristarchus was the intended target for Apollo 18.)



Aristarchus: the brightest spot on the Moon, is a crater 40 km (24 miles) across, at 23.7°N, 47.4W. The tad smaller crater with the dark mare-filled floor is Herodotus. Schroeter's Valley is the very large lava-carved rille.

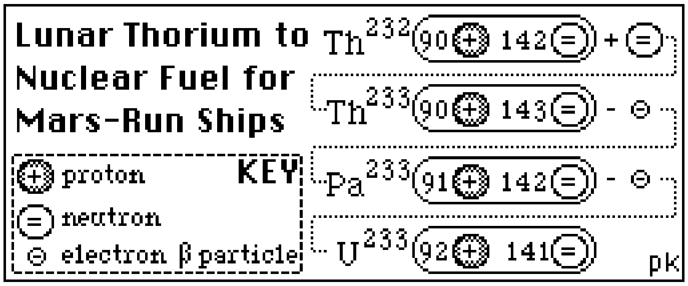
Other emission areas are Mare Fecunditatis (Fertility) and around the Sinus Medii (Central Bay.) As expected, no traces have been found over the farside, where the lunar crust is especially thick.

Economic Significance: Uranium

Those of us who see the continued scientific exploration of the Moon as vital to laying the foundations for future industrial settlements built upon lunar resources, can be forgiven if we are not that excited about radon and polonium. Their industrial significance is relatively slight.

Uranium is a different matter, though it remains to be seen from "ground truth" on site prospecting how rich these deposits are, and whether a future lunar nuclear fuels industry will be base on natural uranium, or upon the Moon's abundant thorium deposits.

On Earth, thorium is much more abundant than uranium and we can expect the same ratio on the Moon. There is more potential energy in the Earth's thorium reserves than in all the world's fossil fuel reserves combined: coal, oil, gas, tar, shale, methane-rich sea bottom oozes, etc. This is because thorium can be processed into fissionable U-233 in a fast breeder reactor. [MMM #116 JUL '98 "Uranium & Thorium on the Moon;" MMM #123 MAR '99 "Lunar Thorium: Key to Opening Up Mars" - these articles have been republished in MMM Classics #s 12 and 13 respectively.]



The choice between uranium and thorium as nuclear feedstocks will depend on several things: location, richness of deposits, ease of mining, safety, capital equipment investment needed, and production goals. At this stage of the game, it is our best use of effort to advance definition of both options, rather than risk a premature pick of the winning route.

Economic Significance: Other Gasses

In the near term, the most important find would be trapped gas pockets rich in nitrogen and/or carbon. Both elements are critically deficient in the lunar regolith, despite some fraction contributed by the solar wind over the eons. These elements, rather than hydrogen, may turn out to be the "pinch-point showstoppers" for extensive lunar settlement and development.

While it is very likely that a "ground truth" probe to the suspected lunar polar ice-deposits in permanently shaded craters, will find that the water-ice has included carbon and nitrogen ices -- after all, the source of these polar deposits are comets impacting the lunar surface over the ages -- it will be most encouraging if future prospecting and drilling finds trapped subsurface gas pockets of volcanic origin with economic concentrations of carbon monoxide and nitrogen. (Carbon dioxide would be a surprise while water-vapor or steam and methane would be most unexpected.)

Currently, we cannot detect such gasses with orbiting instruments. We'll probably have to await onsite drilling in promising areas where radon and polonium leaks have been documented. Meanwhile, we can hope for the best.

Confirmation of tappable carbon oxide and/or nitrogen deposits would lift many of the constraints under which we now expect lunar settlement to struggle. If we have to be stingy with nitrogen which we need primarily as a buffer gas for breathable atmosphere, we can expect the following consequences:

- lower atmospheric pressure standards with reduced nitrogen partial pressure
- lower ceilings to reduce the total tonnage and cubic feet of nitrogen needed: forget those domes and other vaulted ceiling megastructures

If carbon is only available from solar wind deposits in the upper layers of the regolith, we can expect that:

- tax and other disincentives to "withdrawing" carbon-rich items from the biosphere and food production cycles: wood will be priced like gold or diamond: paper, plastics, organic and synthetic fibers will be restricted to uses for which there are no substitutes -- one spartan scenario is cotton for underwear next to the skin but fiberglass for outerwear, anything not next to the skin
- incentives to develop silicone-rich substitutes, all of which still have some carbon, though proportionately less.

However, there is a good chance that we will find comet-derived carbon-bearing ices in the polar water-ice deposits: frozen carbon monoxide, carbon dioxide, methane, as well as nitrogen and sulfur oxides. If this is confirmed, the above spartan conditions will already begin to be relaxed.

But other than polar-cold-trap and gas-pocket sources of carbon and nitrogen, the lunar pioneers will need to foster trade with outposts on Deimos or Phobos, for example, or other cheaper sources that the bottom of Earth's gravity well.

If we can't use radioactive tracers like radon to detect carbon oxide gas pockets, how might we go about it? Ultra-sensitive gravimetric sensors able to map even slight negative mascons may be a help. We might also station carbon and nitrogen sniffers all over the place and hope to get lucky. Future lunar prospectors will be looking for more than ores.

<MMM>

Mail For MMM

on Mars Time woes

04/03/2001. Here it is the third morning after the annual Spring ritual - the switch to Daylight Savings Time, and I still can't get used to having to go to bed an hour later, and stay in bed an hour longer! That may seem strange. or even weird, but then I am one of those minority outcasts -- a morning person! And, as a senior, it seems that most of the adaptability I once had has atrophied.

So seeing as how on Mars, each morning comes 40 minutes later than the one before, judging by the 24 hour day with which humans have evolved, it would be a lot like advancing the clock every day, not just once every Spring. And those changes are going to keep piling up. By my calculator, they will amount to one whole day (less, compared to Earth) every 37 days, or in the space of a little more than 5 weeks.

So unless they come up with a jet lag pill with no side effects, like dry mouth - hate that!, I guess that washes me up and out of the candidate roster for the first Mars Mission.

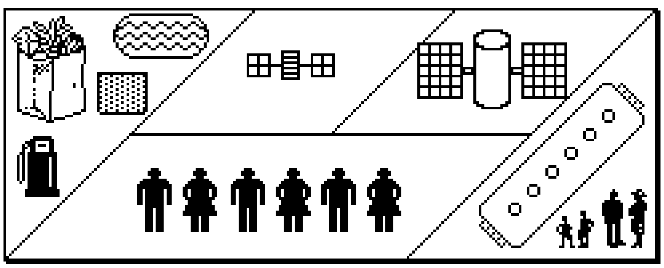
Morning people can't wait until it is time to jump out of bed and get the day started. And older morning people are really a problem. Potential recruits for a Mars Mission should be forced to live by a Mars Time clock during training so that we can wean out before it is too late, those who are not able to adopt well. I am sure there will be enough night people for whom this regime will be sheer heaven.

As a long time reader of MMM< I seem to remember you doing an article about a calendar for the Moon way back, in which you pointed out that all it would take to keep alternating 28 and 29 standard *day months in line with the actual pace of the solar month on the Moon, is a one hour adjustment every 6 weeks or so. Now maybe I could handle that. Plus I've always wanted to stand on a crater rim, with my cane (don't have one yet) looking back at that beautiful globe of swirling blueberry ice cream - Earth.*

I remember you also writing about how we could make use of seniors in the settlement. We do have to start thinking along those lines as what kind of settlement could we have with just people in the prime of life? Ways to integrate the young and old in the productive chores of the settlement are important. There are no polar bears up there to take care of (dispatch) those over the hill!

Tom Heidel, *Milwaukee*

MMM #145 - MAY 2001



Cheap Access to Space for What? It Matters!

What do we want to transport to space? Commodities like water or iron ore which can be sent in variably sized portions? Hundred kilogram micro-sats? A satellite weighing several tons? Human passengers - alone? Or people and cargo both? Large habitat modules? For each case, their could be a different "cheapest" and/or "safest" solution.

Murphy Beds & More on the Space Frontier

Multi-Function Living Spaces in Space Frontier Private Quarters

by Peter Kokh

At the current "toe-in-the-water stage of "space settlement," "personal quarters" are spartan to say the least. Aboard the shuttle orbiters, sling hammocks attached to a handy wall are as coddling as they get. Aboard ISS, telephone-booth-sized personal berth cubicles are still just a promise, given the recent cancellation of the U.S. Habitat module.

Crew tolerate such conditions well for the relatively short periods of time they are on location. Given ample experience in submarines and other naval ships, that comes as no surprise. Yet astronaut duty is not supposed to be military duty, and morale is not served by lack of private quarters for people on extended tours. We are each private persons and need periods of time and reserved spaces in which to escape from duty and communal life.

"As soon as it is practical to do so," spaces each can call his or her own should be provided. Places one can decorate with items of personal value and fitting personal taste. Places in which one is king or queen - cubbyholes in the world which are extensions of ourselves. Places in which no one else is welcome uninvited. Places which are not *common.*

At first the mini-berths planned for the ISS habit modules will do. Indeed, they will be an enormous improvement. At the other extreme, long down the road of maturing space settlement, we may someday be able to provide ample living spaces for pioneers built in modular fashion from locally produced building materials. Here, on the Moon or Mars, as expansion of pressurized structures is difficult, it will be wise to provide at the outset, all the square footage a large family might want, growing into it over time, finishing it off as needed, renting out unused space being an option. [box, top next page]

While this should be the carrot we hold before ourselves, we are not going to reach that state right away. Living Spaces will be much smaller than current North American standard (750 sq. ft. per person). This may take some revolution in the way we handle floor space today. It is common in American homes for each function to have its own dedicated space or room, whether that function is exercised for several hours a day or infrequently. It does not concern us that most of the space in our homes is unoccupied most of the time. It is there when we want it. That is the kind of luxury which we are unlikely to be able to afford on the early frontier.

The Size of Lunar Homes - the "Great Home" Concept MMM #75, MAY, 1994, pp. 4-6. "A Successful Lunar Appropriate Modular Architecture", page 4: [republished in MMM Classic #8]

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.

The extra space could come in handy for startup cottage industry before the new enterprise is 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.

Time for an attitude change! Take a look at the various rooms in the usual types of homes or apartments. Part of the floor space in each room is occupied by items that make the room what it is:

• beds, etc. in bedrooms
• cabinets and appliances in kitchens
• water closet, sink, shower/tub in bathrooms
• table and chairs in dining rooms
• sofa and easy chairs in living rooms, etc.

The space not occupied by such furniture and furnishings is for walking around and through. In the “efficiency apartment” or “studio”, in which some of us have paid the dues of our “independence,” the idea is to provide the furniture in compact interchangeable ways, sharing common floor space, in a multifunction space. The room will have a day bed, a futon, a sofa-bed hideaway, that provide living room seating by day, reasonably comfortable sleeping by night. The kitchen will be all on one wall, or at most, a small “galley”, enough for one at a time use.

In short, an efficiency is a single room or room and a half with bath, in which all the walk-around space is shared, and the furniture is either compacted or multifunctional. One space serves as bedroom, living room, dining room, etc.

Perhaps the epitome of efficiency living is the Murphy Bed* or “wall-bed”, a full-size bed which pulls down from a wall-cabinet or closet. When not in use, it is out of sight, taking up only hidden space.

There are also dining room sets which fold up into small consoles that can be used as desks. It is this kind of inventive multi-functionality that may shape frontier private quarters in the early periods. By today’s standards, such compact “efficient” living, hardly meets “dream home” standards. But in fact, compacted multifunction living space just takes a little getting used to. It provides privacy, supports all one’s at-home activities, and becomes a sanctuary in which we can express our personalities.

Call it 3-shift usage of space. Where space or equipment involves high capital cost, the only way to make it affordable is to see that it is used as in as time-intense a manner as possible. Thus on the space frontier, we’ll need to shed our current unexamined dayshift chauvinism to arrange living, work, and play patterns so that facilities as factories, schools, parks, and other common spaces are in use around the clock. That brings down their per hour cost of use to a third. Or, conversely, we then need only a third as much factory capacity, school rooms, parks, etc.

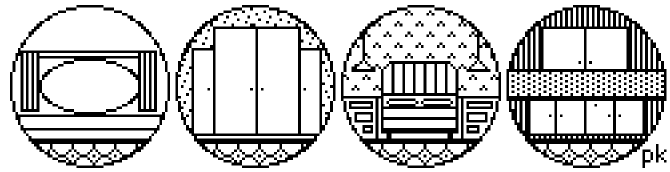
For our private living quarters, it may be our only affordable option to adopt a similar philosophy of squeezing the most livability out of minimal space. We are used to efficiencies for singles. Adapting the concept for families will take some doing.

Pushing the concept to the fullest, each wall would hold the collapsed elements to serve a particular room usage. These would extend, pull out, or pull down to turn the common floor space into a specialized living space. There would be a bedroom wall, an office-den wall, a living room entertainment wall, a closet/storage wall, plus a semi-separate “necessary room” pullout.

A vertical cylinder shaped module could have an internal hexagonal shape with six “roommaker” wall units (not of wood!) Exercise centers and additional guest bedroom walls are options. Not every efficiency home need be the same!

One thing is sacred. To serve as a home a dwelling must be able to express the personality of its occupants. It must be customizable both as to its external façade and as to its internal decor. In that respect, homes on the frontier will be no different.

Habitat module end cap options from MMM # 75



Some of these ideas may prove impractical or only be realized in less than satisfactory fashion. Nonetheless, this may be one direction in which early pioneers will have to exercise their resourcefulness in search of some of that “home sweet home” contentment and satisfaction. From time immemorial the humblest of homes have been homes nonetheless, serving to anchor the lives of those it harbors.

On the Moon and Mars we must start somewhere. How could those going first be ‘pioneers’ without some great hardship to describe to their grandchildren? **<MMM/>**

* The Murphy Bed

William L. Murphy, born in Stockton, CA in the late 1870's, moved to San Francisco at the turn of the century where he met his future wife. He lived in a one-room apartment with a standard bed taking up most of the floor space. Because he wanted to entertain, he began experimenting with folding beds, applying for his first patent in 1900.

The "Murphy Door Bed Company" came into being that year. The first folding beds were manufactured in San Francisco. In 1918, he invented the pivot bed which pivoted on a door jamb of a dressing closet, and then lowered into a sleeping position - many of which are still in use today.

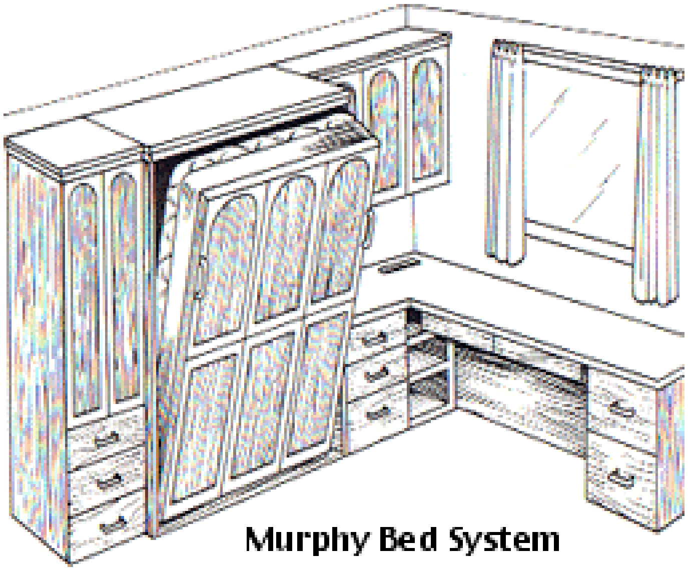
http://www.murphybedcompany.com/history.html

animated gifs of a wall bed opening and closing
http://www.wallbed.com/images/bav6.gif
http://www.wallbeds-cabinets.com/animatedwb.gif

In 1928, Murphy Door Bed Company began manufacturing compact kitchens, called Murphy Cabinettes, and is still doing so today.

During the 1920's and 30's, the popularity of both the Murphy Bed and compact kitchens was high. After WW2 Individual homeowners were not interested in space saving products because of their ability to buy larger homes relatively easy. But the 70's changed this attitude - how to make the most of limited space -- as families found it too expensive to move to larger homes,

Murphy Beds or wall-beds have gained new popularity in fire houses, hospitals, dormitories, and hotels. Homeowners purchase them for double duty guest bedrooms/sitting rooms, dens or media rooms. Often the Murphy Bed is purchased as part of a an office/entertainment wall system. One company offers the mechanisms so that you can build your own -- www.wallbed.com/



The Independent Lunar Farmer

by Peter Kokh

Peter, I'm thinking, about Communities in Space. Is there a Bachelor Farmer equivalent on the Moon in 2050? How do the low-tech families earn their living? Does <earn> mean what it does here and now, when you have to earn air and water as well as food and shelter? Who subsidizes?

David Anderson, Abingdon, VA

Readings from MMMs Past:

MMM #13 MAR '88 Rural Luna
MMM #85 May 1995 p 7. FARM TARNS

The Moon is 14.5 million square miles of quintessential rural boondocks. A settlement or two or three will not change that. There are a lot of other places to hunker down, if one is bold enough, or "foolish" enough, to try to go it alone. Civilization will cluster tightly around the main settlements and the roads that connect them.

Safety and survivability will increase with numbers, and the Moon may always be highly urban. That said, one must keep in mind that a lunar city must "include" the farms necessary to produce its food and fiber, and maintain the quality of its air and water. The lunar city will be "whole" as no Earth city has been before. (Island city-states such as Singapore and Hong Kong offer faint analogies.)

But if one were to set up a private farming operation with a small band of determined pioneers, it would be foolish to locate far off the beaten path. It will take a large pool of people to make any reasonable quorum of the necessities of life on the Moon. If that population is split between communities, some major, some small, all of them had better be linked by regular trade routes.

The smaller the community, the more likely it is to experience an emergency that it does not have the wherewithal to handle. Equipment will not be so simple that a local blacksmith can make do. The farm must be successful enough to sustain its own biosphere, something every terrestrial farmer takes for granted as a given. The farm must maintain not only the quality of its atmosphere and water reserves, but the integrity of its pressurization envelope or hull.

Needs can be kept simpler than in the towns and cities, but not so simple that a lone nuclear family could manage them. A rural farming operation would stand a better chance if it has a couple dozen working adults at the minimum. A superfamily commune might work. Or a localized cooperative cluster of nuclear family farms might thrive.

Another possible formula, for those with the right special stuff, is the monastery farm operation. Monasteries can be sizable communities of highly motivated individuals with minimum needs for gratification from consumer goods.

The essential requirement is a critical mass for a viable biosphere, and for the mix of necessary chores. The smaller the farm "family," the more overburdened with chores will each member be. The original goal, a satisfying life, may be a casualty.

The critical difference with the situation on Earth, is that, on the Moon, one cannot "live off the land." The land is not "fertile" as is. Air and water, rainfall and fertile soil - these are not givens. The farmer cannot just plant seed. *He has to create his own fertile valley*. It can be done. It will not be easy.

Reasons to establish an independent rural farm:

- The "climate" of the settlement biosphere may not be suitable for the growth of the crops species one wishes to plant. One may want a climate that is colder, has periodic frosts, is more tropical, more moist, or more dry. While special climates can be effected in semi-separate parts of a main settle-ment, it may be simpler to have total separation.
- "Variety is the Spice of Life." Specialty export and domestic crops overlooked in tightly planned and eco-balanced settlement biosphere farming operations might include:
  - □ coffee, tea, wines and brandies
  - □ spices & herbs
  - □ fruit and vegetable specialties
  - □ meat producing animals and animal products
  - □ fish farming, bees & honey
  - □ additional fiber producing plants (cotton?)
  - □ pharmaceutical feedstock plants
  - □ dyestuff plants, and more
- Practitioners of one type of farming will want to experience for themselves the proper temperate, subtropical, tropical, or arid climate -- that is, in their own habitat area common spaces, not only just in the farms. Climate is interwoven with culture as well as with agriculture. That is the total experience everywhere on Earth.
- Settlement zoning and land use practices may not favor the farming or horticultural methods to which one is attached. Thus the settlement may have a decided tilt toward hydroponics, as it is more stingy in its pressurized space demands. Others may be determined to try a regolith-based analog of more traditional soil farming needs.
- There may be a need to quarantine some crop specialties from others, reducing risk of transmitted blight and disease. That works both ways, and the settlement may put out the

‘not welcome’ sign even as rural farmers declare their own intent to sequester their chosen crops.

- Many brought up in agricultural settings on Earth will cherish the rural experience and not want to be a part of the city experience, however large an agricultural operation the larger settlement needs to integrate into its biospheric underpinning.

Filling out the rural farmstead economy:

The challenge is to find the right formula, and it will differ from operation to operation depending on the specialty crop or mix of crops, on whether or not the farm produces other goods as by products or in a supplemental industry. It is not impossible that the special character of the local regolith that is ideal for the farm’s specialty crops is also a source of some element or substance not mined and produced by the settlement(s). Wherever the farm is located, other advantages of the site should be explored.

If the farm is located convenient to a main trade route highway in order to ensure its produce has access to markets, its income can also be supplemented through offering roadside services:

- vehicle repairs and servicing
- bed and breakfast lodging
- produce and byproducts market

Such farm-to-market route-side locations are essential. A “Tea & Sugar” fleet of trucks could ply the route regularly, supplying each farm with its needs, and taking farm products to the other farms as well as to the main settlements

Rural farms will not be alone in the vast stretches between settlements. Scattered mining operations, science outposts, and tourist stops will keep them company. In the settlements, outfitters and supply houses will arise to serve their common needs. True isolation will be in no one’s interest.

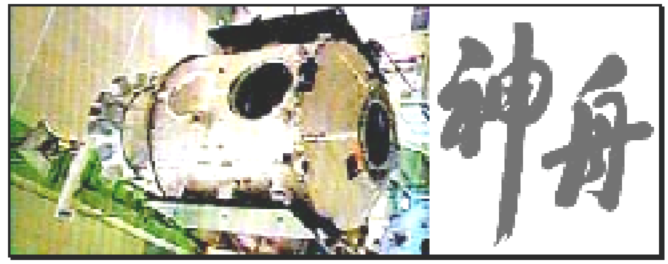
The rural farm might also supplement its income as well as shore up its own labor pool by offering working farm vacations to “city folk” who might eagerly pay for the privilege as an ideal change of pace and change of scenery vacation. The rural farm could also offer “farm camp” experiences to settlement young. Such extension activity will also serve to introduce fresh cultural experiences into both rural farm and larger settlements. Granted, there will be reclusive rural farm hamlets that may want to avoid such cross-pollution!

Not to forget outside markets:

Rural lunar farms need not justify their operations in the lunar settlement market alone. Almost any food grown on the Moon with lunar oxygen and lunar-sourced macro- and micro-nutrients may be cheaper to purchase in any space venue, even low Earth-hugging orbits, than food raised on the Earth’s surface, no matter how much more cheaply and efficiently, but brought up the steep gravity well at high fuel expenditures. Only special delicacies or treats available from Earth alone will make it onto space pantry shelves and into space eatery menus.

Rural Farms add to the total biospheric mass in place on the Moon, increasing the overall chances that lunar civilization will thrive and be indefinitely viable. As such rural lunar farms can play a key role in the future of the Moon. **<MMM>**

MMM #146 - JUN 2001



Here Comes the Shenzhou !

The Chinese have recently test flown their Shenzhou manned spacecraft - unmanned, of course. A Soyuz “takeoff with improvements,” this capsule may soon cary Chinese “Taikonauts” into space, making China only the third nation with a real manned space capability

The Shenzhou Spacecraft

complete with fan club

Full scale mockup of Shenzhou at Harbin Institute of Technology, Nov. 2000. [Xinhua News Agency

Shenzhou Links:

www.friends-partners.org/mwade/craft/shenzhou.htm

www.geocities.com/CapeCanaveral/Launchpad/1921/shenzhou.htm

www.spaceref.tv/china/shenzhou3.html

www.geocities.com/CapeCanaveral/Launchpad/1921/
(Go Taikonauts Site)

Urban Lofts & Settlement Style

Decorating Styles common in Urban Lofts may Offer us a Preview of Lunar Habitat Interiors

by Peter Kokh

"Lofty Ideas" is a weekly program (hosted by Katherine Stone) on Home & Garden TV (HGTV), a cable station offered by many cable networks. For those contemplating moving into an "urban loft" in a recycled old factory or warehouse, and for those just intrigued by the idea, this show gives a fascinating look at how a new generation of "urban pioneers" are making themselves very much at home, thank you, in the heart of cities once being abandoned in droves by residents not up to the new frontier challenges.

Lofts characteristically retain the relatively high ceilings of floors formerly given to manufacturing and warehousing. The interior surfaces of outer walls of lofts commonly consist of exposed brick, concrete, concrete block, and other "industrial" materials, unfaced with plaster or drywall or paneling - those more "civilized" interior surfaces all-but-universal in more "traditional" residences: single family homes, town homes, condominiums, apartments, duplex flats, etc. Floors are commonly concrete or refinishable wood plank with a healthy hint of industrial wear and tear character worked in.

As purchased by their new occupants, lofts also most commonly boast exposed heating ductwork, plumbing pipes, and electrical wiring. And most new loft dwellers choose to keep it that way. To this shell which most lovingly accept, they may or may not add dividing walls (seldom full height), partial step up floors (a loft within a loft, e.g. for a bedroom) window and floor treatments and furniture and accessories. The extraordinary amount of highly personal creativity demonstrated in the half hour episodes of "Lofty Ideas" week after week is utterly amazing. For loft-aficionados, this is where it is at.

What has all this to do with future frontier settlements on the Moon? It occurs to me, that some of the "styles" we see emerging in this new residential medium, will also prove to be the most appropriate, the most efficient, and the most economical, once we are manufacturing modular housing shells on the Moon, for pioneers to turn into "home sweet home" oases in this magnificently desolate new setting. The reason is simple. Adopting the "as is" inner surfaces left by construction of pressure hull habitat modules removes the labor-intensive *burden* of giving them a faux finish, e.g. plaster or wall board plus paint or paper or paneling. The settlers need to save their free time for where it counts. Let's take a look

The Shell (or hull)

The Moon is well-endowed with the all four of the so-called engineering metals: iron (steel), Aluminum, magnesium, and titanium. Metal alloy pressure hull modules are a primary option for the lunar architect and module manufacturer. Lunar concrete, reinforced with steel rebar or glass fibers to give it strength under tension is certainly another. Glass fiber/glass matrix composites are a third. Surface treatment options available to the architect depend both on the character of the material, and on the manner in which the pressure hull is fabricated.

If the hull material is poured wet, and/or hot, into a prepared mold, its surfaces will take on the character of the surfaces of the mold into which it comes in contact and by which it is constrained. Molds can be smooth, textured, embossed, or carved to create surfaces with special design characters.

In the case of concrete, if coarse aggregate is used, and the surface of the cured cement abraded somewhat, the aggregate with all the character and variation it may have, is brought to the surface. If this is not done, character can be imparted by the mold itself. We have all seen the clear telltale imprint of plywood forms on poured concrete walls. If the form, of whatever material it may be, is given deliberate texture or pattern -- and the possibilities are virtually endless -- that texture or pattern will be transferred to the surface of the cured concrete.

This option can be used to endow surfaces with random or repetitive design patterns. I have seen a basement wall of poured concrete that looks like brick, thanks to the pattern worked into the pouring forms. With two inches of styrofoam bonded to the outside, the result is an instant "rec-room-worthy" surface. Surfaces with leaf patterns, coarse cross sawn wood patterns, almost any kind of pattern is possible with concrete. Colored concrete sidewalk pavers with embossed patterns are also appearing. As are concrete shingles that look like cedar shakes. It seems that concrete can mimic almost anything.

We can speculate how we might fabricate habitat pressure hulls from glass composites, but until we have proven, debugged methods and options, we can only guess at the design possibilities. That we can texture the surface seems likely. We may be able to etch it, applying resists and sandblasting. We might be able to color, even grain glass composites, by embedding colored glass fibers in either a random or "raked" pattern in a clear glass matrix.

Metal plate and sheet can easily be embossed, but perhaps only coarse pattern can be imparted to poured metal by mold forms. These uncertainties aside, the use of mold forms in habitat module fabrication and manufacture are a primary opportunity for textural choices with the goal being to use the resulting interior surface as decor in itself, not as a substrate for some hiding faux surface treatment.

Construction-processed surfaces might then subsequently have any mold imparted patterns or textures enhanced by several means.

- wall washer lighting can enhance textural shadow patterns
- colored bulbs or colored glass diffusers can wash textured surfaces with color tints.
- whitewashes based on lime (CaO) or Titanium Dioxide should soon be available to beat the concrete gray blahs.
- perhaps “stains” using metal oxide pigments might be used to highlight textural surfaces in directional patterns, depending on means of application

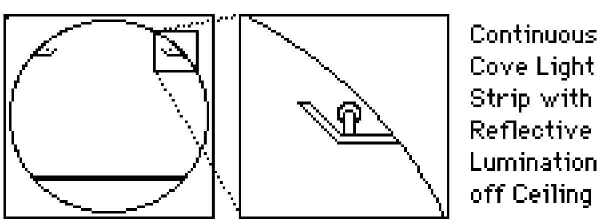
What we are talking about is principally the interior surfaces of the exterior pressure hull. In one-story modules, that includes the ceiling, which, if of concrete, may commonly be whitewashed.

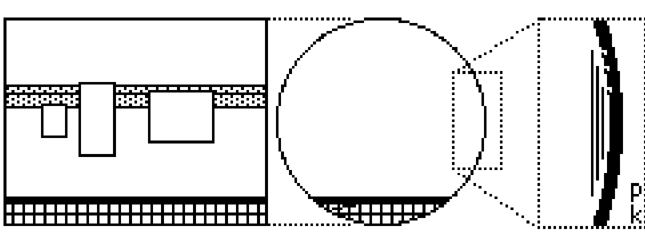
Our point is that here is a method of instant “direct decor” in which the architect and purchaser have many options to choose from, simply by allowing the character (the “grain” as it were) of the chosen hull material to give an “encore performance.” By choosing any of these direct decor options, the lunar habitat is finished and ready for occupancy much sooner. Then any sweat equity required or volunteered on the part of the frontier homesteader can be postponed, saved for other things and features to be added as time, energy, and funds are available.

On the Moon we cannot afford to have housing units “under construction for months.” The ideal groundbreaking to occupancy-ready interval should be much shorter, week at most, but with the ideal of “in one day” ever the target. Construction in vacuum is a risk-involving activity and we want to do it in as manhour-light a manner as possible, reserving man-hour-intense activities for optional interior customizing at leisure.

Hull Details

“Trimwork” (akin to our “woodwork”), if any is desired on interior hull surfaces, can be of sheet metal, ceramic tile, or glass composite, depending on the hull material (alloy, concrete, glass composite.) This trimwork can be of colors and shadings that blend in, compliment, or contrast with the substrate. Glass and ceramic glazes are made with metal oxide pigments, many or which are lunar-sourceable. Steel trim could be rust-finished or even stainless.





Built-in hanging grooves for on-the-wall items

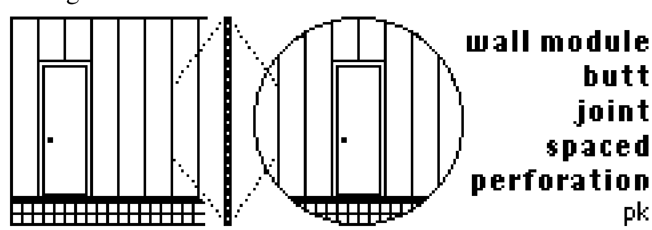
In addition to surface texture, pattern and detail, functional features can be built into exterior hulls, such as coves to hold ceiling wash lighting, chases for electrical wiring or conduit, and well-placed purchase points for hanging shelving, wall art, etc. The built-in features also serve to shorten the construction to occupancy interval. Even bench or banquette style seating can be provided as desired.

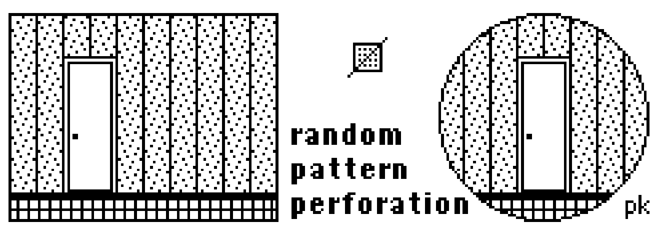
Interior Wall and Floor Stuffs

Interior walls and surfaces of interior ceilings (i.e. another floor above) are also likely to be manufactured, fabricated, or constructed with materials that can provide an acceptable surface. Logical interior wall options are:

- modular half meter sections with steel frames covered with steel panels: finished through a controlled rusting process to introduce relief from gray monochromes, or of stainless steel. They can be variously textured or embossed
- custom built on site using steel studs and Duroc™ panels (a familiar item: half-inch thick fiber-glass-faced concrete sandwiches): the Duroc surface can be accepted as honest direct decor, possibly whitewashed, or stain-washed. Trim-work and/or wainscoting can be of ceramic tile.
- glass block walls - transparent, translucent, or opaque; of clear glass, frosted or sandblasted, or crude formula lunar glass of gray-black tones.
- steel framing “upholstered” with stretched fiberglass fabric over foil-faced fiberglass batting

Interior walls too, even though made of harder materials than we are accustomed to using on Earth, can be pre-fitted with purchase points for hanging wall art and shelving. Consider this:



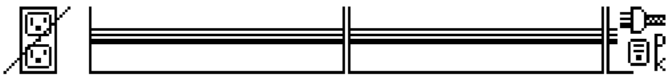


We wrote about wall options in MMM #76, June ‘94, p. 4. “Inside Mare Manor: Interior Walls.”

Exposed Ductwork

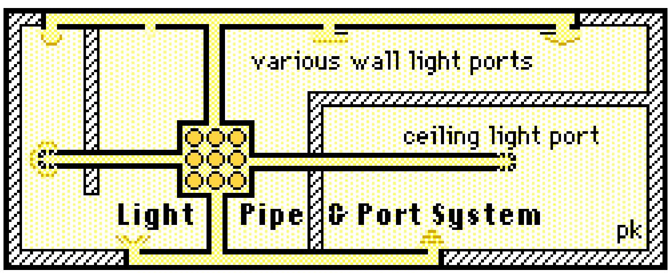
Another commonplace in urban Lofts are exposed ductwork for heating and air-conditioning. Using Systems to Decorate has become a flagship feature of the “industrial” style for many public buildings in the past two decades. Ductwork can be designed to have a simple comeliness of its own, adding interest, not ugliness. The original motivator, of course, is the substantial cost savings of not having to “hide” such systems with false ceilings.

The same is often true of conduit carrying electricity throughout the loft or building. With a little forethought, the design of conduit and other "working" electrical and plumbing elements can be enhanced for eye appeal without compromising utility, and at nominal extra cost. Routing such systems offers another opportunity for input from the interior space designer. Slight changes of placement or routing cost little. All one needs to do is pay attention to the decor effects of various options - an attention that is not ordinarily given, but can be.



Light Pipes

On the Moon, where we have a chance to start fresh on many fronts, one significant opportunity to do things differently is lighting. Light pipe technology has been advancing steadily. Light pipes are passive systems that deliver light efficiently from concentrated sources (solar concentrators, sulfur lamps, etc.) throughout interior spaces, in both straight runs and around corners, to places where the light is needed. Light ports in the pipe/duct system can then be decoratively enhanced by the choice of diffuser or lampshade analog. They can also be shuttered to "turn off the light."



We reported on light pipes in MMM #66 p.7 June '93, "Let There Be Light: light delivery systems for lunar settlements need to be rethought", and on Sulfur Bulb technology in MMM #36 JUN 2000 p 3. "Nightspan Lighting: Sulfur Lamps & Light Pipes."

Flooring

Pressure Hulls have to have curved surfaces to avoid stress points along surface "intersections" that would be prone to fracture, and hence pressure loss. Thus for most hull designs, flat flooring has to be added later. So we will not discuss that here except to mention some of the obvious choices: cast basalt tiles, ceramic tile, glass-composite sheets, concrete pavers, and embossed steel sheeting.

A Frontier Primary Color Palette

The reliance on "direct decor" - letting the honest character of construction materials provide the setting for added furniture, furnishings, and accessories will result in a naturally lunar, frontier palette of hues, shades, and tones to be played to in monochrome, complementary, or opposite suites.

Concrete gray tones can be easily "tinted" by washing them with colored light (bulbs, diffusers, etc.). Eventually, as locally produced sodium silicate and metal oxide pigment powders are produced, applied color "washes" may become an option. Lime or titanium dioxide "whitewash" will surely be the first of these to appear and become popular, on walls and ceilings alike. Metal oxide pigment stains might be used to give highlights to the texture relief.

Tile "trimwork" can accent the concrete, with glaze colors that play to or enhance the natural lunar grays. Steel and aluminum silvers, rust-cured steels or rust-cured steel trimwork can also add accent. Enamels for steels may not come soon.

Natural raw frontier glass will be of variegated moontones ranging from blacker to lighter. If regolith is routinely sifted for glass spherules which are then automatically sorted for color, crude glass with orange and green tones should soon be available.

Mirrors hung on moontone walls can also capture and "import" the brighter colors of added furnishings. Lamp shades, ceramic glazed items, art glass, and, of course, abundant foliage and flowers can add all the "pop and punch" colors one could want. The "industrial" "loft-like" host decor of lunar frontier habitat modules need not be drab. The great creativity and amazing variety of ways in which our urban loft dwellers make spaces with industrial histories very homelike gives us not only insight into the future of lunar frontier homes, but confidence.

It's a wrap ! - of course, those who can afford it will find it chic, appropriately pretentious, to bury the construction-processed surfaces with faux facade treatments of one sort or another. But our purpose here is to show what an "everyman's frontier decor" might be like. **<MMM/>**

What's in the 20,000 lb. Cargo Container of the 2nd Artemis Mission?

29 Mar 2001 12:58:59 -0800
From: Gregory Bennett <grb@asi.org>
Subject: Mission 2

Mission planning time - the Setting:

The permanent lunar exploration base has been deployed. The crew canopy over it, set up geo-phones in the surrounding area, tested all the systems, took lots of pictures, and gathered rock and soil samples. Some little robots are busily sweeping Moon dust onto the canopy to shield the base. The robots also feed a briefcase-sized lunar oxygen pilot plant that is busily munching Moon dust into tanks of compressed volatiles.

The first crew came home safe, happy, and exhilarated. They are off on a worldwide concert tour promoting the new movie and the opening of four new theme parks. You can catch them at the Southern Cross Hotel in Sydney next weekend. After that, they are off to Alice Springs for the inevitable opening of the lemonade stand, and then on to Perth to christen another big boat.

Publicity from the 1st flight and the apparent success of the ancillary businesses has enabled us to raise enough capital for another Moon shot. The Lunar Transfer Vehicle is docked at the LEO servicing facility, refueled. Refurbishment of the Ascent Stage is almost complete, and the replacement fuel tanks launched just this afternoon from Groote Eylandt.

The exploration base awaits its next crew, who are doing their final rehearsal in Belize before they board an FBN Spacelines charter rocket.

A cargo container with a second Artemis Project payload is headed for a launch pad on Matagorda Island. This flight will land 20,000 lbs [10 tons] on the lunar surface.

What's in that cargo container?

Greg

What's in that cargo container? Brainstorm Time!

James Gholston <jamesg@dimensionality.com>

- Guess #1: Mining and/or construction equipment.
- Less ambitious: regolith-moving experimental equipment that might, in a pinch if successful assemble the first on-site construction.
- Subsequent guesses from me are pending...

Michael Eckardt --http://orbitalhabitat.com

- Solar concentrator & crucible & mold making stuff => cast basalt pavers and other items
- Additional mining/processing equipment to actually make things (sintered regolith blocks?) out of. The sooner we can get away from importing materials from Earth, the sooner we can have a real base.

Kirk Pierce <kpierce@mrj.com>

- My vote is for a first try at a closed-cycle electrolysis/fuel-cell energy storage system, with big ol' solar arrays.
- To do serious industrial work (i.e. digging) we need (in the immortal words of Tool-Man Tim Taylor) *"More Power!"* Electric motors just won't cut it for doing real regolith-moving in any sort of short timeframe. I'm thinking internal combustion of H2 & O2 with total water recovery.
- I'm also thinking of some kind of system with "rechargeable" modules that hold H2 and O2 for fuel-cell or combustion, also with a reservoir for the water. When a module runs out of gas(es), plug in another one and send the expended one to the solar farm to be recharged. These modules could come in different sizes, too, from hand-tool sized up to bulldozer driving monsters.

Access Systems (Bob) <accessys@smart.net>

- Radiation hidey hole,
- Bigger first aide kit
- Geology gear (is there a lava tube nearby)
- Precious metals?
- Water?
- More photovoltaics
- Wheels (lunar rover)
- Spare universal space suit
- Small greenhouse
- Start of something to put in small greenhouse
- Some sort of power storage for overnight survival (human/vegetable/equipment)
- Real food
- More film for cameras (IMAX???)
- Whatever is needed for permanent manning of base, next mission stays -- overnight???
- Redundant O2 H production facility (2 small better than 1 large)
- Another antenna
- Permanent landing beacon(s)

Charles Radley <cfrjlr@netzero.net>

- 20% of the robots have already failed, we'll need spare parts, tools, repair manuals and a service robot (or two).
- The O2 production rate is painfully slow, we'll need more robots, more solar arrays, a second oxygen plant (incorporating lessons learned from the first one).
- More tanks (e.g. inflatables) to hold the volatiles being produced.
- Closed loop life support equipment, water purifiers, hydroponic greenhouse.
- Multimedia DVD player(s); movies and audios.
- Telescope for looking at Earth, Moonscapes, celestial objects.
- Several autonomous or teleoperated rovers with metal detectors (our search includes meteorites)
- Seismometers, seismic charges, portable seismic survey thumpers, other stuff for seismic surveys - we will be doing excursions in the rover, using seismic methods to search for lava tubes.
- Mortar grenade launchers (similar to Apollo) to fire seismic charges over several kilometers to extend the lava tube seismic search area.
- Robot rover with an experimental ground penetrating radar - to complement the seismic stuff.
- Long range (100 km) pressurized lunar rover.
- A couple of winch cart robots.
- Experimental robot to convert Si-metal slag to structural components for solar dynamic generators.
- Freon for heat exchangers.
- Mountain climbing equipment. We'll want to put some repeater stations as high as we can get them.
- How about a portable pressurized tent.
- Deployable tower antennas (if no nearby peaks)
- Lots of towels; a vacuum cleaner for the dust.
- Lots of duct tape.

Andrew Newstead

A.Newstead@pop3.appleonline.net>

Good ideas on what the Mission 2 cargo should be!

B*ut what should the "container" become?*

- Perhaps this Cargo Container could be designed to serve as a workshop/machine shop once it is unloaded. The experience of Mir found (I suspect ISS is duplicating this) that maintenance became a major issue for the cosmonauts. A machine shop and a comprehensive range of tools that would allow for creative (Io unplanned) engineering, I personally think, is a must.
- Pack the module with lots of other stuff for the trip to the base (at least one bag of Thornton's Special Toffee!).

Roger <roger@escore.demon.co.uk>

- A machine shop is good
- Duplicates of critical items from first mission
- Ground radar and robot to move it (change location)

George MacDonald <gmd@slip.net>

- I wouldn't mind sending up some robo-miners to harvest H2, O2 before a team arrives. It might take the robo-miners a year to fill up a fuel cache, but then the visitors would not need to haul the return fuel to the Moon.

Vik Olliver <vik@olliver.family.gen.nz>

- We don't really want to melt or heat up regolith outside of the factory if we can help it. Heating it up drives off all the desirable volatiles.

Organizing all these suggestions

Charles Radley <cfrjlr@netzero.net>

To reach a conclusion the mission definition needs a step by step process. Greg has kicked off a brainstorming activity, usually the first step in a development process. This brainstorming has already resulted in several small shopping lists.

These should be consolidated into one big shopping list. Next we need to assign a cost/benefit to each item and come up with a list of priorities.

- The cost is primarily its weight, with volume a secondary cost (small and light are good).
- Benefit is a bit more subjective, and depends heavily on the business model and near term mission objectives. How many of each item do we want to take? What is the risk that this stuff won't work? We don't need expensive dead weight.

Individual crew preferences should also be considered. For example, we should probably allocate a fixed weight of, say, 100 pounds for personal morale items, this should include the DVD player. Food supplies are a separate allocation and should also cater to crewmember preferences, this would include the Kendall Mint Cake and toffee.

I can see a lot of discussion about personal preferences to put in the 100 pound limit. This is fun and worthwhile in itself. But in practice, we all know it is really too early to spend much time on those issues, fun though they certainly are. For the Artemis plan to get funded, we need to ponder at more depth and length *on the remainder of the 19,900 pounds of the package*.

We should first categorize (then prioritize) the types of items we want. The types of items depend on mission objectives, which could include these (not necessarily in order of priority):

- life support/survival (top priority)
- oxygen production
- energy production
- communications infrastructure
- transportation infrastructure
- finding lava tubes
- equipment repair and maintenance
- health management (e.g. exercise, medical)
- consumables management
- temperature control

We need to decide the priorities of these objectives, some of them are interdependent. What that then means is we need to design a model of what functions we want the post-Mission-2 base to terraform and how these functions interact.

- The items from the master shopping list should be categorized under an agreed heading.
- Then the weight of the items in each category needs to be estimated.
- Then we can have a focused debate on the relative importance of each of the item types with respect to the mission objectives, and the cost of each item type in terms of its weight and volume.

Ten tons or a hundred, or one -- many times?

Arthur (apsmith@aps.org)

Nice outline there. Is this premise of 10 tons of cargo the right starting point though? We would certainly be better off with *100* tons - the more resources we have, the faster we can grow. On the other hand perhaps we can get by with just 1 ton packages, delivered more frequently?

What *are* the practical limits and considerations on the mass we can get to the lunar surface? If we can get anywhere starting with 1 to 2 tons of payload, we might be able to avoid the heavy-lift and assembly pieces that seem so expensive. Maybe then mission costs would be in the hundred million range instead of billions? Even manned payloads -- do you really need much more mass than a typical SUV for a 3-day trip for 3-4 people (assuming things have been arranged on the ground ahead of time)?

Do You Want to Join in Discussions Like These?

This fascinating discussion took place 4/29-5/5/2001 on the Artemis Discuss List. If you are a Moon Society Member (and thus also an Artemis Society Member) you can take part in the creative and constructive mind-stretching, preconception-adjusting fun activity simply go to the following web page and follow the easy instructions:

http://www.asi.org/adb/09/03/artemis-list.html

The Editor's 2 Cents: "Overnighting" and Early Lunar Stone Age Industry Attempts

Having been brainstorming how to grow a starter Moonbase for a couple of decades, here is my attempt to answer Greg's Question.

In the light of the major "unattainments" of the Apollo Mission Series*, the first strategic goal of a back-to-the-Moon-to-stay effort should be to demonstrate the capacity to "Overnight" and to do it productively. So whatever we need to do this for the first time, or do it better than the first time if the first mission succeeded in this major, major feat, should be unquestionably our Number One Priority. The previous posts do not mention this milestone, or take it for granted.

"Overnighting Ability" is the first holy Grail of Moon Missions very much on a parallel with "Breakeven" for Nuclear Fission Experimenters. Accordingly, here is the Cargo Manifest for Mission #2:

- Energy Production Equipment
  - ◇ Solar Concentrators

- ◇ Solar Panels
- ◇ Nuke
- Energy Storage Equipment
  - ◇ Fuel Cells, more of them

Next Priority should be to prepare for more serious lunar industry: handling and sorting regolith; lunar oxygen production; cast basalt products; powdered iron products

- regolith handling equipment or more of it
  - ◇ regolith sifting equipment
  - ◇ sortation bins galore
  - ◇ compacting, sintering, equipment: molds
- magnet to extract pure iron fines
  - ◇ equipment to test powdered iron products

Relevant MMM Back Reading Online

MMM # 88 SEP ‘95, p 3. Starting Over on the Moon: I. Bursting Apollo’s “Envelope”
www.asi.org/adb/06/09/03/02/088/bursting-envelope.html

MMM # 90 NOV ‘95, p 7. Overnighting on the Moon
www.asi.org/adb/06/09/03/02/090/overnight.html

[Both articles republished in MMM Classics #9]

Mail For MMM

MMM #143 articles on Phobos and Deimos

May 10, 2001

I finally had a chance to read your commentary in the March issue about a "forward base" on the Martian moons. I always enjoy your unconstrained thinking and clever ideas, but I think you may be getting a bit strident and carried away lately. Perhaps it is a sense of frustration that I notice in some of your recent articles.

For example, on page 1, you suggest making "demands" on mission planners and describe the need for data on Phobos and Deimos as "desperate". Not just a little hyperbole there, eh?

As a satellite engineer, I would question the practicality of justifying a base on a Martian moon for the purposes of a more unified approach to robotic exploration of Mars. Certainly, setting up such a base has political ramifications relative to the commitment to the human exploration of that planet, and I acknowledge that that may indeed be the main point of your article. But such a viewpoint must be based on some notion of reality, and the reality is that there is no way that building probes on Deimos will be less costly than building them on Earth.

Setting up a manned base on Deimos just to integrate, recycle, and control surface probes is going to be vastly more expensive than doing that from Earth. There is no real technical advantage, and the costs of establishing a manufacturing infrastructure locally will be prohibitive. Setting up a base with "a supply of programmable landers" (page 5) needs to be compared to other options such as shipping multiple landers to a Mars polar orbit and setting them down as determined by previous missions. This is another way to work around the Earth-to-Mars launch window constraint.

I could go on, but I simply wanted to point out that while I support your effort to change the thinking about how to explore Mars, there are still some real technical constraints that you may need to consider. Additionally, I think and that there are other approaches that could return the same sort of data, but they may not meet your need for redirecting the political winds.

Before we can achieve the goal of an "uncancelable opening of the Mars Frontier", we need a sound economically justifiable reason why we must do so. If not, the reasons will be based on science and politics, and it appears to me that neither of those is adequate for Mars advocates.

Michael Mackowski,
<mackowski@specastro.com>

EDITOR’S RESPONSE: I could hardly agree more with the point of your last paragraph. We do need to establish an economically justifiable reason to embark on an “uncancelable opening of the Mars Frontier” - my words. That is my problem with Zubrin’s and the Mars Society’s political push to get a government commitment to a manned Mars program.

We have homework that WE should be doing first, before we dare demand anything. That homework includes what is called a “discovery phase.” What is there on, or about Mars, that would make opening the Mars Frontier an economically viable proposition? Are there unknown and unsuspected resources on Mars that would both greatly reduce the costs of such an effort and generate cost-defraying income?

We have a start on such a “discovery” project, but only a start. The pro-Mars community has collectively brainstormed aerobrake technology. Zubrin himself has introduced “live off the land” “in situ” production of fuel needed for a return to Earth from Mars atmosphere. These help reduce costs considerably. Yet very considerable costs still remain.

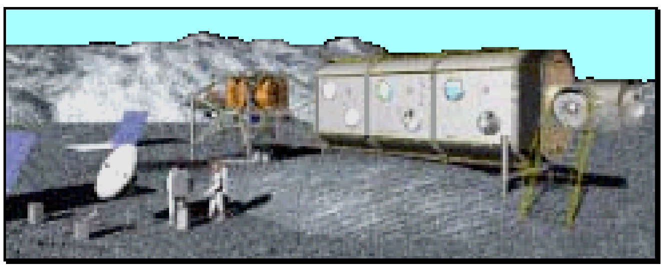
When it comes to establishing a permanent presence on Mars, we have much to do in locating, quantifying, and qualifying resources such as metal deposits, permafrost water ice, and possible ready to use lavatube shelters.

That is the whole point of my essay! At one or two missions every 25 months, and with response time to data from ongoing missions for the purposes of designing new ones added in, this “discovery phase” is going to stretch out decades. I tried to sketch out an alternative “meta-mission strategy.”

I agree with you that the establishment of a major manufacturing operation on Deimos would be both prohibitively expensive and itself consume years of effort. In an effort to fit the essay into the space I had allotted for it, I may have been too economical with my words. That is not at all what I was calling for. IF there are resources on Deimos that can be turned into crude low-performance-required products needed for the Deimos to Mars orbit or Mars surface mission *with* the kind of regolith-handling technology we propose to develop for the Moon regardless of whether or not it is useful on Mars mini-moons, then that would be worth deploying and could probably be put in place at a worthwhile cost *if* that resulted in the time-telescoping of the series of missions needed to earn us the information we need to make this economic case.

As to the stridency of my tone towards NASA. Please do not read that as hostility. Read it as deep disappointment that a once proud agency now habitually underperforms. NASA seems to have no drive, no élan, none of its youthful “can-do, sir!” brash confidence. This is not entirely NASA’s fault. The agency is repeatedly hamstrung by both successive Congresses and Administrations. If the Administrator were to protest *“Now see here, senators, etc., we demand a full commitment to this and that, and will not accept this or that cut,”* the only result would be his summary firing. -- PK.

MMM #147 - AUG 2001



Two Mars Analog Stations, None for the Moon

Last year, the Mars Society, with funds from excited sponsors and individuals, fabricated a Mars Hab-Lab analog station and erected it on Marslike terrain on Canada’s far north Devon Island. This year they have built another for the Utah desert. At right is what a similar Artemis Moonbase analog station could look like, given an equivalent effort.

Urban Lofts & Settlement Style

Part II: More Clues from Loft-Living Styles

by Peter Kokh

In the MMM #136, JUN ‘01 issue, we tried to sketch out what the “feel” of lunar settlement interiors might be like, taking pages from the urban frontier’s “Loft” decorating trends. Loft styles have been called “industrial” and that is fitting considering the origin of loft spaces - former factories and warehouses. But that origin is really incidental and does not get at the essence of the style, which I would prefer to call “direct decor” -- accepting the surfaces of construction materials (e.g. brick, concrete, steel, ductwork, etc.) as they are, not as a substrate for adding layered faux (false) surfaces such as plaster or drywall (sheet rock in some parts of the country) or paneling for walls and ceilings.

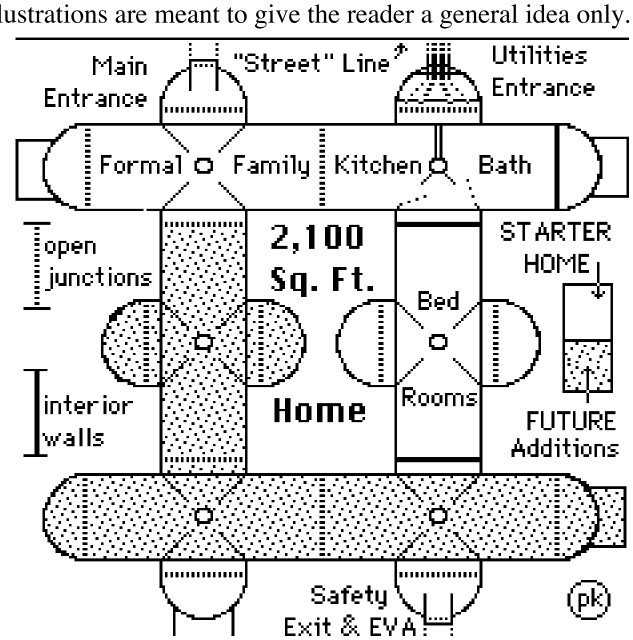
In a Lunar, or Martian, frontier setting, use of “direct decor” would allow faster occupancy, and showcase native materials instead of let’s-pretend-we’re-still-on-Earth “secondary” surfacing. Thus in addition to having modular habitats ready to occupy much faster, this type of transplanted loft style will go a long way to create unique and genuine Lunar and Martian home decors. But we have not exhausted the list of “Lofty Ideas” worth transplanting.

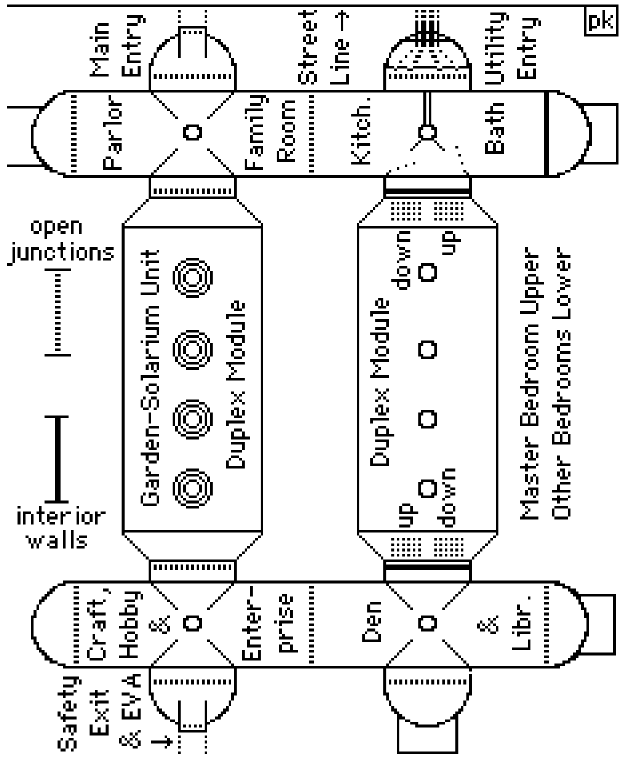
Open Floor Plans for Common Spaces

In the prior article, we suggested a number of ways interior walls could be built to be direct-decor friendly. At the same time, it would be beneficial to pioneers eager to occupy their homesteads quickly, if the amount of interior wall structures needing to be built was kept to a minimum. Of course, such walls could always be added -- and moved -- later as desired with evolving life styles and family needs.

Urban Lofts commonly preserve as much of the “wide open spaces” feeling of their host shell as possible. Interior walls, often not extended up to the ceiling, are provided only where privacy is needed, and then commonly only to interrupt sightlines rather than to provide complete enclosure -- for bathrooms and bedrooms. To be sure, “great rooms,” “keeping rooms,” and other open floor plans for “commons” areas of the home are also growing in popularity in conventional new home construction and also in older home remodeling. The open plan fits today’s life styles. Yet many “compartmentalized” older homes, such as my own, have floor plans that resist being “opened up.” They serve well enough, however.

On the lunar and Martian frontiers, homestead construction is likely to consist of various assemblies of pre-manufactured modules. In MMM #75, May ‘94, pp. 4-6 [republished in MMM Classic #10] “Lunar Appropriate Modular Architecture” we showed how a “language” of only a few basic module types would permit quite a variety of “expression.” Use of modules provides spaces that have identities, even if the passage from one to the other is unrestricted. Such an architecture allows interflowing common spaces easy to individually dedicate to special uses: kitchen, dining, family, library, garden atrium, etc. It also minimizes linear footage of privacy walls needed for bedrooms and baths. Below are some illustrations from that issue altered to show which module seams are open, and which are fitted with walls and doorways. Again, the layout options are endless -- these illustrations are meant to give the reader a general idea only.





For a more expansive floor plan (that of the Lunar Reclamation Society's tabletop Moon Base) see:
http://www.lunar-reclamation.org/page11mm.htm
Photos of this display are at:
http://www.lunar-reclamation.org/page12.htm

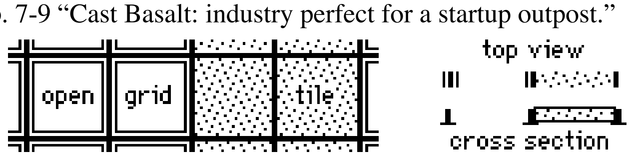
Working with the open floor plan

As is clear from the floor plan samples above, the space within each of the interconnected modules is already "distinctive" by its shape, how it meets or intersects with adjoining modules, and possibly by customer-chosen mold-impression texturing. Each of these is a bonus not all terrestrial urban lofts offer. With this built-in distinctiveness, it is easier to give each space its own ambiance and personality.

1. Distinctive Flooring: While pioneers can elect not to build interior walls where privacy is not an issue, they cannot elect not to add flooring unless they wish to confine their walking to a narrow strip along the bottom. This is so because pressurized modules in the full or near vacuum environments of the Moon and Mars must be either spherical, cylindrical, or toroidal to avoid critical level stresses on their structures from interior air pressure. Thus they "come with" curved bottoms. We must add flat flooring. A framing platform of metal alloy or glass composite members must be installed, in which can be set tiles, slabs, or other types of floor panels.

The choice of metal alloy panels restricts the amount of decorative freedom somewhat. Different surface textures can be used, along with contrasting color (i.e. a different metal alloy) "inlay" borders or stripes might be possible.

We wrote about using cast basalt tiles, especially wear and abrasion-resistant, for flooring in MMM #135 MAY '00, pp. 7-9 "Cast Basalt: industry perfect for a startup outpost."



Cast basalt tiles are self-glazed -- there is no opportunity to "add" color by glazing. However, there may be room to vary the shading of gray-tones by choice of basalt feed stocks. That color range will be very subtle at best. Perhaps the best option here is to impose distinctive surface textures by varying the mold shapes. One could also vary the size and shape of cast basalt tiles and create patterns in that way.

Once we start producing metal oxides for use in producing better alloys, we will be able to use many of those same oxides as colorants for stained glass and ceramic glazes. That will open a wide range of decorative possibilities.

Panels made of glass composites can be made in various "moontones" by varying the mix from which the matrix glass is formed. Once we are able to cast clear or transparent matrix glass, then we could add color by using metal oxide powders to dope the glass batches used for making the glass fibers that give the composite its strength. Then we might also play around with combing or otherwise arranging the glass fibers in the matrix to give distinctive "grain" or other patterns to the composite. Nothing like this has yet been tried as glass composite research has been stuck in the lab, totally ignoring a potentially tremendous Earthside market for products like boat hulls, architectural elements, and high end case goods furniture items (where appearance, not price, is important.) We wrote about that line of terrestrial R&D in MMM #16, JUN '88 "Glass Glass Composites."

2. Arrangement of Furniture & Furnishings: even if we pass on the opportunity to create extra distinctiveness of continuous areas by playing with flooring options, we can easily create distinctive "room settings" by simply clustering furniture and furnishings into cozy groupings. Creating a focal point for each setting will help. We are used to doing this here on Earth. Focal points can be a picture window, a fireplace, a catch-your-eye painting or sculpture, or a beautiful area rug. In time, Lunan pioneers will create enough home grown options to do likewise. If there is a generous "heirloom allowance," allowing each settler to bring along one personally special item from Earth within certain reasonable weight and volume restrictions, then a painting, a rug, or as piece of sculpture from "Old Earth" could be used for such "focal points."

3. Using Accent Colors: On Earth, many homemakers in recent decades have chosen to go with neutral or monochrome color schemes. Some even go so far as to profess a certain "superiority" for such choices. That is a very euphemistic way of diverting attention from their fear of being able to handle color in a non-gaudy way. We humans see in a full range of colors, and *enjoy* them. Not to play to that pleasure within our homes is a personal self-inhibiting choice but hardly a mark of higher culture.

On the Moon and Mars, where the exterior landscapes are so extremely monochromatic to begin with, almost everyone will feel the need to use abundant colors indoors, especially those not to be found out on the surface. Pioneers will cultivate their green thumbs to an extent unusual on Earth. With no life at all outdoors, abundant green foliage and flowers will be welcome and pursued with dedication.

Other coloration options will come slowly as we learn to extract specific elements and element combinations from the regolith. On the Moon, true white (calcium oxide = lime, aluminum oxide, titanium dioxide) and true black (ferrous oxide, manganese dioxide) will help “bookend” the gray-tones with classic emphasis.

Among the first real “colors” will be ferric iron oxide or “rust”. Sulfur provides a pale yellow, chromium oxide a green. The holy grail will be the isolation of cobalt: cobaltous aluminate produces the brilliant “cobalt blue.” These oxides can be mixed to produce in between colors and shades. There seems to be no lunar-sourceable inorganic source of either brilliant yellow or true red. We’ll have to satisfy our appetite for these colors with flowers, and maybe birds. See also MMM #63 MAR ‘93, pp. 10-11 “Color the Moon anything but Gray.”

Once such colorants are available, they can be worked into the decor scheme as stained or art glass (including lamp shades or light diffusers), fiberglass fabrics, ceramic objects, “regolith impressionism” paintings, and other ways. Giving each “room setting” a different accent color or suite of accent colors will help create special areas.

4. Dividers: on Earth we frequently resort to “room dividers” to subdivide large rooms or create special settings in great rooms and lofts. Dividers can be made of anything, and be either freestanding or suspended from the ceiling. One attractive option for use on the Moon especially is suspended carpets. Carpets, and fabrics in general, are very useful for acoustic sound deadening. The problem on the Moon is twofold: first it would be prohibitive to produce carpets (or other fabrics other than for clothing or towels) from the usual organic or synthetic organic fibers. That pretty much leaves us with glass fibers. We have been producing fiberglass draperies for years and they work well for one reason: very little wear and tear. We do not walk on them or sit on them. Fiberglass is not very wear resistant. Happily, on the Moon with its light gravity, the natural cushioning of our feet and buttocks may be enough. We can still make fiberglass carpets, possibly of unlimited color and design options, if we put them on walls or if we suspend them from ceilings. Carpet dividers will be a great way to subdivide inter-module common spaces.

5. Accent & Mood Lighting: Another way to create “room-like” settings in larger open spaces is with controlled, discriminate lighting. In the past, one often had only one choice: ceiling light fixture or table/floor lamp -- each at one set level. The introduction of three-way lamp bulbs, then of dimmers created many more options. Today with all new light bulbs (especially, halogens and folded fluorescents) and new recessed lighting options, the possibilities for controlled accent and mood lighting are endless.

It is too early to say which light bulb types are best suited for local manufacture on the Moon. One option is to keep light sources, and the heat they produce, on the surface and use fiber optics and light pipes to deliver light where needed in homestead interiors. Movable shutters can throttle the amount of light delivered to any one spot. Working in special diffusers will multiply the special lighting effects available. Shades can be made of glass, ceramic, and punctured sheet metal. Light diffusers of stained glass can lend color to the whole surrounding area.

Take two identical pioneer homesteads: same floor plan, same furniture, same furnishings. Give one only full-on high level general lighting. Install full control lighting in the other so that one room can be fully lit, another have just task light by an easy chair for reading, other areas just enough light to find one’s way without stumbling. In the first, the colors are fixed. In the second, you can alter the colors to suit your mode just by switching colored diffusers. Obviously if it is a comfortable home that we want (and we need to prevent gross defections back to Earth,) providing a full range of lighting options is important, not just to defining interior spaces but to the level of comfort and satisfaction.

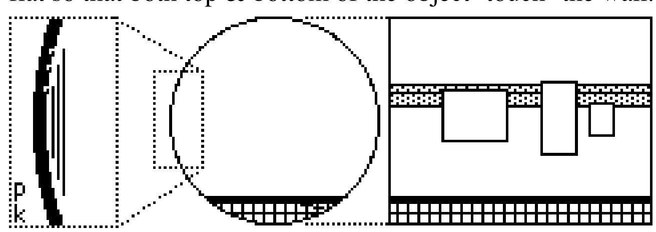
Open Shelving

Another choice one sees in some Lofts -- it is by no means common, however -- is to scratch the high expense of wall cabinets for kitchens and other areas by using open shelving systems, which can be built in a number of ways. Doing so involves a deliberate choice to let the shelf contents provide decoration.

In kitchens this is relatively easy if one has tableware and utensils worth showcasing. One can choose to do this elsewhere as well, in bedrooms and bathrooms for example. Here, if decoration is a goal as well as simple storage, one can either sort items by color (sweaters, towels, blankets, etc.) or arrange sundry items into pleasing “vignettes.”

In MMM #76 JUN ‘94 p.8 “On the Wall” we described ways in which the curved walls of habitat modules could be designed to make shelving easy.

On the horizontally concave outer walls of cylinder modules, only the central portion is suitable to hold things flat so that both top & bottom of the object ‘touch’ the wall.



A series of built in *hanging strip grooves* is a solution that may work, and even presents decorative possibilities, i.e. as broad horizontal striping. Objects can be hung anywhere along the length of the wall, utilizing the hanging groove that best suits their individual height. While the result may be that pictures and other objects are hung slightly below the customary “eye-level”, the hanging grove stripe, perhaps differentiated by texture and/or color from the rest of the wall, will be at the top of this range, serving as a visual corrective of sorts.

Shelving is cheaper and easier to provide than furniture-quality cabinetry. So this is yet another “Lofty Idea” with appeal to frontier pioneers. **<MMM>**

Is the Moon a wasteland?

“There is no such thing as waste,
there are only resources we are too stupid
know how to use.”

Arthur C. Clarke
– to Walter Cronkite during launch of Apollo 13

Return to the Moon: What's in it for Earth?

by David Dunlop

For many Americans, including those in the in the science and aerospace technology community, "been there, done that" is the almost reflexive intellectual and emotional response, to those who mention much less openly advocate a return to the Moon initiative. This quick dismissal is also symptomatic of the general public apathy toward the space program and the only modest level of political support That NASA generates in Congress. The Apollo program is the political high water benchmark of faded glory days for NASA It is also a huge historical achievement by what is now termed the greatest generation, ranking up there with the winning of W.W.II , and the Manhattan project.

The Apollo Program Benchmark

The American public was largely indifferent to the two most recent US lunar missions, Clementine, a test of SDI sensor technology that happened to use the Moon in its first mission phases, and the *Lunar Prospector* which was the first and the least expensive of the Discovery Mission initiatives to fly. Yet these missions did fundamentally change the perception of the Moon. With the discovery of ice at the permanently shaded lunar polar craters the Moon is now perceived as a place much more capable of sustaining a human presence. This human presence can in theory be much less expensive to maintain by the use of local water-ice.

Elsewhere, I believe the Moon is perceived differently. Only the Americans have sent men to the Moon. The Russians didn't make it. No one else was even in the running in those cold war years. Yet today, the capability to send men to the Moon exists no where. The capability to do so still exists as as a benchmark of technological progress and of the strength of the national economy. In a psychological sense the rest of the world is still in a "catch-up" mode. The "Luna Club" is still an exclusive one with only the US, Russia (former Soviet Union), and Japan having successfully achieved Lunar missions.

Today, the Japanese and the ESA are planning lunar missions. The Japanese Planet-B will orbit the Moon and send two penetrators to the surface. NASDA talks of a long-range Japanese intention to develop a lunar colony in the 2020-2025 time frame. While the Japanese funding commitment to NASDA is not great only NASDA and large Japanese corporations are talking about lunar bases. The Japanese clearly see the Lunar benchmark as an important measure of technology achievement, a spur to technological excellence, and as part of the economic future of a vibrant and leading Japanese and world economy.

The ESA mission, SMART-1 is the first European counter part to NASA'S new millennium series. It will use an ion drive motor to push their package out of the Earth's gravity well and into a lunar orbit. It will finally qualify the ESA as a member of the "Luna Club."

Clean Energy For Sustainable Development

Other US initiatives have been proposed such as the Inter-Lune One initiative which was submitted as a Discovery Mission Proposal by the University of Wisconsin. This proposal with Harrison Schmidt as the Principal Investigator along with the Fusion Research Institute at UW Madison proposed a lunar lander which would have measured the helium-3 concentration in the lunar regolith. Commercial fusion reactor technology has been the "holy grail" for nuclear research for the last thirty years but has diminished support. The 'Green' forces have limited the appeal of this research initiative as have the lack of a short term payoff. With an energy hungry world however this lunar derived Helium-#3 resource still is a potentially big part of a sustainable, clean, high tech and prosperous global economy. The broad international collaboration on fusion research is clear evidence that all the major technology players understand this.

The fusion initiative doesn't get much space in the headlines and has struggled in recent years from diminished funding. It also is a benchmark of scientific capability and would not only be the engine of "clean and sustainable" economic growth for the world but it would also be the breakout technology for human expansion in the solar system. Fusion reactors would provide the means to make "short" transit times to Mars and the Asteroid belt a matter of months rather than years. Even long journeys to the outer solar system could be feasible with fusion technology as the enabling technology.

Engineering Development as Aerospace Corporate Welfare

In the absence of a cold war, the retreat from basic research, and the ascendancy of "bottom line" political rhetoric, the NASA space program might evaporate, and the same disease affects ESA and NASDA. There just isn't the political horse power of the Apollo and cold war era to fuel further development. The costs of investment are so large and the risks of failure are so great that private capital cannot be attracted for a "reasonable short term prospect of profit. Thank God for corporate welfare. The NASA, ESA and NASDA enterprises and their corporate dependents are the best bet for continuing development. Under the umbrella of the International Space Station work will continue.

The completion of the ISS will force a crisis for these enterprises. They could face a great scaling back unless they come up with "the next big thing" for self perpetuation.

A return to the Moon for developing a Lunar Base would provide such a ticket. It is important to learn whether Lunar gravity is sufficient to maintain cardiovascular function and whether Lunar micro-gravity is adequate for the rest of the biosphere on which we humans depend. It will maintain an international scientific collaboration which permits the addition of national partners such as China, India, and Brazil in this very expensive enterprise.

A Return to the Moon will necessitate several Engineering Developmental Challenges:

1. A truly cheap reusable system providing manned access to LEO is needed. Now that the single stage to orbit approach has been abandoned by NASA for the moment, a two stage approach to LEO as now seems necessary will be a immediate goal.

2. A cheap heavy lift capacity to LEO is needed and a high production volume big dumb reusable booster is needed. Several such vehicles were proposed in the 60's which would

still be providing much less expensive costs per pound to orbit today with an expendable design. A reusable design might not mean reusable in the sense of returning to Earth but in the sense of creating large habitable volume in orbit for fuel storage or atmospheric gases, habitable volume, or merely enclosed vacuum volume for safe EVA assembly work on repair of satellites. or solar array subassemblies. Such dual use considerations of large dumb volume would of course mean a heavier tank structure, but there is no free lunch.

The potential use of the shuttle external tank has been studied and the creation of "new land" in the ocean of space with each launch should not be missed. This cost will of course will not be cheap but each such tank should be first designed for reuse in the future and should be outfitted with a solar array driven, electrodynamic tether fuel-less propulsion system as is now being developed for flight testing. This enhancement of large booster will make them more expensive but will also permit them to be stored in orbit for future use. The flight test of this fuel-less propulsion system in the next two to three years will tell how effective such a system could be in now only station keeping for large mass structures but how high a storage orbit can be attained.

The creation of a annually small but growing inventory of large dumb volume environments could reduce the subsequent costs of many future projects:

a. creating new volume on the ISS
b. providing fuel and storage capacity as a back-up to the ISS in case of catastrophic losses in a meteorite storm
c. providing fuel and atmospheric tankage capacity on the lunar surface for a lunar base.
d. providing fuel and atmospheric tankage capacity and human habitation capacity in GEO for a human tended construction station for a solar power satellite
e. providing fuel and atmospheric tankage and habitation capacity for an L5 outpost for the development of an O'Neill colonies.
f. providing a standard structural component for a large rotating space station such as originally envisioned by Von Braun.
g. providing fuel and atmospheric tankage capacity for a Mars space station. We might consider sending a space station into Mars orbit in support of a Humans to Mars program. with the capacity to support and provide a back-up environment in close proximity to the surface as an additional fail-safe system to the Mars Direct strategy.

I'm sure this list of potential future uses of large dumb volume could be expanded. All this to underscore that a tank in orbit is a terrible thing to waste. All this to underscore that a commodities market for such tankage should exist for those willing to provide the incremental cost of designing for such utilization and paying for the cost of the fuel-less propulsion systems needed to get them to a high safe storage orbit. As the reader may have noticed the frequency of their use for storing fuel and atmospheric gases is the least cost and most likely best use of these tanks. Retrofitting these tanks in orbit would be cost prohibitive for many purposes. Large dumb volume capacity should be extensively needed as a human spacefaring civilization expands. It is only very short term bottom line thinking that makes this proposal "unfeasible." Storage and reuse of this capacity would greatly lower the cost of many subsequent projects and therefore should be studied as a "futures infrastructures commodity."

3. An orbital transfer vehicle is also needed to expand and tend GEO platforms and provide a supply chain to the Moon (and later to Mars).

4. The further development of TransHab will provide next generation modules for extending the life of ISS, providing capacity for space tourism, and making a modular system for Lunar Base development, and a future Mars Base.

5. The just canceled funding for the Lunar/Mars base mockup initiative at JSC will need to be restored so the CELSS will be mature by the time it is needed.

6. The development of mag-lev launch rail launch systems for high frequency low mass payloads to orbit is needed.

7. An orbital debris mitigation program should be initiated to limit and decrease the hazards of "space junk" to expanded levels of manned activity.

8. An international rescue-crew return vehicle capability or mini-shuttle. Recent new of German interest in developing this option will provide a manned vehicle for ESA.

9. Rather than scaling back aerospace corporate welfare in the G-8 nations these challenges can maintain employment, stimulate engineering education, and rekindle the Apollo vision in the next generation. These pieces of infrastructure not only provide the support for a Lunar Base initiative but also pave the way to a serious contemplation of Mars.

The Political Economies of a Lunar Initiative Partnership

The number and scale of these investments also provide plenty of "room' for spreading the work among the international space faring nations. Getting the political commitment to undertake new Imagineering objectives as the global economy develops is still going to be difficult. It is reasonable to expect more national economies developing to the point where they have the capacity economically and politically to support aerospace industry initiatives which lead to space faring partnerships. The development of cheap access to space should greatly lower the cost of participation by nations that are now in the second and third economic tier. Nations with maturing industrial and academic capacity will see the educational stimulus of such participation and also see participation as an important national political asset for national pride and as a benchmark of economic progress.

The best arguments for this view of of the political economies of third world countries are:

a. The stubborn refusal of Russian to retreat from their spacefaring capacity even though as present their economy can't "rationally" support the "luxury" of a space program. Could military requirements and defense of national sovereignty be worth it?
b. The persistent and long term commitment of the Chinese to develop and refine their missile program and now a manned capacity.

c. The persistent and successful efforts of India to expand its booster capacity to GEO capacity.

d. The growing capacity of Brazil in aerospace and the development of its own equatorial launch site.

Like the International Space Station, the effort to ramp up to a lunar base project will be a complex political as well as technological partnership. Part of the glue that has held the ISS together has been the international perception of disgrace due to the unreliability of any member withdrawing from the project or not honoring its commitments. It clearly has not been easy for the Russians to continue but they have. When the ISS has become unpopular with the US Congress due to perennial cost overruns the issue of honoring international commitments has carried weight. Japan's stagnant economy while limiting new plans has not detoured their commitment to the ISS.

Another art of the glue that drives this partnership is the sense that the national partners cannot permit themselves to fall behind others in technology capability. Just as the emerging economies feel a need to catch-up there is the resentment of allowing one country to develop a commanding lead. The US is continually poised on the razor edge of the competitor/ partner position as the remaining superpower. It must itself not fall behind or face the treat of losing its leadership position. Selling the Moon Base to domestic political constituencies on its own scientific merits may not create a ground swell of domestic political support among the current Space Station partners but the persistence of entrenched bureaucracies to press for this commitment to their own perpetuation is not unrealistic.

Commercialization

While a Lunar base is sufficiently high risk and of a scale beyond what private capital will now risk, the enterprise will create many smaller opportunities for commercialization. The recent announcement of a withdrawal of the US from some ISS commitments is an example that has resulted in the Italians stepping up to fill the gap of a needed habitation module. Their multipurpose logistics module design will be upgraded to provide a habitation module. This lets a new initiative emerge.

The development of an orbital transfer vehicle that can provide the boost to the top of Earth's gravity well can also provide a more robust way of reaching GEO. The GEO communication satellites of today are surely destined to become enhanced communications platforms with huge solar power arrays and more powerful signals. GEO antenna farms will be developed by telerobotic technology which will permit the delivery, installation and removal of telecommunications equipment. The exploding demand for phone and data communications will mean a continually expanding market for such communications platforms capacity. The saturation of GEO orbital slots will require the upgrading of the capacity of existing slots. It is therefore probable that an orbital transfer vehicle and telerobotic system capable of creating and servicing the GEO platforms will result. Since the high value of the GEO antenna farms has a well established market, it seems a reasonable bet that a commercial development of this technology will result. It remains to be seen, however, whether this will occur with a limited government partnership or without a major government subsidy. The potential for a commercial orbital transfer vehicle being developed may not be far off.

The deployment of telerobotic arms systems on the ISS which will participate in the further construction process is the beginning demonstration of systems that could be used for next step projects such as an expanded GEO broadcast satellite platform, a prototype solar power satellite, or orbital retrieval vehicle which could retrieve dead satellites. Commercialization of niche markets which have a prospect of growth and stability of utilization is likely to be a force in the creation of some of the missing pieces of a return to the Moon.

Summary

The Return to the Moon offers many benefits to the earth including education, corporate welfare employment of high technology industry capabilities, the maintenance of international partnerships, hope for a clean energy future, and support for expanded telecommunications capabilities. These benefits will still be propelled by government funding as the predominant mode in the next 20 years, but with expanding private funding where growth in demand for commercial services is foreseen to be consistent and relatively low risk. The return to the Moon is f credible in providing these benefits. The "been there and done that" reaction of many would suggest that the rationale above is not understood. It think the arguments above will prevail when at the end of the ISS construction we come closer to determining "the next big thing."

<DAD>

"As Long As We Are Here ..." Entrepreneurial Opportunities for the First Lunar Return Mission

July 24, 2001

Oregon L5's abstract for "**As Long As We're Here....**" has been accepted by *Space 2002* for presentation in Albuquerque next Spring. Members of the Oregon L5 Lunar Base Research Team [lbrt] have already been working on this and other papers.

"As Long As We're Here...." is about small and medium business opportunities that will arise when lunar bases become a reality. As a one-time small business proprietor myself, I'm looking forward to developing this thesis.

Bryce Walden
Lunar Base Research Team (Oregon Moonbase)
Oregon L5 Society, Inc.
http://www.OregonL5.org

Working "In Situ Enterprise" into the Artemis Moonbase Reference Mission

by Peter Kokh

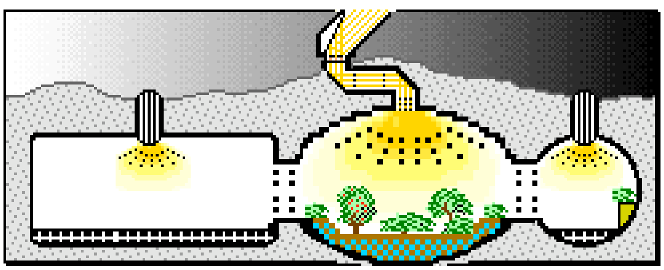
The Oregon L5 paper under preparation by Bryce Walden and his colleagues is a very important study with relevance to the success of the first commercial Moonbase. "Day one" entrepreneurial opportunities will lay the foundation for an enterprise-based settlement. More importantly, earning income to defray the costs of establishing the first for-profit outpost, will make that endeavor much more viable, and therefore more likely to happen at an earlier date -- something we all hope for.

Indeed, the moneymaking capacity of the Moonbase must be seen in a much more all-embracing sense than that of "entertainment enterprises." Systems and equipment developed by contractors looking to prove the performance of their products so as to be marketable to many or even all missions to follow, might "contribute" them to this first mission, in exchange for the crew's efforts at field-testing them: new carbon dioxide scrubbers, new water recovery systems, new thermal management systems, new closet-sized salad stuffs agripods. Of course, there is a real risk in integrating equipment into the mission that "needs to be proven." Mission planners need to weigh the risks. Free is hard to argue with.

Other firms may also contribute optional equipment and pay the Moonbase Company to field test and debug it. But then there are new enterprises chosen for pioneering by the Company (TLRC) for extra profit-making potential. It is this class of activities the Oregon L5 team is endeavoring to illustrate.

If everything about the mission, not just its entertainment value, is looked at as an opportunity to make money, the enterprise may just succeed.

MMM #148 - SEP 2001



The Heart of a Lunar Home: An "Earthpatch"

On Earth, if there is a feature that is considered 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 *below*.

In Focus Thinking Outside the Box & Lessons from September 11th, 2001

The successes achieved by the September 11th terrorists caught most everyone by surprise. The public can be forgiven for this surprise, but not our security forces. We have all heard that "a chain is only as strong as its weakest link." The terrorist's job is to look for that weakest link. Security forces should be looking for it too. That they failed to see that a fully fueled commercial plane could be used as a missile demonstrates their failure to habitually "think outside the box." They failed to think "like terrorists" and in this, by their complacency, they let us all down. They settled for "quick fixes," for a "false sense of security." And they may do so again.

All Tools are indifferent. Any tool can be used for good or evil, constructively or destructively. It is the user alone who determines the morality of the work done by tools. Down deep, we all know this. Technophobes, of course, miss the point, much to the discredit of their own intelligence. Thinking outside the box is a "force" with "a dark side" too. And as with all tools, it is easier to put this to destructive use than to constructive results. Those impatient for results, find quicker gratification in destruction.

Thinking outside the box is a mental discipline that aims at identifying ways to "break out" of the constrictive set of expectations and assumptions imposed by the "conventional wisdom" *in any area*. Ways to open the Space Frontier are no exception.

Few people ever think outside the box of conventional wisdom - this is not a discipline that comes easily. Not surprisingly, people interested in space are no exception. Both terrorism and space are frontiers, however radically different, where conventional mental exercises can be expected to produce only marginal and trivial results. Conventional Wisdom is a millstone around the neck of anyone who aims to open or help open a frontier. The smugness of conventional thinking must bear much of the blame for the painfully slow and trivial progress made in opening the space frontier over the past few decades.

Conventional Wisdom, when it is accepted without reservation, is *the true enemy inside*. It straitjackets our minds, preventing us from seeing, testing, and developing alternative strategies.

NASA is not, and never has been the enemy. The agency itself has used "thinking outside the box" to make many breakthroughs. But in anyone or in any organization, successes "settle in" and create a new complacent expertise. Thinking outside the box is something that *must* be practiced continuously and *afresh forever*. And that is where we all tend to drop the ball.

That the startup rocket companies are all essentially pursuing "outside the box" strategies, some more effectively than others, is clear. NASA has sought to publicly discredit these efforts, seriously damaging their ability to attract venture capital. Does this demonstrate a culture-belief that only they are qualified to brainstorm - the High Priesthood Syndrome? Or do such spokespersons believe that "thinking outside the box" has already been pursued to the limits and that there is no more to be learned?

Those of us who are unwilling to settle for the conventional wisdom that space can be opened only by enormous bureaucracies with bottomless pockets refilled from general taxation, owe it to ourselves to operate as "cells" with cell mentality and strategy -- not for destruction, but in ever being on the search for breakthrough concepts, means, technologies, methods, and concepts. Again it is no agency that is the enemy. It is the smugness of conventional wisdom with its unsuspected, unexamined assumptions and presumptions of which we need to be wary.

On the technological front, it is simply not true that NASA has already tried everything. All too often a premature decision is made among competing technological concepts. *The right way is to develop all the options and let the results pick the winner*. Politics, political favors, and personal fancies often have more to do with the paths we choose. “The Path Not Chosen” may have been the better one.

Financial pathways, too, have been widened into paved freeways of “infrastructure” without careful and patient thought given to alternatives. “Private enterprise” options are dismissed because existing forms seem inadequate. But the need is again to think *outside* the box. What is there that has not been tried? Those who assume we have tried everything need to be ignored and left behind.

We are all impatient to possess the “truth.” That is why people choose religious dogmas and political ideologies. They cannot stand being uncertain, to recognize and accept that what we don’t know is more than what we do. We are people of the 21st century. We “know.” *No, we don’t!*

Faith passes itself off as knowledge and on that non sequitur rests so much hatred and evil. *We too believe*. We have faith that there is a place for humans in the solar system at large. We do not know that, we believe it. But that faith should motivate us to keep looking for the weakest links in the chain of the conventional wisdom that would bind us to Earth forever. We must borrow the tools of terrorism but without “dark side” applications. Like those who brilliantly planned the attacks of September 11th, we must brilliantly plan assaults on the many bonds that threaten to keep us Earthbound. -- **PK.**

"Earthpatch"

Anchoring Lunar & Martian Homesteads

by Peter Kokh

Stating the Question

In the past two issues of MMM (#s 146, 147) we talked about the effect lunar habitat construction modular architectures and building materials would have on early settlement interior decor styles. This month we want to talk about something even more basic -- the effect that the total absence of a host biosphere on the Moon (or Mars) will have on frontier homestead interiors.

On Earth, except in the driest of deserts and the rockiest of mountainscapes (and at sea, of course), human habitat structures are inanimate islands dotting the green continuum of the host biosphere. Earth is *still* Eden!

On the Moon and Mars, the host continuum is inanimate, barren, sterile, and life-snuffing. And it is intensely monochromatic - either shades of gray or shades of tan. The table has been turned “180°.” It is pockets of green life, “Patches of Old Earth” that we need at the core of each frontier homestead to provide the same reassurance as does the hearth on Earth.

To the designer of initial short-term occupancy starter Moonbases, talk of garden green spaces within habitat (as distinct from closets of LED-lit plant trays in hydroponic racks) is sheer extravagance, a luxury that is quite out of the question. But to the designer of frontier habitats intended to serve as lifetime homesteads for pioneers who are ready to commit to forsaking return to Earth indefinitely, this is not a luxury, but an absolute psychological necessity. We are not talking about what is needed to keep our bodies alive. We are talking about *what is needed to keep spirits alive* -- and productive.

Spacecraft hardware engineers operate in a feedback vacuum quite unlike CEOs of large corporations who have learned that increased perks mean increased productivity and increased profitability. To “get” you have to “invest,” -- the corporate translation of “no pain, no gain.” Green Oases at the core of frontier homesteads on alien life-hostile shores are precisely the investment needed to tilt the steep odds against successful off-world transplantation of humanity *towards* odds in our favor.

Supporting Argument - Modular Biospherics

Given that there will be community agricultural areas that will grow both in number and in total area as settlement populations increase, given that these agripod units will be designed to provide complete nutritional balance for all, given that these units may be designed to provide adequate bioassist air and water recycling -- given all that, why would we also need in homestead gardens? There may well be more than these six good reasons:

1. Interior air quality *will be a problem*. We all know how quickly the air inside a tightly shut space becomes first stale, then sickening, and finally suffocating. Now we can rely on chemical scrubbers and community fresh/stale air ducts and fans, or we can hedge our bet with abundant house plants to keep air fresh and sweet. In the tightened up homes of today, we rely on air exchangers to replace stale air with fresh. On the frontier, “air-exchangers” will not be an option. There is no “air” “outside” to exchange. We have to refresh our air “in place.” NASA has already done considerable research with plants that are especially effective as air-scrubbers and eaters of airborne pollutants.
2. In the course of everyday life, not all settlers will spend time in or passing through the agricultural areas. Knowing that out-vac, out the air locks, there is only vacuum and sterilizing UV and cosmic rays, abundant foliage in the homestead where everyone will come into daily contact with it, will reassure us all that we have indeed brought along a pocket of life-cradling Mother Nature, a patch of Old Earth. The home garden will be a psychological security blanket as well as a “feast for sore eyes.” Air freshened by plants is not only fresh, but fragrant.
3. Relying on settlement-wide systems, shares not only benefits but risks. Supplementing the settlement air and water recycling / refreshing utilities with in house systems provides a *risk-distributing* backup.
4. Homestead gardens can be integrally linked to human waste *pretreatment* systems, greatly *reducing* the burden to be handled by settlement-wide utilities. The Bill Wolverton system is very promising in this regard. [Check http://www.wolvertonenvironmental.com/dww.htm]

by treating 95% of the problem at its source, the settlement biosphere can grow in modular fashion instead of as a megasystem much less adequately buffered and much more prone to failure.

5. Without the multi-shade greens of the garden, without the bright colors of blossoms, flowers, and fruit, the gray (or ruddy) monochrome color schemes enforced by available building materials will become dreadfully dreary. The home garden will provide an ever changing feast of eye candy.
6. Sunlight, filtered to remove unneeded heat from the infrared, flooding the garden area will spill beyond its confines to flood adjacent areas of the homestead. We all know how important sunshine can be for morale -- even if it alternates 2 weeks on 2 weeks off with artificial grow-lighting.

And in fact, there is at least one more good reason. The homestead garden promises to be an especially prolific incubator of frontier "cottage industries". More about that in the follow-on article.

How do we provide for home interior gardens?

To have a garden in a habitat pressurized against the exterior vacuum and thermal extremes, we need to provide water and light. *For the sake of argument,* we accept the statements that hydroponics are much more efficient than soil-based geoponic systems, and that blue and red LEDs are much more efficient than sunlight. That may indeed prove to be the way to go in the community agricultural units, at least for some crops which do especially well in hydroponic growing conditions. (We are unconvinced that *all or most* crops do better with hydroponics.)

Soil-based horticulture on the Moon is quite feasible. In the process of handling the raw regolith, there is opportunity to sift out the powdery fines that could clog drainage systems, and to transform many of the regolith minerals into zeolites by baking. *All this experimentation has been done and is well documented.* Plus the regolith has many of the nutrients that would be needed, without resort to wholesale importation from Earth. Desired organic content can come from in home pre-treatment of human wastes and composting of kitchen scraps.

Sunlight delivers too much heat, yes, but that can be filtered out easily enough. Or sunlight can be used to generate electricity to run full-spectrum lamps that are designed to produce reduced heat.

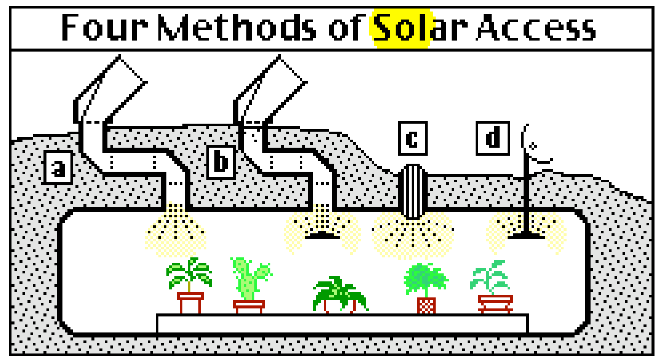
The biggest argument of all is esthetics. If any reader has heard of a garden show that attracted throngs of people by its beauty, in which all the plants were grown hydroponically and shown under banks of LEDs, my conviction might be shaken a bit. We have thousands of years of conditioning of our sense of beauty by soil-based gardens.

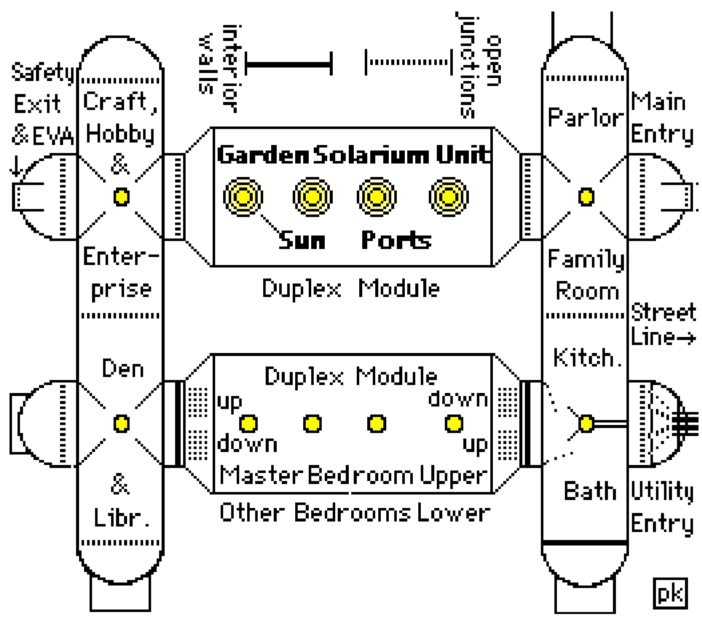
If soil-based horticulture is somewhat less efficient, that is immaterial. It has already been granted for the sake of argument that all the required nutritional needs for full dietary balance will be provided by the settlement farms. That means that home gardens are relied on *only for surplus and to provide treats* not planted in the settlement farms. The exchange of some degree of efficiency for much more beauty and satisfaction is a fair trade.

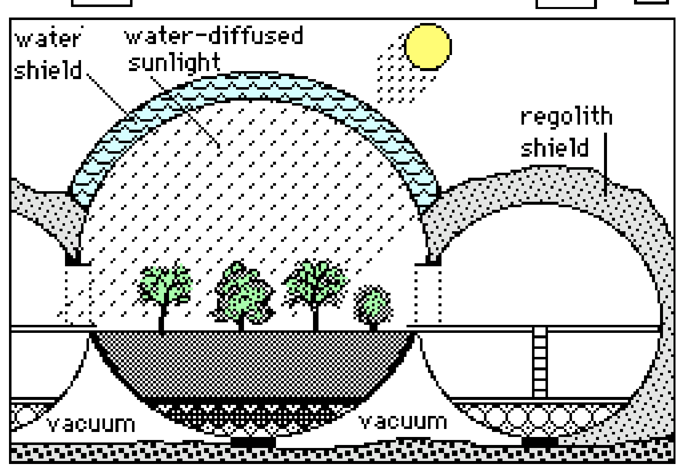
Architectural Provisions

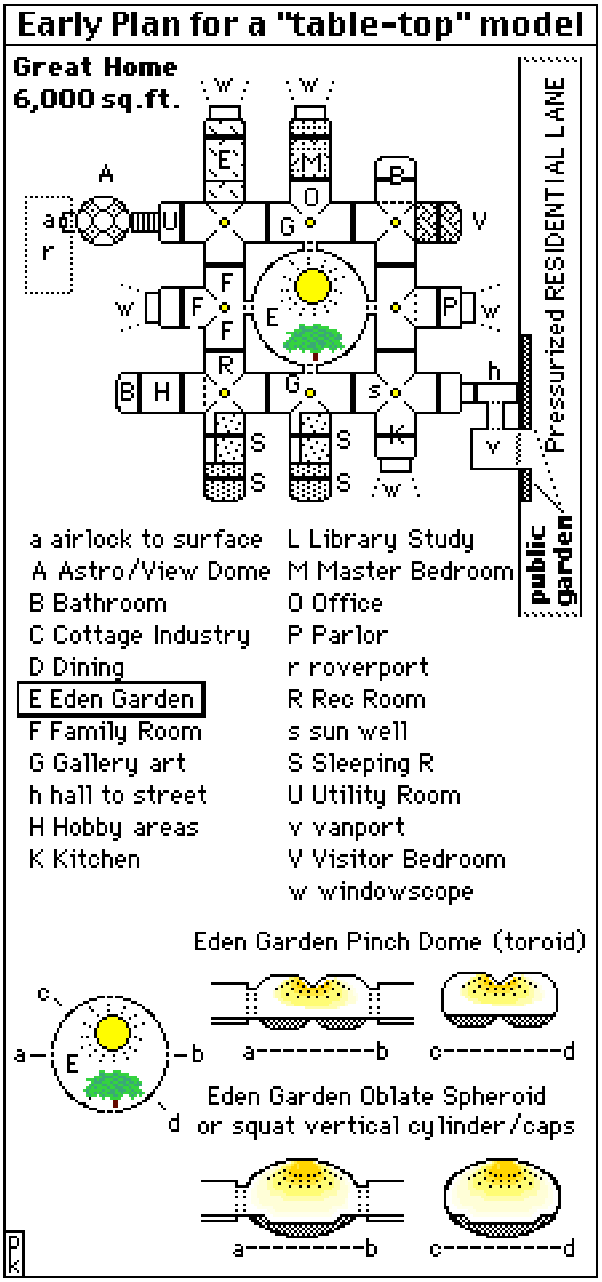
How can the frontier architect, working with pressurized structures and locally produced building materials, design in sunlit garden spaces? Once one is convinced of all that is to be gained by having "Earthpatches" and how much is to be lost by not designing for them, this will not seem like a design burden, but rather a design delight. It will be a chance for the frontier architect to be creative, much as they are with churches. While form follows function, that is not a 1:1 determination. Architects will find many ways, some better, some cheaper, some more satisfying. Variety is the spice of life.

We have suggested a number of ideas in past issues for modular homestead layouts in which sunlit garden spaces were a key element. Below are a few.









The plan of the actual table top model of our modular "Moon Manor" introduced at ISDC '98 can be seen at www.lunar-reclamation.org/page11mm.htm

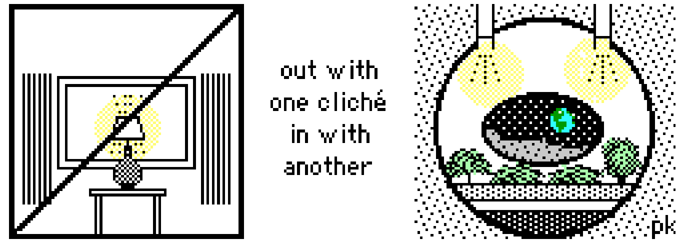
There are many architectural solutions for this concept and it is not our purpose to pick any one but simply to help the reader visualize some of the possibilities.

One interesting architectural allusion to some familiar terrestrial homes would be a frontier homestead built on the atrium garden courtyard plan with the living areas surrounding and opening onto a central garden area. Realizing that concept with modular construction methods in locally produced building materials is the challenge we put to would-be lunar architects. There is too much to be gained from realization of this idea to let initial difficulties stand in the way. *It will be done sooner or later.*

Extending Garden Spots throughout the Home

Solar access can be arranged not just for the central garden area, but throughout the homestead, delivered from central access ports through light tubes to areas above planters as well as areas needing accent or task lighting. Thus there could be islets of greenery wherever one wanted to have them.

We might want planters, not lamps, in front of "windows" - be they "periscopic" units or live video screens - to act as reassuring living "filters" through which to view the magnificent but chillingly barren planetscapes beyond. Light pipe ports could funnel in sunlight.



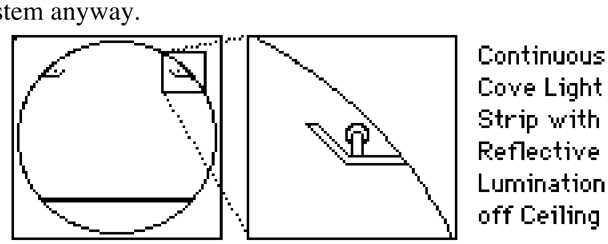
Using light pipe layouts to channel sunlight during the long dayspan and light from central sulfur bulb megalamps during the two week long nightspan, we can place planters, brimming with foliage and flowers, wherever we want them: along sidewalls, in the middle of large rooms, in sweeping curves or simple straight lines. Thus sunlit planters would be an especially great way to divide large spaces into cozy room settings. The pools of light would tend to visually obscure what lays behind them, making a virtual visual "wall" between areas with different functions.

How flexible would such a biological room divider system be? In other words, would the light pipe system and its ports be "rearrangeable?" After all, there are those homemaker types who quickly get bored with any given furniture arrangement, no matter how well it is tailored to the the living space shell (walls, doors, windows, fireplaces and other immovable particulars.)

Given that light pipe systems would likely be installed only with customer involvement in placement of runs and location of ports (light fixtures), it is most likely that they will be consist of modular components. If so, it is probable that they can be rearranged. At the most, it might involve ordering a few more modular connectors etc. However, pointable "spots" from a center ceiling-mounted pipe run should do the trick of channeling the dayspan sunshine (or nightspan substitute) wherever desired.

However, to the extent that some light access components are likely to be built into the various habitat modules, those would be more or less fixed. "Use them or lose them." These features would include the sunlight point of entry "sundows" of various designs. [See the illustration "Four Methods of Solar Access" at the top of page 4, Col. B]

Another built-in lighting fixture is likely to be coves to hide ceiling washer lights -- of little use to a plant lighting system anyway.



From MMM #75: "Lunar Appropriate Modular Architecture"

We could make use of the lower part of some of the curved module walls for terraced plantings without taking up floor space that can be used for walking. Many kinds of plants are suitable for terracing, including hanging ivy,cactus collections, even bonsai “forests.” These terraces need not be geometrically regular. Freeform ones would be more nature-like and even include mini-waterfalls. The illustration above shows a such garden side-wall terraces on the left, opposite built-in cabinets on the right, neither infringing on walking space.

Streetside Gardening Opportunities

Our homes are usually set on lots with front, rear and side “yards” covered with grass, shrubbery, flowers etc. On the Moon or Mars “lots” are barren and lifeless and without access to water or useful air. The “front yard” and “garden” has to be interiorized, located in the “reclaimed” space within the pressure hull complex. This “reclamation” process allows us to create “Earthpatches” in these unlikely settings.

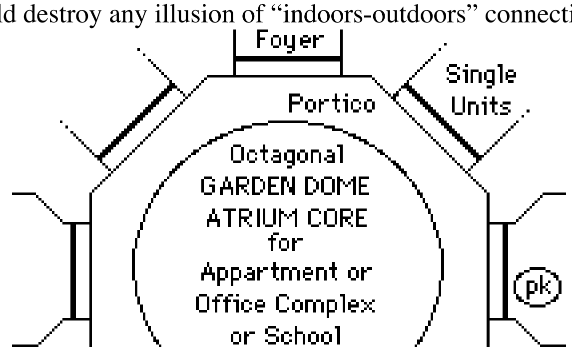
Homesteads will not exist in mutual isolation but be interconnected in a larger biospheric maze, each opening via a securable pressure door onto a pressurized “street” on the analogy of our terrestrial residential blocks. If these streets are sunlit at intervals, then these frontages are also opportunities for gardening - in public view.

Connecting Indoors and “Outdoors”

On Earth, a few older homes and many new ones, are specially designed “to bring the outdoors inside.” This is done with generous windows and window walls and patio doors. Outdoor plants seem visually connected to indoor ones. Using the same floor material on an outdoor patio as in the inside room opening onto the patio strengthens the illusion.

On the Moon where the “outdoors” strictly speaking is barren, lifeless vacuum -- the “Out-Vac” -- such a scheme is not possible. There is no vegetation outside the window and windows cannot be anywhere near as ample to keep depressurization risk at bay. But we can still establish a “connection.” Japanese style sand and rock plantless “gardens” are a model. Lunan homesteaders can place areas of bare regolith and lunar breccia rock, artfully arranged, in front of windows, and fringe them with plants, *safely* inviting the “Out-Vac” inside.

NOTE: not only would the regolith to be brought inside first be sifted to remove the ultrafine and troublesome “powder” but the remaining regolith “sand” would also need to be magnet-purged of as much of the free iron fines content as practical. These fines have kept their “virginity” as far as contact with moisture is concerned, intact for eons. Once in a pressurized and humid environment, they would rust. The gray tones of the regolith would start to take on rusty hues. And that would destroy any illusion of “indoors-outdoors” connection



Options for Lunar Apartment Living

Homestead Gardens will have their counterpart in multiunit housing commons, with resident associations taking care of maintenance and upkeep.

Water for the Gardens and Planters

Gardens require water, but not necessarily “extra” water. There is no reason why the water to be used in the gardens and planters, even in fountains and waterfalls, can’t be waste water in some stage of treatment. Indeed, some interior plant beds can be integral to systems that provide primary treatment for human wastes, both liquid and solid. Bill Wolverton, a retired NASA environmental engineer has had such a system running trouble-free in his Houston home for decades. Not only is it surprisingly odor free and pathogen-free, but the air within his home is always fresh and sweet. We’ve written about his system before in MMM #116 July ‘98, “A Modular Approach to Biospherics” and incorporated a representation of it in our table top Moonbase. [See the link on page 5 col. A.] Read about Wolverton’s work at:

http://www.wolvertonenvironmental.com/dww.htm

His just-published book, “Growing Clean Water”, joins his previous work, “How to Grow Fresh Air.”

On Earth, every pound of living human flesh depends upon hundreds of pounds (or tons) of plant matter, every pound of which is supported by many tons of water -- consider the oceans! On the Moon it would be foolhardy to depend on marginal quantities of water. Even with conservative practices in both industry and agriculture and domestic use, we are going to need a lot of water. But we can stretch water much much further if we put it to work at every stage of its recycling loop.

Given these considerations, and the wisdom of building homes with integral primary waste water treatment systems, means that ample water for domestic garden spaces *will be available -- must be made available*. The “Earthpatch” concept is not only doable, but a must from several points of view: overall waste water and stale air treatment strategies, psychological health of the pioneer population, and opportunities to raise vegetables, herbs, spices, dye stuff plants, and flowers not included in the community gardens and agricultural areas. In a future article, we will explore how homestead gardening can be the foundation of a versatile, varied, and thriving “Cottage Industry.”

Summing up

Quite by serendipity, it came to my attention recently that the Japanese word for “home” when written in the older Chinese character, is rendered by a compound character with one part being the character for “house” and the other “garden.” I suggest that the Japanese have it right. A house without a garden, inside and/or outside, may be a cozy house, but it just isn’t quite a “home.”

On Earth, the biosphere is a planet-wide given. We can get away with “ignoring” it in designing, building, and furnishing our homes. The biosphere will coddle us whether we make an effort to “integrate” our homes with it or not.

On the Moon, even on Mars, there is no given biosphere. In each settlement, all habitable spaces and structures will share a pressurized "safe house" and a shared minibiosphere nourished within it. That human-installed biosphere will always be at risk. Partially distributing the happy task of maintaining it by the modular approach to biospherics that incorporates an "Earthpatch" and primary waste water treatment system in every living quarters is a strategy that makes sense.

On the frontier, we will have to "interiorize" the biosphere. That needs to become not only public, communal practice, but also "second nature" for each pioneer individual. With this approach, frontier children will grow up with "the biosphere instinct" and be green-conscious, freshwater conscious, fresh air-conscious. It is hard to see how frontier settle-ment can survive long term without establishing such a "culture" of *greening wherever possible*.

To be honest, not all of us (myself sadly included) have "green thumbs." But that may be less a case of inborn talent than of how we were individually raised. Started early, most children can learn how to care for plants, and learn to enjoy doing so.

"Patches of old Earth" will be welcome everywhere, but *"Reclamation Starts at Home."* **<MMM>**

Music of the Lunar Spheres

Cosmic Weather Flux Translators for Unique Sound & Light Shows

by Peter Kokh

Are any of the phenomena of the Moon's cosmic weather sufficiently variable over a range that would allow their "translation" via automatic devices to "cosmic music," or better, "sound & light shows?" Perhaps, perhaps not.

Nature provides the example: the Aurora

A prime example of what we have in mind exists here on Earth in Nature herself. The natural processes that produce the "Northern Lights" or *Aurora Borealis* might be thought of as a "Solar Wind Flux Translator." Northerners occasionally get to see this unpredictable spec-tacle, especially in the countryside far from the glare of city lights. In Canada and border regions of the U.S., the odds are best. For those who flee/ have fled character-forging winters for Cottonelle Climates, the lost Aurora is part of the trade off package they bought into.

The Aurora is caused by charge particles funneling in towards the surface at Earth's geomagnetic poles. These poles do not coincide with the North or South geographical poles but are displaced from it somewhat because the magnetic dynamo of molten iron in Earth's core seems to have its own displaced axis. The North Magnetic Pole is not far east of Resolute and Devon Island. Thus North Americans are much better placed to see the aurora than northern Europeans or Asians.

These auroral displays are "ribbons" of light that are constantly changing in color and intensity. Watching them change color, height, and brightness is an enthralling, captivating experience. All this activity indirectly captures *and "translates"* into a visual medium we can enjoy, the flux of within the Solar Wind. That flux varies greatly over time and is most prominent during periods of high activity on the Sun's surface, in an eleven year cycle.

The Moon lacks the powerful magnetic dynamo in its relatively tiny iron core to make the Solar Wind particles dance to its tune in this way. So the Aurora is something Lunans will probably never enjoy. I say probably, because there is a definite local weak magnetic field centered in Mare Ingenii on the Farside, at the antipodes of the catastrophic impact that carved out the Mare Imbrium basin on the Nearside. It would be an interesting experiment to see if we could coax a visual show out of this mini-field by detonation release of a cloud of charged particles overhead of this point.

Such idle speculation aside, it might be worth investigating to see if the Moon's cosmic weather elements can be put to work by one artificial electronic device or another to create a unique sound and light show. Such a uniquely Lunar, however man-assisted display might become something for many future Lunans to enjoy, making up in some small way for all the beauties of Nature in the Earthly paradise they have left behind: the clouds, sunrises, sunsets, and auroras; lightning.

What we have to work with

- The **Cosmic Rays** that wash the lunar surface constantly and relentlessly would seem to do so with no significant rhythm or variation. They are probably too monotonous and "noisy." But not to be dismissed without a college try.
- Ditto **Micrometeorites**, which fall in a constant soft "rain," except possibly during seasonal "meteor showers, " the same Leonids, Perseids, Aquarids and others we enjoy on Earth. Only Lunans, having no atmosphere to heat them up into streaking blobs of plasma, won't get to enjoy these showers as we do. But again, could we create some substitute intercepting medium that would transform this invisible show into something we can sense, if only on a screen?
- **UV** - only some comparatively innocuous fraction of the Sun's ultraviolet rays get through to Earth's surface. They strike the Moon's surface, however, in full strength, fury raw, and untamed. Does the rate vary with solar activity cycles, does the spectral mix of the incoming UV vary over time? These are things worth investigating.
- **Solar Flares**, when uncharacteristically strong, are a nuisance for our highly electronic civilization, creating a lot of havoc with the upper atmosphere. On the Moon, with no Van Allen belt to even partially deflect their blast, they can be lethal to anyone on the surface poorly protected. They come and they go - a crescendo, climax and and an anticlimax. Again, are there patterns here, and enough variation to be translated to some sort of awe-instilling, soul-touching beauty? We'll have to experiment.
- **The Solar Wind**: This we have already talked about [bottom of column to the left]

Variation and Time Scales

Variation in "volume" or "frequency" or "wave length" can easily be handled by the right choice of logarithmic scales on which to base the "translation" of the flux to within our normal audible and visual ranges. No problem.

The only showstopper is monotony -- real monotony, not just apparent lack of variation. If some cosmic weather phenomenon varies in intensity or wavelength etc. only over boringly long times out of synch with human attention spans, that just means that a "live translator" is not a workable choice. We can adjust the "speed" to one at which what variation there is catches and holds our interest. That is, we produce "recorded sound & light shows."

One possibility is to take "cuttings" with distinctive characteristics, and using them as words or elements, compose Nature-inspired sound and light works that are a collaboration of Nature and a human artist. This too would be enriching.

The Screen

Nature produces the Northern Lights on the sweeping stage of northern nighttime dark sky horizons. No such "screen" is available for future Lunans. Any inventive "cosmic weather flux translator" they devise (or we, for them) will have to be "played" on a man-made stage of some sort.

The auroras vary swiftly and in each circum-lunar direction. There is probably enough to work with in the Solar Wind that if we can come up with an analog electronic translator, we will want to display it on a very wide (eye-wide) high definition screen.

Other phenomena of cosmic weather washing the Moon's surface may have less degrees of variation and require simpler displays systems -- a normal HDTV screen or even just surround sound alone.

So What's the Point?

We have no suggestions how inventors can work around these many challenges, but we are confident that given enough creative resourcefulness and a few serendipitous eurekas along the way, it can and will be done. Whether they produce satisfying results in each area of cosmic weather or only in the one we know has the right ingredients (the Aurora-making Solar Wind,) the results could prove popular, even with say the same cross-section of people who like New Age music. And the ultimate natural screen saver could be a byproduct!

Cosmic weather flux translation broadcasts will not enthrall everyone, but then not everyone pays attention to a beautiful sunset (or aurora!(. But if it enthralls some, that will be a plus.

Actually, Nearside Lunans (Farsiders, too, by "cable") are guaranteed one sky spectacle that no one on Earth can enjoy -- the spectacle of the ever changing colors, seasons, phases, cloud patterns, snow cover, and urban night lights of an Earth globe hanging in the sky, a globe twice as wide and sixty times as bright as the full Moon we get to enjoy. Our point is to add more nature-tuned "performances!"

The ancient Greeks spoke about the "Music of the Spheres." Future Lunans may collaborate with Nature in arranging performances that many can enjoy. On the Moon, where pioneer will have given up so many of the delights of Earth, can we begrudge them of such "celestial" delights? **<MMM>**

Let's design, fabricate, and deploy a "doable" M.A.R.S. - like L.U.N.A. Analog Station

by Peter Kokh

[L.U.N.A. Lunar Utilization & Necessities Analog]

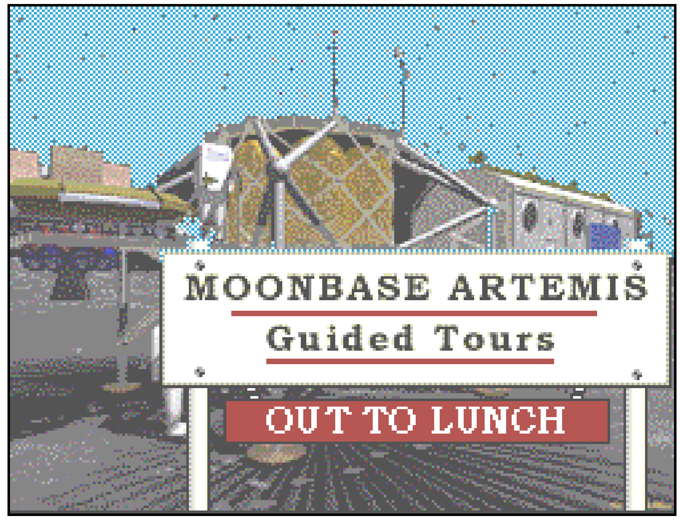
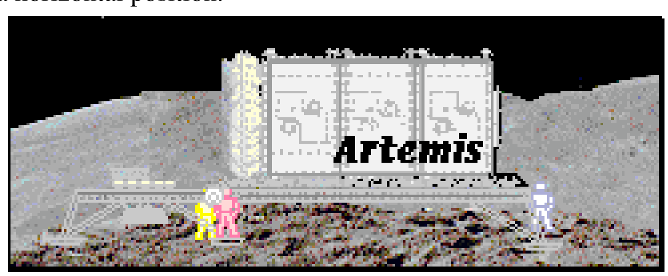


Image ©1998 Vik Olliver

In fact, the tour guides have been out for lunch for three years. The Moon Society has its Project LETO plans. There seems to be little agreement on how to start on what would be a very elaborate education-tourism-research facility. *But without a "doable" Phase I,* LETO is "at risk" of never being built.

Design, Fabricate, Deploy - a serviceable Artemis Moonbase Analog Earth Station

The design for a first Artemis Moonbase™ that is currently worked into the Artemis Project™ Reference Mission is a complex that consists of three duplex SpaceHab modules ganged together side by side along with an airlock, sitting on the framework that was used to lower it off the lander stack to a horizontal position.



You can see this deployment scheme at:

http://www.asi.org/images/asi199500026.mov

The great advantage of using duplex SpaceHab modules, especially in comparison with the MarsHab design favored by the Mars Society, is that these modules exist. They are an off-the-shelf item, the only existing ready-to-buy and space-tested habitat space, and available at a relatively cheap price.

While the Mars Society has been able to have two versions of its design fabricated at a reasonable price, the real thing does not exist except on drawing boards, and will not become real except through a very costly government development program. "A bird in the hand ..."

So in large measure, the design process comes down to decisions on interior outfitting. SpaceHab modules are built for use in zero G not on the Moon. So we need to determine a vertical orientation and floor system, and passageways between the connected duplex modules, plus an airlock. We don't have to go into details, just come up with a design that will work for operations simulation purposes.

The next step would be to put our a request for proposals from various potential fabricators of our serviceable mockup "analog station." AND put out a plea for major sponsors as well as individual donations. The Mars Society did not finance its two analog stations, one in the arctic, the other to be deployed in the American Southwest, from general funds. The whole concept of a reasonable analog station where people can practice operations on Mars' (or the Moon's) surface is evidently exciting to a large cross-section of the public. "Build it, and they will come!" Only here, by build it, we mean build the design and have cost estimates from real fabricators. What "will come" is the money.

It is extremely hard to sell such a concept to leaders who have had to struggle with perennially limited budgets - the idea that you can do something exciting without touching the group's treasury. It has proved impossible to convince the National Space Society of this, and that very frustration absolutely necessitated creation of a new "have gutzpah, will do it" society, the Mars Society, whose growth has been phenomenal. People can see that here is *one* outfit that will not rest with talk-talk, but it determined to "just do it." These are bitter words for others who cannot make the paradigm shift, and dismiss the Mars effort as so much grandstanding. Rather, it is those who only talk, and dare not do, that grandstand.

The Moon Society, and the associated Artemis Society in which there is joint membership, has remained small to date. The concept of the Artemis Project™ is great. Predictably, it does not win over those addicted to government socialized space. But to grow, we don't have to win Apollo Program junkies, we simply have to build our Field of Dreams. We regret any perceived stepping on toes that such a suggestion involves, but it needs to be done.

Where should L.U.N.A. 1 be deployed?

Note that we do not have to determine the deployment location of our L.U.N.A. station in order to design it, call for RFPs from a variety of potential fabricators, and make funding appeals. There is time for site selection. But it *is* important to begin determining how much space we will need to allow for adding such things as an agricultural unit, fabrication shop, sunshade ramada, solar power arrays, etc.). We should allow 2 or 3 times as much growth space as we now think we might need -- at least.

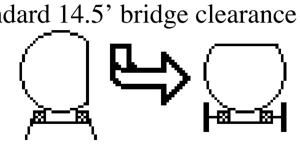
Next we should look at how much space we might want for a tourist visitors center slash forward base camp. This space should be nearby (e.g. within a mile or two) but need not be contiguous. There are such things as busses, ... er shuttle craft! Public parking access at the L.U.N.A. is unnecessary.

Experimentation and fabrication shops can be at either location. Those that would be on Earth in a real scenario can be at the Tourist Center. Those that need to be on the Moon would be at the L.U.N.A. site.

Space for the analog outpost itself can either be purchased or leased by agreement, say with the National Park service. The idea here is to have the actual analog outpost not on just any old piece of vacant desert rock and sand, but in a barren moonlike terrain with minimal vegetation and some geological analogies to features we will find on the Moon. There must be many sites worth considering besides the Nevada desert -- Death Valley National Monument, Oregon lavatube country, Craters of the Moon National Monument, etc. to name those that come easily to mind. I'm sure that there are others.

Redeployability

The chosen inline complex of airlock / three ganged SpaceHab modules on a truss platform makes it eminently trailerable. This is a distinct advantage over the redeployable Mars Desert Research Station. The M.D.R.S. has to be taken apart, moved, and then reassembled. The L.U.N.A. complex only needs to be disconnected from on site utilities, and then towed. Actually, we will need to rotate the 13.5' high SpaceHab complex on its back (or tummy, in order to be within standard 14.5' bridge clearance requirements.



SpaceHab Cross Section

This clearance requirement will pose some constraints on how the airlock is sized and shaped and how the structure is tied to its truss frame as well as wheel placement. But none of these considerations would seem to be a lurking a showstopper.

As is to be done with the redeployable Mars Desert station, the L.U.N.A. station could have both its research seasons and an off-season in which it goes on tour to various space centers around North America. Moon Society membership will swell.

Advantages of having a L.U.N.A.

The upside of such a project is considerable:

- We will be able to greatly improve the first lunar return mission plan by our operational simulations, finding the need for outbuildings and for equipment that we had not considered
- We may find design flaws that need correction if the facility is to provide maximum support for lunar surface operations, etc.
- We will have a chance to try various schemes for emplacement of regolith shielding over the base
- We can test the merits of the various competing biologically assisted waste recycling systems, some of them combined with food production
- "Overnighting" exercises are at the top of the list in overall importance. ***Until we can safely "Overnight" on the Moon, we* won't *be back to stay!*** -- We will be able to simulate abundant power operations during simulated dayspans as well as test various ways to remain productive while using much less energy during simulated nightspans. For the former, we can use powerful floodlights at night to simulate continuous dayspan periods. For the latter, we can have a large frame for a light-blocking tarp - or more

simply, just shutter the portholes of the outpost. Helmets could have dark glass or filters that turn blue sky to black

- We can try sunshades over the entry porch area and dust-cleaning surfaces on airlock stoops.
- We can test various schemes for storing abundant dayspan solar power for use during nightspan, looking for the advantages and disadvantages.
- We could field test different interior outfittings from season to season to test ergonomics and effect on operations productivity, crew morale and satisfaction. We could hold an interior layout design competition with given set specifications for equipment and functions to be accommodated and crew size. Competition entries will give us an early idea of the kind of generic attachment points we may want to build into the structure.

Some of the lessons to be learned have already been clarified by operations simulations at the Mars Arctic Research Station on Devon Island. It won't hurt us to validate them, however. But that brings us to the topic of differences between the Moon and Mars that will affect how astronaut pioneers operate in the two different environments. We have already touched on simulating the 29.5 day long lunar dayspan / nightspan cycle. The M.A.R.S. and M.D.R.S. stations impose a ten minute built in time delay in two-way radio communications with "mission control." Our L.U.N.A. station needs only a 3 second time delay.

The Moon has a much more severe range of thermal extremes. Clinging dust is a problem on the Moon. We don't know that about Mars yet, but on that world, dust storms are a problem. The Mars people will be looking for fossils of algal mats and bacteria whereas the lunar astronauts will be looking only for minerals and geological features.

Analog Fidelity:

The L.U.N.A. outpost structure must be faithful only to the point that it can support simulated operations which should reveal how long different operations will take, how difficult and/or fatiguing they will be, and what kinds of equipment not previously thought of would make each task easier.

The same is true of our simulated Moonsuits. They must provide the same degree of cumbersomeness that we will experience on the Moon, the same ventilation, thermal control, drinking arrangements, communications, etc. Radiation-proofing, puncture-resistance, and amount of thermal insulation need not be duplicated for the suits to play their major supporting role in simulating outpost operations.

Labor Costs to Operate L.U.N.A.

If we follow the system proving eminently workable for both the M.A.R.S. and M.D.R.S. analog stations, all personnel are there *as volunteers*. It has proved no problem at all to attract volunteers with considerable expertise in the various fields of operations to be simulated. The Mars Society *does pick up* transportation costs, food, and en route lodging. This lesser burden is also covered by enthused donors.

"People have been talking about establishing a simulated human Mars exploration base for at least 20 years; we finally made it happen. It was done through the efforts of Mars Society volunteers, not just those who served in the crew, but hundreds of others. It was Mars Society volunteers who first developed the plans for the station, who raised or contributed the money, who helped publicize the project, who went in to get the fabrication work done at the factory, who pitched in building the hab on Devon last year when the chips were down, who worked out the mission communication protocols, who designed and sewed the spacesuits and soldered their packs, who helped with the planning and logistics, who manned Mission Support and our public outreach portal at Kennedy Space Center. Still more volunteers, right now, are working to create analog pressurized rovers that will take to the field as part of our Mars Desert Research Station when it becomes active this fall." - R. Zubrin

The challenge for us is to do the same and stand up and be counted, rising to the occasion.

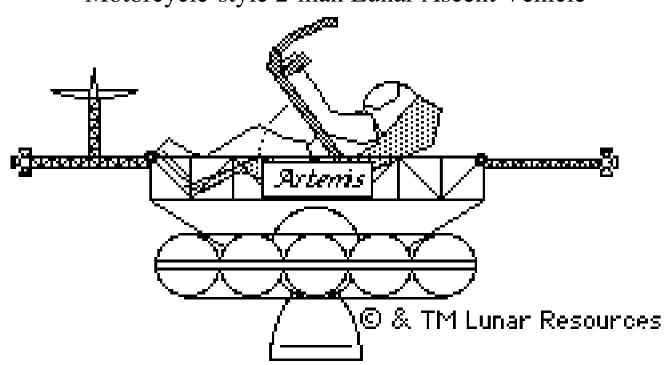
L.U.N.A. and Project LETO

L.U.N.A. is the right place to start. Building a tourist slash educational facility first in order to find the funds to do research is frankly an "cart-before-the-horse" approach with a very strong risk of stalling out in an early phase. Further, the LETO approach would seem too dependent on major casino-scale infusions of capital. And, ... *we would become beholden to stockholders who do not necessarily share our vision of how the complex should develop.*

L.U.N.A. does not need a sugar-daddy, at least not one with pockets so deep. To become real, L.U.N.A. only needs to tap *advertising budget moneys* rather than investment moneys seeking a good return.

With L.U.N.A. as a reality, it'll become much easier to segue into the envisioned Project LETO complex. We begin with a Tourist / Visitors Center -- a conference room, library, museum, exhibits, and gift shop, etc. -- not necessarily in that order.

Motorcycle-style 2-man Lunar Ascent Vehicle

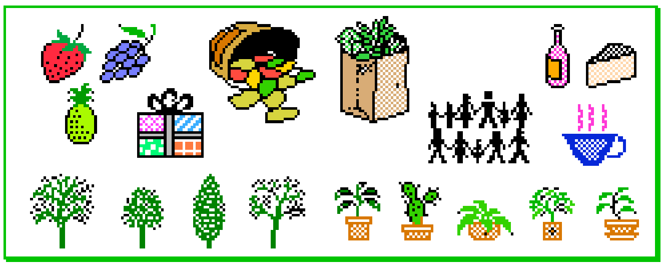


- A mockup of this vehicle is guaranteed to be an exciting exhibit in the Visitors Center, especially if tourists can take turns trying out the couches. A little appropriate music, rocket engine roar, liquid CO2 "smoke", and vibration please!

We could find ourselves waiting years for money that never comes to start an endless project as a way to *eventually* be doing what we should be doing in the first place. Or we can put the horse *before* the cart and have L.U.N.A. up and operating within two years. First we have to agree that this is the better way to begin, and then, step by step, *just do it!*

NOTE: The ideas, concepts, and strategies outlined in this article are those of the author only, and have been put forth as a trial balloon without consultation with the Moon Society leadership. Our continued dedication to the purposes of the Society are in no way conditioned upon a favorable hearing of these ideas. it is our belief that *all ideas* and concepts are best matured (become more fully "baked") in the heat of alternative ideas and concepts. While unpleasant, no duty is more helpful than that of a devil's advocate in this respect. We wish to offend no one. **PK**

MMM #149 - OCT 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 space frontier homestead gardens pursued as cottage industry enterprises. For more, *see below*.

In Focus Distributing Risk - Lessons from September 11th, 2001

[continued from MMM #148, September 2001]

"Those who do not learn from history are condemned to repeat it." One of the things that jumps out from the kamikaze airliner attacks of September 11th, is the very different results between the two targets: total destruction of the World Trade Center towers, *relatively* minor damage to the Pentagon. Yet both facilities were of a similar order of magnitude in total square footage and occupancy numbers.

The towers were essentially *vertical* structures where a local failure *at any height* inexorably doomed the entire structure. Gravity acted on cue to cascade the initial local damage throughout. Here the "Failure Mode" risk was *shared*. Additionally, in each tower there was only one escape route, and when that route was severed by the invading aircraft, those above that point were doomed.

The Pentagon is essentially a *horizontal* structure where gravity worked to collapse only the local sections damaged. In this case the Failure Mode risks were distributed. Additionally, the Pentagon is essentially a loop-type structure, with escape routes in either direction (clockwise, counter-clockwise).

The use of large airliners loaded with both people and fuel as piloted missiles was something unexpected by the architects in either case. Yet even so, air accidents have always been at least a remote possibility. Too remote to design for, perhaps.

On the Moon or Mars, where there may be no one to pick up the pieces or come to the rescue of possible survivors, and where impacts from the sky cannot be ruled out even though the odds are low, it would be insane to design a settlement megastructure with a *shared* failure mode: *failure anywhere dooms everyone*. The popular artist-inspired vision of lunar and Martian cities under glass domes are an example of fate-tempting architectural bravado. Puncture the glass "firmament" anywhere and poof!

On the other hand, settlements built of interconnected modular elements, would, if connections could be sealed, distribute the risks. Some, perhaps most, would survive all but the most unlikely strike. This is not to say that we won't see any domes at all. Domes anchored to bedrock in order to resist the outward push of air pressure could someday appear over parks and city "squares." Such domes would be quite local, and surrounding sections could be sealed off if the dome's integrity were compromised.

Given that it makes sense to go modular in the first place because that is a method of construction that suits growth patterns, a modular settlement may select from any number of overall plans. A *linear* plan of expansion along a spinal transportation corridor might be highly efficient. But given the lessons from the Pentagon event, such a plan risks cutting the settlement into two mutually isolated sections if there were a breach anywhere. But any "urban plan" which provided multiple interconnectivity between various sections, a loop being the simplest of these, would preserve the continuum of the settlement, no matter where compromised.

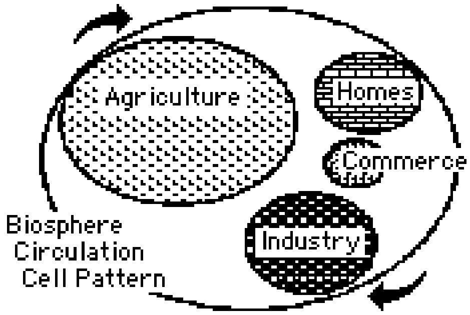
Building architectures are not alone in their vulnerability. In human chain of command / information structures, strictly vertical chains risk collapse if there is a failure at any level. Communist party "cell" architecture, with its multiple connections, is an early 20th Century parable worth learning from.

Decentralization and Polycentric Infrastructure

On the Moon and Mars, the integrity we need to protect includes the pressurization "hull-plex" and also the utility systems: fresh and waste water lines, fresh and stale air ducts, electrical power and communications. Again multiple connections will serve us well whereas an efficient and cheaper linear settlement plan would magnify any catastrophe.

In MMM #53 March 1992 pp. 4-6 "Xities and XITY PLANS: settlement layout options" ["xity" being our word for any settlement that has to provide and maintain its own biosphere], we suggested that it might work much better to design neighborhood scale utility systems. Instead of one central plant for each utility system, we would simple build additional plants as we added additional neighborhoods. Our intent was to accommodate variable growth patterns *and*, not to commit the settlement to soon outmoded systems. If the settlement's utility structure was also modular, newer areas could have the benefit of improved systems when available.

For this to work, each neighborhood cell must have all the "zones" it takes to function as an autonomous biosphere unit: residential, industrial, commercial, agricultural.



But in the light of the recent attacks on New York and Washington, the idea of neighborhood-scale utility systems and nerve centers makes even more sense. The "urbicell" plan, as we dubbed it in the back issue cited, avoids putting all our utility eggs in one basket. On the space frontier this will be much more important than in the Pentagon. Because we live in a planetary biosphere, the utilities could all shut down and we would be only inconvenienced. Not so on the Moon or Mars. We have to make sure that everything that makes the settlement or outpost work is polycentric so the destruction of any center remains a non-critical, survivable matter.

The same goes for the intrasettlement transportation infrastructure. We court trouble not only if we design a linear system, but also if we design around one central hub. If, as the settlement grows, we had additional neighborhood hubs, we will be able to recover from the crippling of any one. Consider L'Enfant's plan for Washington D.C. as an example.

[Grid Highlighted by MMM Editor]

Admittedly, Washington acquired a downtown along the way, to the north of the White House. But in today's world, with the Internet and other electronic means of teleconducting business, commerce and finance, such concentrations of office and commercial space are less essential, if at all. "Infrastructure lasts forever," and while in the past decade many urban downtowns have seen a major renaissance, this rediscovery is driven more by the perceived plus of clustering entertainment and cultural activities than by the traditional pillars of commerce, finances, and transport hubs. Stuck with these relics, we have been voting in ever larger numbers to put them to good use.

On the Moon and Mars, where we can build with a clean slate, it makes more sense to build a series of hubs. While this make sense from a security point of view, it also avoids the historic pattern of city growth in which an ever growing downtown ends up swallowing the residential neighborhoods that surrounded it at the start, much like a black hole keeps swallowing up hub-hugging stars in a galaxies nucleus. With a modular urbicell plan, this pattern of continual displacement becomes something of a past. Neighborhoods are free to be the *stable* life-fostering zones they should be.

Not only should the frontier city grow a number of co-equal hubs, the hub and spoke patterns of various systems should not overlay one-another. In New York, new subway lines and stations were built at the time of construction of the World Trade Center, routed to conveniently run through the Center complex's basement levels. These stations and tunnel sections are now in ruins. They should have been nearby, not under. That is hindsight, but hindsight we can learn from. Thus electrical substations, transport hubs, water and sewage pumping stations and treatment facilities, communications centers etc. should all have their own grid systems, so that the damage from any breach of the settlement pressure hull-continuum inflicts minimum damage, and is as survivable as we can make it.

None of these considerations are put forth to ensure survivability of our settlements from a "terrorist" attack. There may be human terrorists in space someday. But our real concern should be the non-human "mindless" terrorism of events of cosmic weather, including larger meteorite impacts.

Again, we must ever keep at the forefront of our attention the absolutely critical difference between settlements on Earth and settlements elsewhere in the Solar System. The former enjoy a given, surrounding planetary biosphere. One can flee to the "outside" and survive. In the latter, the "outside" is a life-snuffing environment, not a life nurturing one. Fleeing a disaster is much less of an option. Our only option is to disperse all our assets in as decentralized and polycentric a pattern as we can.

That said, even after we have planned as dispersed a network of functional assets as we can, there is another scalar level of risk that comes from population density. The conventional wisdom of science fiction writers and professional thinkers as well is that off-world settlements are going to be very compact. We'll be living cheek by jowl and have to get used to sardine can living because building on the space frontier will be expensive.

As always with conventional wisdom, the above consensus rests squarely on commonly shared assumptions that are to say the least, questionable. We need to develop building materials, architectures, and construction methods that will allow us to build new pressurized spaces and modules by relatively inexpensive and labor-light methods. We do not have to model off-world construction on methods and practices that work on Earth. "Elbow Room" is a quality of life issue that should be a major goal. Not only will it make for better morale and mental health, the lower population density will be safer.

Unfortunately, we're a long way from building settlements off planet. But much more humble outpost structures could be designed and built to distribute risks and failure modes to minimize chances of *total catastrophe*.

Fire and Smoke

The Pentagon incurred only limited impact and collapse damage. Unfortunately, there is more to the story. Fire and smoke spread through extensive sections of the building to either side of the impact zone. Designing a building to isolate risk is one thing. Designing its utility infrastructure accordingly is another. Utility disconnects and automatic duct sphincters or fire and smoke barriers are another. The damage at the Pentagon was much greater than it had to be. Fire also spread through unbaffled chases in the roof structure.

On the space frontier, we will have to design all our utility systems - water, electricity, communications, and air - to isolate problems and damage quickly and effectively without impairing continued network operation, through alternate routing.

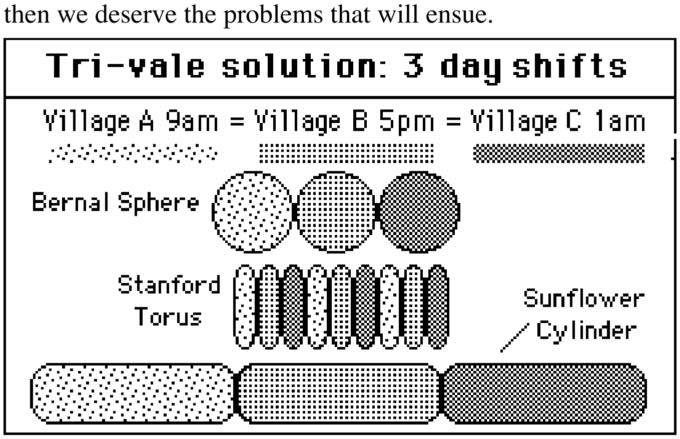
Lavatube Settlements

Lunar lavatube sections that are intact today have been intact for three and a half billion years or more. They are the ultimate "safe houses" in the solar system. Martian lavatubes are a billion years or two younger and probably equally safe. Impacts on the surface above can be expected to produce some spallation, breakoff of some ceiling/roof material, but little more. Modular settlements within these tubes would provide maximum safety. Whole low-pressurized lavatube sections, more likely on Mars than on the Moon because of the scarcity on the Moon of Nitrogen for air, should also be fairly safe.

Vulnerability of Space Settlements

The "classic" space settlement designs known as the Bernal Sphere, the Stanford Torus, and the Sunflower cylinder - Gerard O'Neill & Co.'s "Island I, Island II, and Island II", respectively, are all unitary megastructures. As such they put all occupants at shared risk for any critical failure.

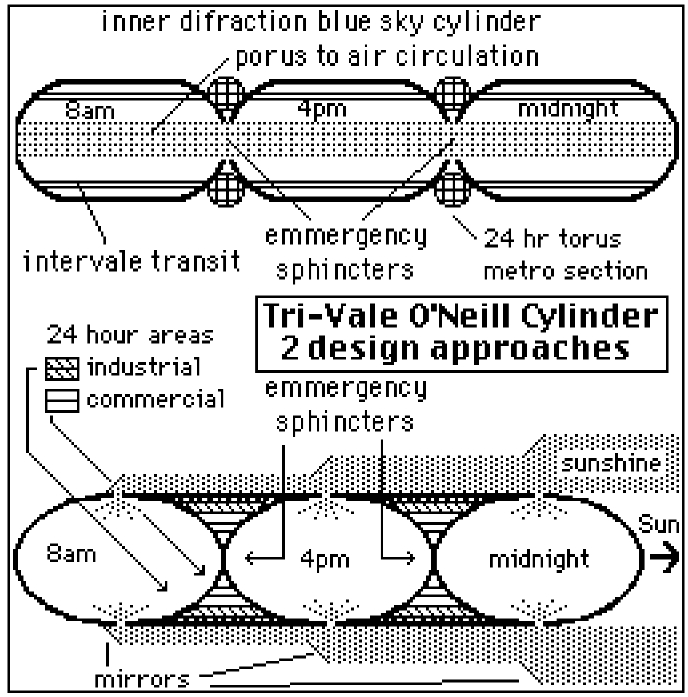
While these designs are revered, it *must be said* that academics, businessmen, bureaucrats, and many others envision things encumbered by the horse blinders of what we have called "day shift chauvinism." These structures will be expensive. If the stores, shops, schools, playgrounds, factories and other expensive investments are used just 8-12 hours a day, then we deserve the problems that will ensue.



The only sensible approach is to segment each space oasis into three residential parts (or multiples thereof) with staggered time zones, and with all these expensive facilities in 24 hour zone areas. Happily, if we do that keeping risk distribution in mind, we will come up with new architectures that are more efficient *and* have a significantly lower construction and cost threshold (for implementing the first of the three parts, at least) *and* are safer, more survivable.

See MMM #87, July '95, pp. 3-8, "Space Oases: the Next Generation"] and the LRS White Paper at:

http://www.lunar-reclamation.org/oases_ng.htm



This, of course, is much easier to say than do. We do not pretend to have solutions to the architectural challenges of such major redesigns, e.g., how to redirect available sunlight to triplicated units. Our purpose was merely to point out that classic designs leave much to be desired operationally, i.e. for how human settlements actually operate, *and* financially.

We also focused on the jump-the-gun decision to design for "One standard Earth gravity" *without any concrete evidence that fractional gravity is as bad for the human physiology as zero gravity* (no person has spent more than a few days in fractional gravity, i.e. the Apollo Moon astronauts.) This decision, coupled with tolerance limits on the rate of spin or rpm, mandates that 1 G structures in space be immense, and therefore unnecessarily prohibitive to build - *indeed insuring that they never will be built by placing the construction threshold needlessly high, all because of a 1-G chauvinism that is unsupported by any real data.*

If experiment shows that at 1/6th g (lunar) or 3/8ths g (Martian) levels, physiological deterioration levels off at an acceptable plateau, we can build smaller, lighter oases, putting less people at risk in any one location. We lost too many lives on September 11th. But we can learn from this tragedy how to save many times more lives on the space frontier. **<PK>**

Homestead Gardens & Early Cottage Industries

by Peter Kokh

Revisiting our Assumptions

This month we want to delve into the economic benefits of equipping lunar homesteads with garden spaces. But first, lets revisit our assumptions.

The common expectation that the first people to return to the Moon will be living in very spartan and cramped quarters is most probably right. Habitat space will be brought up from Earth, sized to fit either the Shuttle payload bay or top-mount farings of big boosters. We *could* sneak in some elbow room via telescoping modules or rigid-inflatable hybrids of the TransHab or Moonbagel types. But chances are that extra elbow room would be used for operations, lab-space, storage, and other non private purposes.

It will only be once we have mastered the many tricks of handling mischievous lunar regolith and processing it into suitable building materials and coming up with modular architectures that permit fast, manpower-light construction with quick occupancy that personal quarters will start becoming more truly livable on a rest-of-one's life basis.

Once we reach this threshold of learning how to live off the land, the holy grail of lunar construction will become "spaciousness". Here on Earth, we can tolerate closer quarters when need be because we can go "outside" if needed to get relief from interpersonal pressures. Walk out the door and go for a walk, putter around in the garage, do some gardening. On the Moon, all our getaway relief spaces will have to be in pressurized structures. If we want a garden, be it for growing food or just for enjoyment, that garden has to be "indoors" and lit either by artificial light or by channeled sunlight, or both.

Last month, we talked about the "Earthpatch" or "patch of Old Earth" atrium garden space as the heart of the lunar homestead. It will take a while to get to that point, But make no mistake, if we do not reach that stage of "gracious living" in due course, the prospects for *permanent, healthy* human civilization on the Moon are not good. Hardships that are endurable on a short term basis become unbearable if there is no real hope of ever getting past them.

A garden is what one makes of it

Not every homesteading family on the Moon who gets to move into a new modular home equipped with an atrium garden space is going to want to be growing fruit, vegetables, herbs, and spices. Many, no doubt, will be quite content to enjoy relatively carefree greenery and some perennial flowers, perhaps. (and why not songbirds?) Even purely ornamental gardens will serve the essential purpose of producing sweet fresh air and pretreating waste water.

Some, however, will be anxious to try their hands at growing vegetables and fruits not planted in the settlement farms, in search of a more interesting diet and more varied menu choices. Among these will be some "green thumb" types who are good at it, good enough to produce surpluses worth selling to others as raw fresh produce, canned goods and preserves, juices and ciders, or other garden byproducts.

So while the original dual purpose of having an "Earthpatch" is to provide healthier homes and citizens with higher morale on the one hand, and to ensure that each home functions as a modular organic cell of the settlement biosphere at large, for some, these homestead gardens, "yours to do with as you please", will becomes a real foot in the door for off-hours and weekends "cottage industry."

Cottage industries enrich the lives of those who engage in them, provide the benefits of harvest to themselves, and by sale or trade (barter) enrich the lives of others. They also provide real personal satisfaction that may be lacking in their "day jobs."

Roots of Opportunity: the Quest for Variety

The settlement agricultural areas are likely to take a minimalist approach: providing a balanced diet in as efficient a method possible. That is likely to involve a relatively short list of basic crop "staples." While these staples will provide for all nutritional needs for the body, we all know that there is much more than that to human eating patterns, and there always has been. Food has to be more than nutritious. We want it to be tasty, and reasonably varied. But at first, providing for varied, interesting menu options and "cuisines" will rank as secondary.

This understandable priority will leave a lot of pioneers wanting more, and wanting it badly. Of all the pleasures we humans enjoy, the most regular and most consistently valued, is good tasty food with plenty of variety. The vacuum left by the short "basic" list will create an insistent demand which will surely intensify over time. Yet importing treats and specialties will be prohibitive. But we can expect to see some freeze dried specialties make it to the tables of pioneers for special occasions and holidays.

Given this situation, anything for which there is demand but is *not grown* in settlement agripod units, will lure would be entrepreneurial gardeners provided with a gardenable plot. This will include more fruits, additional vegetables, herbs, spices and seasonings, and beverage stuffs. The shortcomings of the settlement food production system will, in effect, create a vacuum. Nature, including human nature, abhors a vacuum. The appetite for *more* will become a necessity that will nourish a lot of inventiveness.

Only one "climate" may be supported within the farms: tropical, subtropical, or temperate. Any of these choices will rule out many crops favorites. If it is possible to support special climates within homestead gardens, one could cultivate items in demand.

To be honest, it may be easier to raise strawberries and other northern food plants that require frost cycles in large separate agripods than in homestead gardens that are integral to living space. But given the incentive, we doubt it would be impossible.

Yet another factor motivating home pocket farming is that some who seek assignment to the farms may be attached to farming or gardening methods that can't or won't be practiced there. The settlement farms may be largely hydroponic, for example. In that case, the homestead garden could provide an outlet for those rooted in the soil.

The Market for Home Processed Food Items

The settlement farms may provide only “raw” produce. It is more likely, however, that in order not to waste fruits and vegetables with low “shelf appeal” yet perfectly nutritious and tasty, that basic “canned goods” items and other lightly processed stables will be available, and sought after. That will still leave a lot of room for specialty products, especially as herbs, spices, and seasonings become available. Thus some homestead gardeners may well concentrate exclusively on raising such taste enhancers to add to store-bought staples in canning homemade taste enhanced labels at premium prices.

We can expect special marketplaces to spring where would look for such specialty items (as well as home produced arts and crafts, and other cottage industry items). Cottage industries of all kinds will seek to fill the shortcomings of settlement stores.

Resources for Homestead Gardeners

Where would homestead gardeners get seeds and seedlings, soil additions, tools, special processing equipment and other things required to support this kind of in-home light industry? Keep in mind that while the settlement fathers may need to concentrate on a few basic crop staples, it is still in everyone’s interest that enterprise-grown supplements to this minimal fare be supported and encouraged. It should be settlement policy to provide a varied seed “bank” and provide needed tools - even importing such items until they can be manufactured locally.

Seeds, seedlings, and shoots may be available even for nonfood or food ingredient plant varieties. Increasing biodiversity within the settlement should be a major goal in its own right. So it would not be surprising if even those gardeners who are interested only in purely ornamental plants and flowers find official support and encouragement.

Cottage industry, however modest at first, is a primary pathway to economic diversification of the settlement. At first such efforts may arise mainly to fill local pent-up pioneer needs. But in time, many such enterprises could expand beyond their humble homestead beginnings to become major day job operations producing products for export. Keep in mind that anything produced on the Moon could likely be supplied to other off-Earth markets, such as tourist meccas in low-Earth-orbit, at a real cost advantage over equivalent products shipped up the steep gravity well from Earth’s surface.

In the U.S. most state universities with agriculture departments have “Extension” programs supporting agriculture and horticulture. Even in its earliest phase, any Luna University should have such an Extension service, as well as support services for home industry entrepreneurs in general. Again, both biological and economic diversification should be the goals of such an institution. Here on Earth, many universities and colleges do see enterprise support as a core function right alongside education and research. Indeed, such support efforts follow from research quite logically.

Even prior to the opening of a “university,” a Settlement Economic Development Office should foster such efforts. Given this favorable environment, it is likely that import of requested specialty seeds might be subsidized by the settlement government. The lunar settlement may start as a government-major industry consortium. But human society will not truly be transplanted to the Moon or elsewhere until free spontaneous private enterprise on all scales becomes a coequal sector of the economy.

We have already seen [in the “Earthpatch” article last issue, and this month’s In Focus essay] that even if cottage industry products were not at stake, decentralizing biosphere maintenance is. By supplementing settlement farms and community parks with homestead gardens integrated with point of origin primary waste treatment, we provide a much more flexible, varied, and buffered biosphere life support base. And that translates to security, morale, and long term viability.

Gardening & Food Processing Coops

Okay, you buy all this, but ...! How can a family garden in a small plot that can probably not be expanded, sustain any kind of economically viable food product operation? The scale is just too small.

We agree. In all but very special cases, this does not seem to be a viable way to proceed. But why assume that each family has to operate in isolation and self-sufficiently? On Earth, where family farming with much larger areas under cultivation has become economically untenable, giant corporate farming has made major inroads. But there is another option, and one that has been successful in many fields: dairy, livestock, as well as crop farming. We are talking about coops co-owned by farm families.

Let’s say you have identified a market for raspberries, not grown in the settlement farms. Other families could join you to raise raspberry bushes on staggered harvest cycles. Together you could market them as fresh produce and even down the road invest in processing operations outside homestead settings. The tested coop model may work on the Moon as well.

Now of course, this sort of coop-supported activity becomes more realistic as the population of the settlement rises. The amount of such endeavor is likely to grow exponentially as the population soars past a hundred to a thousand, ten thousand, and ... It is a commonplace that beginnings are very humble, and in retrospect, even invisible, unrecognizable, and untraceable. Still it *is* possible for just one family to break the ice and demonstrate the cottage industry path to adding new items to the diet.

It could well be that the settlement fathers will stick to their plan in producing only absolutely necessary basics in the communal farms, turning a deaf ear to those clamoring for coffee, tea, chocolate, wine, beers and other semi-addictive nonessentials. It may be left up to garden coops to take the plunge in such areas, and they will find a supportive market, no matter how inferior their initial products.

Once the first homestead garden coop appears others will quickly follow. New fruits, vegetables, herbs and spices will become available in Gardeners’ Markets. Premium lines of canned goods and new processed food items like fruit and vegetable juice cocktails will follow. Coops could produce partially processed recipe makers such as gravies and sauces, soups, condiments. They could also market compost, seeds and shoots, house plants and much more. Thus diversifying the menu and supporting more interesting cuisines for family home cooking as well as for restauranteurs will be just the first area of home garden supported cottage industry.

As versatile food crops increase in number, a wide range of interesting eateries will appear. That can only help the Earth tourist trade and intersettlement tourism as well. The tantalizing aromas and odors associated with these new restaurants will soon become taken for granted. Of course, the first of these eating establishments may well be coop-owned.

Coops will give birth to trade magazines (the "Mother Moon News" and the "Earthpatch Farmer") and offer basic and advanced courses in home gardening. They could organize home garden shows and cook-off competitions such as an annual "Taste of Luna City" event. Coops could conduct fundraising tours of outstanding home gardens, even contract with tourist companies for some gardens to be on one of the regular tour extension circuits.

All such public exposure will surely work to increase the percentage of homestead gardeners engaged in "production." Enterprising individuals in other talent areas will be inspired to follow the cottage industry and coop trail. The excitement of helping build a new civilization will spill over to other areas of the economy. Enthusiasm is contagious

The lesson here is that by bringing together different areas of expertise, by marshaling real economies of scale, and by joint processing and marketing, the coop can combine the seemingly insignificant energies and abilities of individual home gardeners into products and activities that will make a real improvement in the daily lives of most settlers. It will be an improvement that just may tip the scales for many of those weighing the merits of returning to Earth or committing to life on the Moon indefinitely. Perks will be crucially important in creating a population that considers itself truly at home on the Moon. Coop-produced perks can help immensely.

Enter the Realm of Plant Byproducts

Homestead Garden enterprises can be aimed at other than the food, seasonings, and beverage markets. Plants are the source of fiber, with which to make rope, fabric, and paper. They are the source of natural organic dye stuffs like henna and indigo and many others. They exude resins useful in various ways and fragrances. Some plants produce substances of medical and pharmaceutical usefulness.

Gardeners could cultivate plant species as a source of any of the above, harvesting the plants for further processing in coop owned facilities. They might want some of the processed pulp, dyes, and other extracts to use for homestead produced arts and crafts and other uses. There is no one fast model.

Wood is not a likely product of homestead gardens. Hard wood suitable for carving into jewelry value items (on the Moon, wood *would be that rare*) is more likely to come from fruit trees grown in the settlement orchards - apple, cherry, pear, pecan and others. Some of that wood could support cottage artisans making small but valued keepsakes and high-end cabinet hardware (knobs and pulls).

Pulp for home-crafted paper can come from the stems of many plants otherwise destined for the compost piles or biodigesters. Such papers can be turned into gifts or greeting cards by family artists. Some would be sold at the Gardeners' Markets for others to do likewise.

Temporary art (art du jour) materials both for children to use to develop their abilities of creative expression and for short term advertising needs can use dried leaves, beans and seeds, corn cobs, and other items from the farms. Additional "special" items from home gardens may carve a niche here.

Even byproducts that represent but a small fraction of the total garden plant biomass might prove worth pursuing given that the remainder can find some use as fodder, mulch, compost or simply raw material for the biodigesters producing tofu-like supplemental food products. Such biodigesters will even make cotton raising reasonable.

Servicing the Home Garden Market

In addition to activities engaged in by coops, a number of enterprises might pop up to serve the horticulture market. Some of these services may be developed by homestead gardeners themselves out of necessity. After all, anything one succeeds in doing well for oneself is worth marketing to others.

But those not engaged in horticulture directly may have also applicable expertise, gained from servicing utility systems, manufacturers, and other sectors of the economy. Where there is a need to be filled and a buck to be made by filling it, someone will surely rise to the occasion. In the settlement's early days, many of these needs may go unfilled, and gardeners will find less help. But as the settlement population grows ever larger, the more certain that any identified or perceived vacuums will be filled.

- composting service & equipment
- water handling systems: pumps, filters
- installers of "water features"
- fertilizers and nutrient suppliers
- lighting systems
- thermal management & climate control
- automated systems
- software programs
- canning & pickling supplies: jars, lids, labels
- packaging consultants
- garden doctors and consultants
- garden planners and "architects"
- pollinators and pollination services
- recipe makers
- marketing consultants
- networking clearing houses
- restaurant suppliers

The Bottom Line for the Settlement

Lunar frontier pioneers will not enjoy the immense variety of domestic and imported products to which we are so accustomed here on Earth. The costs of transporting any goods or products, tools or parts *not absolutely necessary* up through Earth's gravity well will mean that the settlers will be largely left to their own ingenuity and creative enterprise if they want to supplement the spartan "issue" items regularly imported. This is true not just for food, but for apparel, furnishings, and entertainment and hobby items. In each of these areas, ingredients produced in home cottage industry gardens will play some role in the campaign to provide the variety that is the spice of life.

Widespread homestead vegetable gardening will create a decentralized Food Growing System to supplement the settlement's farming operations. This will promote the settlers ability to survive blight, plant disease, and crop failure emergencies.

In all these ways then - biological diversity, biosphere decentralization, point-source waste treatment, support of more diversified menus and special cuisines, art and craft materials, apparel choices, art du jour stuffs, even alternative nutrition supplements homestead gardens will be a major player in the transformation of our "intentions" to remain on the Moon indefinitely into genuine viability.

But it is the contribution of cottage industry that to us seems the most important consideration. From the outset, the lunar settlements will be hard pressed to reach the economic breakeven point that will turn them from tentative ventures into outposts of humanity that are truly "established." Garden-based cottage industry will play a significant role in diversifying the economy and intersettlement trade.

The breakeven point will be reached when the total value of items produced on the Moon for export *sustainably* exceeds the value of items that must still be imported both to maintain the settlement and fuel its continued growth. The struggle to reach that point will govern everything, underpin everything.

That strong all-transcending priority means that all "day jobs" will need to be either directly or indirectly supportive of production for export. In other words, we will need all able-bodied or able-handed personnel to be so involved. Vital "indirect" support will be provided by agriculture, utilities, and domestic market manufacturing products needed to sustain a growing local populace.

This does not mean that there is no room for economic activity aimed at filling "nonessential" and discretionary needs of people in search of the good life and greater comfort. It is the fact that people do not live by *bread* alone, no matter how *nutritious* (both these terms used both literally and metaphorically), that will motivate some more talented and more enterprising pioneers to use their off-hours to produce things that will feed the need for taste, variety, and a richer life.

Once the settlement has established itself and seems to be a sustainably viable partner in a Greater Earth economic market, we will see these off hour economic activities emerge into the mainstream. People will engage in meeting these good life needs of their fellow settlers on a full time basis. The domestic market will emerge as the primary market in the economy, with export/import activity assuming the supporting role. When that happens, the settlement will "have made it."

Not by good food alone ...

The homestead garden is but one of several cottage industry enablers. We plan to talk about other likely fountainheads of cottage industry in future articles. As these humble beginnings begin to produce items that can be exported to help tilt the settlement's economic equation, some of these humble "cottage" industries will evolve into main sector day job industries employing many new settlers.

On the Moon, we'll be behind the proverbial eightball. We'll need to work every angle. **<MMM>**

Back Reading

MMM #2 FEB '87 "Moon Garden" [MMMC #1]
MMM #39 OCT '90 "Saving Money on Food in Space" [republished in MMMC #9]
MMM #148 September, 2001 "Earthpatch" [earlier in this file, MMMC #15]

Pre-landing a Greenhouse on the Moon: Pros and Cons of a Salad Bar Greeting for the 1st Artemis Moonbase™ Crew

by Peter Kokh

Recently, on the Artemis-list email discussion forum, "Matt" <Bluepig4u@aol.com> brought up the idea of pre-landing a "greenhouse" module that would greet the first Moonbase crew with fresh salad stuffs ready to harvest. That certainly would be a great welcome! The fresh food item most craved by astronauts has consistently been fresh salads.

As the discussion cited above went on, the emphasis seemed to shift more to the idea of doing preliminary plant growth experiments. Let's take a look at the idea from both angles and see how practical it is or is not. First, let it be understood that we do not wish to discourage the idea. Our purpose is to play Devil's Advocate and point out all the obstacles and challenges so that we end up with a full-baked concept, not a half-baked one. It won't be easy, but it does seem that going through this brainstorming exercise will prove worthwhile.

Farm Module - Moonbase Interface

First off, it seems obvious that any such plant growth chamber, if its crops are to be harvested, must have *a docking adapter* so that the Moonbase, once landed, can attach to it. Not so fast!

This in turn would seem to suggest that:

- the site must first be graded and prepared so that docking is easy enough on a shared grade
- we must be able to land the Moonbase "on a dime" (a homing beacon prelanded with the growth chamber) and then have some mobility so that it can taxi into position to dock with the prelanded growth chamber - OR
- the growth chamber must be passively mobile so that the Moonbase crew can bring it into position and dock it with the just landed Moonbase

These are tough requirements, but none is a "show-stopper." Next: the growth chamber will need:

- air controls: plants inhale and exhale just as we do and the O2 / Co2 balance must be maintained
- proper temperature levels must be maintained through the dayspan-nightspan cycles needed to bring the plants to harvest as the crew arrives
- power supplies must either be independent of the solar cycle (i.e. nuclear) or take advantage of the solar cycle to store adequate power to be able to operate at reduced "maintenance" level at night
- the chamber and its equipment should be "off-the shelf" (SpaceHab module?) and lightweight.

Maintaining the Crops during Nightspan

To what extent can you reduce the amount of light delivered to the plants during the two-week long lunar nightspans so that they retain enough vigor to go on to eventual harvest with alternating two-week long dayspan “light feasts?” This was the topic that in 1990, gave birth to LUNAX - The Lunar Agricultural Experiment Corporation - an offshoot of the Lunar Reclamation Society. The idea was to get high school biology and agriculture science teachers and classes doing experiments and turning in data. Many did do the experiments but did not bother to turn in the data. The data we did get was encouraging. Good lighting for a few hours each nightspan day was sufficient. Previous experiments by the Soviets showed that there was another option: simply go with the thermal flow and maintain a refrigerated (but not freezing) temperature in darkness for the two night periods, and the plants will make it through to the next light feast period.

To make nightspan lighting burdens easier, if we choose to go the reduced lighting hours option, we have since discovered that low-power LEDs of the right color give plants the light food they need with much less power (and much less heat - heat being a measure of lighting inefficiency.)

Other Considerations

The power supply landed with the growth chamber could serve as an emergency low-level backup to the Moonbase power system in emergency.

The plants would be grown hydroponically. As much as the author is a soil-farming advocate, it would be an “advanced project” to prepare raw lunar regolith and introduce it into the chamber as a growth medium. We’d have to robotically sift out the aggregate breccia “pebbles” and the fine drainage clogging powder element. And we might want to pre-heat it to 150 °C to transform some of the minerals into zeolites. Way too much for a first mission!

Talk on the discussion list centered on the robotics needed. Balderdash! Teleoperation is much simpler, and, at Earth-Moon distances, very feasible. The new wireless web-cams would be part of a lightweight tray-mounted teleoperation system.

This *should not be* a mission to determine if plants can grow in 1/6th gravity! Such experiments can be done in a ***TransLife*** module in low Earth orbit. Nor should it be a mission to do research on other aspects of lunar agriculture. Those experiments can come later, when the first crew is on hand.

“Keep it simple, stupid!” is the axiom that should guide us. Our object should be the first one proposed not more elaborate research priorities. The only goal that makes sense for a pre-landed “Greenhouse” is to greet our first crew with a fresh salad feast.

> "No grimmer fate can be imagined than that of humans, possessed of god like powers, confined to one single fragile world."
>
> -- *Kraft Ehricke*

Mail For MMM

What to send on the 2nd Lunar Mission

I have been touring outside the USA and just received the June issue of MMM. I am a member of the Artemis Tourism List and have a standpoint on Lunar development which I hope you will disseminate to a wider audience.

In response to the brainstorming question posed therein, "What's inside the 10 ton container which mission 2 will deposit on the moon?" I would like to suggest a practical, moneymaking answer: TOURISTS!

Just joking. Actually, 5 tons of the payload should be in the form of a tourist module which is not deposited on the moon but merely flies by the moon and takes the tourists back to LEO for transport to Earth. This module would guarantee an income stream from the gitgo, an income stream which would concurrently finance lunar settlement.

I'm sure everyone can see that the revenue stream from lunar tourism would be more solidly reliable than the hoped-for revenue from a PR campaign which is subject to faddism. [For instance, there is a waiting list of people who want to pay $70,000 to go up Mount Everest, one of the worst trips imaginable! They do it because "it is there" and it is uniquely hard to get to. (And we all know Dennis Tito spent $20 million for a few days in orbit.) But little money is spent on the purchase of Everest keychains or posters. A lot of people paid to see the IMAX movie called "Everest!" but once a movie is seen, there's no more revenue stream such as there is with tourism.]

The other 5 tons of the cargo payload should be deposited on the Moon and must contain power generators such as solar collectors and photo voltaic arrays. Just as in every historical society, the biggest job on Luna will be to build buildings. Therefore, the Lunar power system's first priority is to operate a kiln for making glass and/or basaltic building blocks. Scientists are nice to have but the majority of the Lunar pioneers will, of necessity, be "hard hats!"

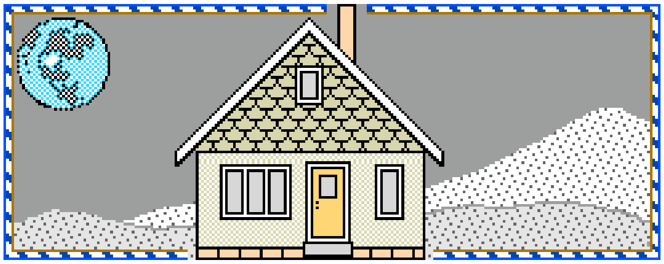
In summation, the Mission 2 cargo module should be split 50/50 between expense-paying tourists and power supplies for making buildings. Indeed, the subsequent Lunar program should largely rely on tourism money to meet expenses. Greg Bennett would surely agree as he lives in the dry desert valley that became Las Vegas -- through tourism!

Cheers
Allen Meece
<Beanstalkr@aol.com>

"Clarke's Law"

New ideas pass through three stages:
* Stage 1: "It can't be done."
* Stage 2: "It probably can be done, but it's not worth doing."
* Stage 3: "I knew it was a good idea all along!"

MMM #150 - NOV 2001



Will we ever feel "at home" on the Moon?

We won't succeed in establishing truly permanent settlements on the Moon until we've learned to quit seeing it as an "alien" place. When we return, "job one" will be to engage the Moon on its own terms. We won't have come "to go back home", we *will be home!* We'll have to learn to perceive, feel, handle our new home as natives. More *below*.

"At Home" on the Moon:
No Longer *Treating* the Moon *as* "Alien"

by Peter Kokh

Our First Encounters with the Moon

While our Apollo astronauts were on their scientific picnics on the Moon, back in what's getting to be ancient history, "job one" was to protect them from "the hostile and alien conditions" of their temporary surroundings - *"returning them to Earth safe and sound."* Their moonwalker space suits and their Lunar Excursion Module tent were designed to keep the Moon out, and Earth atmosphere and other "necessities" in. These precautions were totally understandable. We did not know *for sure* how benign or insidiously life-quenching the lunar environment might be. We were there to do science, *not to make ourselves at home*.

Lessons Learned

Thanks to these six excursions, we know that while the cosmic weather to which the lunar surface is exposed has potentially life-threatening hazards, there is nothing in moon-dust per se poisonous to us or plant life, however troublesome the fine powder fraction can be to housekeeping etc. The next humans to go to the Moon will have to take the cosmic ray and solar flare dangers of the lunar environment just as seriously as did their scouts. But armed with what they have learned, those returning to establish a beachhead will be there to learn

how to engage the Moon
and deal with it -- on its own terms.

They will be there to test and verify equipment and strategies that will enable them to remain on the Moon throughout the dayspan *and into and through the nightspan*. Our previous explorers had been on the Moon in "mid-morning" conditions only.

They will be there to test equipment that will allow them to explore the regolith as a reservoir of potential resources: oxygen and various materials for fabricating useful products. "Pure" science will continue to be a mission goal, but *from now on* pure science will become secondary to practical applied science as the main goal. We will have returned to the Moon with *the ultimate goal of becoming Lunans*.

Becoming Lunans -- that's a status that has to be earned. We will have to achieve a respectful intimacy with the Moon, combining a "second nature" awareness and responsiveness to the dangers our chosen new homeland poses with engagement at every opportunity. We're sure some will be offended by the analogy but it is appropriate - we'll have to learn to enjoy "safe sex" with the Moon. How?

First we must become at home with the Moon's pulverized surface blanket - the "regolith"

- We have to practice "dust control" *by 2nd nature*
- We must learn to do arts/crafts with regolith-derived media
- We have to learn to build living space out of regolith-derived materials

Not only must our engagement with the Moon show in our homesteads and how they are constructed and furnished, but we need reinvented "moonsuits" that will help our senses truly *engage* the Moon when we are out and about. And, we need Out-Vac sports and hobbies which allow us to enjoy being out on the "alien life-hostile" surface as well as in our comfortable homestead retreats.

In short, we must get past our defensiveness, not by ignoring the dangers and risks, but by learning how to deal with them as if by second nature, the way we in Wisconsin deal with the winter dangers that give sun-coddled southerners the dreads. it is only by such a degree of comfortable familiarity that we can go on to enjoy such a bogeyman climate: enjoying the beauty of fresh-fallen snow, the crunchy sound and feel of cold snow underfoot, the cold kiss of winter air on the cheeks, skiing, tobogganing, ice-skating and other winter sport pleasures. Knowledge and skill must replace paralyzing fear before we can truly enjoy. And the path that northerners and others who have settled in niches once deemed hostile by those in "more benign" homelands, is a cultural and psychological journey that Lunan pioneers and settlers will take as well.

For sure, Earthlubbers will always think of the Moon as a hostile, alien, impossible place. Their loss, our gain. The Moon is a frontier, no more, no less. Perhaps the most challenging yet. But who of us would be ready to change places with a polar Eskimo? The accommodation can be done. The acculturation will be made. And those who succeed in this process will learn to love their new adopted homeworld and pine not to return to Mother Earth.

This is a prediction we make based on some idea of the tremendous range of possibilities, of the potential of the Moon to serve our needs. But this conviction is based even more solidly on the nature of being human: adaptation is something we are extremely good at. We will do it because we can!

Cosmic rays, solar flares, intense raw ultraviolet, extreme heat and extreme cold, two week long dayspans and two week long nightspans, insidious moondust, dryness beyond that of baked concrete, the ever black sky, isolation from the immense diversity of Earth's consumer goods shopping heavens and the general unavailability of so much that those left behind take for granted, having to do without or make do with "inferior" substitutes, isolation in general, no nature-given biosphere to take for granted and to enjoy in shirtsleeves without breathing assists -- the sad litany goes on and on. Oh yes, one thing, the Lunan settlers will be anything but sad. They will have learned to love the Moon. It's a bet. **<MMM>**

Learning to Not Fear the Night

by Peter Kokh

My first response to a bloke who dismisses the Moon with "been there, done that" is to point out that we haven't been to the Moon "at night", much less for "a single full night." Like I've been to the middle of Siberia (Bratsk) -- but it was at the end of July and the beginning of August (1981) -- big deal!

You haven't been to a place, not really, until you've been through a whole cycle of seasons. On the Moon, the cycle of seasons and the cycle of day and night are pretty much one and the same, the 29.5 day long sunrise to sunrise or sunset to sunset cycle. When the sun comes up, it stays up for almost 15 days. When it sinks below the horizon, it stays out of sight for almost another 15 days. "Dayspan" and "Nightspan" are the terms we've been accustomed to using in MMM. Put them together and you have a Sunth, not a month -- the interval from Sun up to Sun up, not from new moon to new moon. It's a matter of perspective: we're looking at it from the Moon's vantage point, not the Earth's.

The Apollo crews visited the Moon in "mid morning" periods only. Not only did they not dare stay for the night, they fled before High Noon. If you are afraid to stay and experience the Moon full cycle, how dare you say, "been there, done that!"

Fear of the nightspan is rooted in two factors. It gets quite cold and solar power is unavailable. If all we are doing is pitching a tent - a Lunar Lander - the bitter cold may well be a problem. If we put up an outpost *and shield it with regolith* to protect from radiation, then we will also have buffered ourselves from both the extreme high noon heat and the post sunset extreme cold.

If we rely solely on direct solar, then power is a problem. But we can easily generate excess solar *while the sun shines,* storing reserves for nightspan use, as well as including backup nuclear power.

If we take the first "enhanced solar" route, we can meet any power deficit half way by planning our operations to concentrate on energy intensive tasks during the dayspan, reserving labor-intensive ones for the nightspan. In approaching the problem this way, we will set up a rhythm of life and operations that is one with the Moon's own rhythm. We will no longer fear the Nightspan, because we will have faced it on the Moon's own terms. Nothing "alien" about it!

Relevant articles from MMM issues past:

#43 MAR '91 "Dayspan"; "Nightspan", The "Sunth" [MMMC #5]
#90 NOV. '95, pp. 7-9 "Overnighting on the Moon" [MMMC #10]
#115 MAY. '98, p 8. High Noon: Coping with Dayspan Heat [MMMC #12]
#126 JUN '99, pp. 3-8 "Potentiation: a Strategy for Getting Through the Nightspan on the Moon's own Terms" [MMMC #13]
<MMM>

Learning to Love Moondust : Domesticating the Regolith

by Peter Kokh

Effective Regolith Symbolism - Early Days

Be they on short-term tours of duty or the first prospective settlers, if everything around the pioneers has come from Earth, the Moon will remain cast as alien, as something from which we must keep ourselves safely apart. One way to break this psychological "quarantine" is to begin as early as possible to start making useful items or even merely decorative "accessories" from raw regolith.

Humble crude starter industries that should be in reach of early pioneers include:

- sintered metal products made out of pure unoxidized iron powder fines harvested from the regolith with a magnet
- sinter-cast regolith items using microwaves or a crude solar furnace
- glass and cast basalt products made with a solar furnace
- crude ceramics

Additionally, larger moon rocks or "breccias", surface dust removed, can come inside, as is, or cut and polished to reveal hidden beauty inside. Regolith particles, sorted for color, would allow "Moonscape" "sand paintings" as are familiar in our Southwest.

Sculptures for wall or tabletop, useful items such as glass or ceramic tableware, planters and flower pots, napkin holders, and cast basalt table top slabs will all serve to "bring the regolith inside" in a safe way. This kind of simple, relatively easy blending of raw native lunar and made-on-Luna objects into a habitat setting made-on-Earth, pierces the veil of quarantine by showing that the stuff of the Moon is just as much a medium for human creativity and artistry as is the more familiar "earth" of Earth.

As such "made of moondust" artifacts become more sophisticated, they will find an export market both in other space locations such as LEO orbital Resort Hotels and space liners and on Earth itself.

Bringing the Outside In & the Inside Out

Especially and effectively symbolic would be indoor Japanese style gardens of "raked" moondust dotted with carefully placed moon boulders. First the fine and troublesome powder fraction can be sifted out of the regolith. Then any pure iron fines must be removed by a magnet, less the regolith "rust" in contact with indoor humidity. These modifications are relatively easy to accomplish and leave the "domesticated" regolith looking very much as it did "out-vac" on the exposed surface.

Of course, it would be equally legitimate to let the unpurged regolith rust naturally. This would be a Moon-appropriate way of bringing in a range of familiar "earthtone" hues as relief from the gray monochromatic scheme of regolith *au naturelle*, and another way of "domesticating" it.

Another way to merge inside and outside is through the use of cast basalt pavers inside, and again outside on the approach to an airlock, for example. cast basalt floor tiles can sport the full range of regolith hues and variation and possibly even smoothed breccia inclusions as highlights (casting temperatures permitting) in random patterns. Cast basalt tiles are a known technology on which we reported in MMM # 135.

Other "interior" furnishings such as tables, benches, chairs made of lunar iron, cast basalt, lunar concrete, etc. could also adorn Out-Vac "patios" and walkways. Regolith domesticated for indoor uses could thus return transformed to the surface, reinforcing the mutual accommodation of Moon and Man.

On all new and strange frontiers past, people have first begun to make themselves at home by using local resources to meet *some* of their needs - indeed, as many of their needs as possible to an insistently resourceful spirit. This kind of artistic accommodation is a toe-in-the-water first step towards a much greater commitment to learn how to "live off the land" as thoroughly as possible. The artists, crafters and collectors will be the first pioneers to say with their proud achievements, "hey, we're here! Might as well make ourselves at home for the duration!"

Longer term, Lunan artists, craftsmen, architects, furniture makers, and interior designers will be able to do much more by way of integrating lunar materials into their new homesteads so that the our settlements "grow out of the moonscape" so to speak. The Moon will have ceased to seem alien, because we will have learned enough of its secrets and ways to rely upon it for shelter and even our livelihood. Our point is rather that we can, *and must,* take humble but real steps in this direction from the very outset.

Food from Regolith?

Post Apollo agricultural experiments with returned moonrock samples showed not only that regolith is not toxic to plants, but that it contains useful nutrients and can be transformed into a superior rooting and growth medium. First the fine powder must be sifted out lest it clog the drainage systems. Then, as an improving option, the soil can be heated to 150°C which results in an appreciable fraction being transformed into zeolites that hold waterborne nutrients well. Treated human wastes and kitchen compost can be added. Nothing will exonerate the reputation of regolith more than using it in household flower and vegetable gardens that provide food, fiber, freshened air, and color. Hydroponic gardens might be easier to set up and maintain but they will require greater import of nutrients and be less "reassuring." But to each, his own.

From Regolith, Lunar Architecture

The next stage will be to build expansion habitat space itself from regolith derived materials: lunar steel or other alloy, lunar concrete, glass-glass composites, etc. Each of these materials, each characteristically different from Made on Earth analogs, will bring a uniquely lunar quality and feel to the inside spaces they frame. In the process, homestead structures will in a very real sense "grow out of the moondust," further rooting their occupants to their new home world.

Even on the outside, the marriage of Moon and Man will be evident. There will be the telltale pattern of shielding mounds, lavatube entrances, and outside storage ramadas. Some homesteaders may choose optional "'lithscaping" of their shielding mounds, with boulders and breccias, with ceramic and cast basalt shards, with coatings of lunar lime (calcium oxide), glass, etc. As the settlement ages, we can expect to see such attempts at refined sophistication, Moon-style.

We have also talked about lunar architectures that "take back the surface" in MMM #137. And in issues #55 and 111 we described lunar-appropriate "skyscrapers" which sprout out of the surface, breaking the horizons as if they belong, because they will. Unlike the first "outposts" which will be made on Earth and "dropped on the Moon," future human settlements will be *homegrown*.

In short, the Moon is more than a location where we will settle. It is a location *out of which* settlements will grow. In such a mutually involving process, Lunans will hardly feel like "Strangers in a Strange Land." They will feel at home, because they will be at home.

Relevant articles from MMM issues past:

#3 MAR '87, "MOON MALL"
#5 MAY '87, "LUNAR ARCHITECTURE"
[both in MMM Classic #1]
#16 JUN '88 "GLASS GLASS COMPOSITES"
[MMM Classic #2]
#55 MAY '92, p 5. "SKYSCRAPERS ON THE MOON?"
p. 7 "MOON ROOFS" [MMM Classic #6]
#63 MAR '93 p. 5 "Sintered Iron from Powder"
p. 8 "GLAX: glass-glass composites; GLASS"
p. 9 "Ceramics"
p. 10 "Color the Moon Anything but Gray"
[MMM Classic #7]
#74 APR '94, p. 5 "Lunan Homes; Shielding & Shelter"
#77 JUL '94, p 4 INSIDE Mare Manor: "Cinderella Style"; "FURNITURE"; p. 6 "SCULPTURE"
[both in MMM Classic # 8]
#89 OCT. '95, pp. 5-6. "Dust Control"*
[in MMM Classic #9]
#91 DEC. '95, p. 4 "Startup Lunar Industries"*
[on MMM Classic #10]
#111 DEC. '97, p. 4 "Lunar Skyscrapers: Shattering Low Expectations" [MMM Classic #12]
#135 MAY '00, p. 7. "Cast Basalt: Industry Perfect for a Startup Outpost"
#137 JUL '00, p. 5. "Take-Back-the-Surface Architectures"
[both in MMM Classic #14]

<MMM>

Embracing the Moon's Rhythms: Adopting a Moon Calendar

by Peter Kokh

Living and working by the "Sunth"

The slow two-week long crawl of the Sun across the black lunar skies would surely seem to merit the term "alien" along with the equally interminable wait for the Sun to rise again. Meanwhile, in all our activities, we will be in constant scrutinizing communications with Earth. At the beginning, the clock and calendar of our sponsor nation(s) will govern all activity schedules. *Not so!*

Many activities from field work to mining to energy production will necessarily be timed to the rhythm of local sunrise and sunset -- to the "sunth." Now surely personnel on the Moon can observe such schedule constraints while continuing to use Earth's international calendar for all other purposes.

TERMS: the 29.5306 day long period from sunrise to sunrise *at any spot* on the Moon is called a **lunation**. By **sunth** is meant the *equivalent* length of time *as reckoned from a set location*, and as used as a calendar division of time.

But as temporary personnel on limited tours of duty are gradually phased out to be replaced by a growing number of volunteers willing to stay much longer, even indefinitely, the sense of adopting a truly lunar calendar will begin to become appealing. Most people prefer a predictable routine over the long term, however welcome occasional breaks may be. The plain fact is that the pace of the Sun, and whether or not it is currently dayspan or nightspan, will greatly affect the agenda for the (calendar) day for most everyone, in most every occupation. If we had a calendar which enshrined this natural lunar rhythm cycle, it would regularize everything.

Reconciling the 24 hour day with the 708 hour long sunth will be the easy part. Lunans would simply alternate sunths of 29 and 30 days, adding a leap hour every 7 weeks or so for a longer night's sleep -- never a shorter one! Of course, that would mean a gradual drift off of whatever terrestrial time zone they had started with -- Houston's Central Time or London's Greenwich Mean Time (Universal Time, Zulu time.) That way they would just be "democratic," sharing clock time with one time zone after another.

The benefit of this observance of sunth time would be considerable. Local sunrise and sunset would occur on the same dates every sunth, give or take a half day depending on whether it is a 29-day or 30-day sunth. This means that work scheduling that depends entirely on the local day/night situation can be regularized from sunth to sunth. Life would take on a certain predictable rhythm. And most people do strongly prefer predictable rhythms.

Factoring in the "week"

One could go further if -- (shrieks of horror from Jewish, Christian and Islamic fundamentalists) settlers adopted a variable length week. Five 7-day weeks with three interspersed 8-day weeks makes 59 days or two calendar sunths exactly. That would put local sunrise and sunset regularly not only on the same date, but also on the same day of the week.

Would people accept this? Historically, *the seven-day week has been the single most change-resistant timekeeping interval*. But there are ways to compromise. The seven named days could remain, with the occasional intercalary eighth day occurring on the weekend, say between "Saturday" and "Sunday." There would be little resistance to nineteen 3-day weekends a year -- three 3-day weekends every two sunths! -- except by the business sector, of course. The extra day could even be adopted by religious leaders for scheduling seasonal feasts and other religious observances. This presumes some good will on the part of religious leaders and some willingness to adapt their schedule of religious feasts to the lunar calendar. Freedom means that some will simply govern everything by Earth calendars. So be it.

The Weekend

On Earth, many businesses must operate around-the-clock day in, day out -- "24/7." That means that work schedules are staggered or even put on a rotation of 6 or 8 days ("not 7") so that everyone takes his or her turn working weekends. On the Moon it will be even more important to keep expensive capital equipment and expensive shared facilities such as schools and parks *open and running all the time*. So what is a true "weekend" for the largest number will surely not be so for all. How the settlers decide to "be fair" or "flexible" will be up to them.

The Weekdays

Now I put "Saturday" and "Sunday" in quotation marks for a reason. You see, the sticking point will be that in a system with periodic eight-day weeks, the named day of the week on the Moon cannot long remain the same as the universally named day of the week on Earth. With the very first 8-day week, the next lunar "Sunday" would fall on the next terrestrial Monday. In a little over two months, the days of the week would coincide again -- temporarily. There can be only one way to avoid confusion: adopt a totally new set of names for the lunar days of the week, seven constant and one periodic.

Now there is nothing very religious about the names of the days of the week in most modern languages. The days are named after the seven celestial bodies known to the ancients: Sun, Moon, Mars (Tiw), Mercury (Woden), Jupiter (Thor), Venus (Fria), and Saturn (in English using the Scandinavian equivalents given in parentheses.) So there should be nothing either sacrilegious or antireligious about adopting a totally new set, to avoid any confusion.

Fundamentalists, of course, believe that when it is Sunday on Earth it must be Sunday everywhere in the Universe. In fact it can be Sunday one side of our International Date Line and either Saturday or Monday on the other side, and no one looses sleep over that. Avoiding confusion with Earth's calendar will be essential, just as is avoiding confusion between Metric and English units of measurement. Some suggestions for day name sets of 7(8) names are given in the MMM #7 article cited below.

Sunths and Years do not neatly mix

So far so good. The real sticker comes if we attempt to assign a year number in a lunar calendar. One Earth year, and the Moon does share this once-around-the-Sun pacing, works out to twelve lunar months (sunths from a Lunan's perspective) of 354 days plus eleven and a fraction days left over. That's quite inconvenient, it would seem. In the Hebrew calendar, an adjustment is made by inserting a thirteenth month from time to time. In the Islamic calendar, there is no attempt to keep pace with the solar year count -- the year is counted as 354 days and so shifts constantly with respect to the seasons.

The Metonic Cycle to the rescue

However, there will only be a problem if the Lunans adopt an annually rotating set of sunth names. Happily, there is a way to avoid this. Just by chance, the lineup of sunth and month repeats every nineteen years in a pattern known as the

Metonic cycle. In short, 235 "sunths" is very nearly 228 calendar months (a total deviation of only 2 hours!). Now if the Lunans simply numbered the sunths from 1-235 they could still observe the shared terrestrial year count.

There really is no other "elegant mathematical" solution. We've tried to brainstorm the problem in various directions for the past 15 years. Such a solution has been sought in vain by lunar calendar partisans for millennia.

Numbering the sunths from 1-235 with a repeat every nineteen years will work just fine. We could assign them short, *easy to remember* compound names, using the first syllable roots of the Latin names for the numbers 0-9: ni, un, du, tri, qua, qui, si, sep, oc, nov -- or some euphonic variation thereof.

Quioct = #58, Septri = #73, Novni = #90,
Unquasi = #146, Dutriqui = #235 -- etc.

Starting Points

So where or when would we start counting? The answer is simple, on any nineteenth year in which our January first happened to coincide with a "new moon" or "full moon" -- whichever standard we wanted to adopt. When we see a full Moon, observers on the Moon would see a new Earth (the night hemisphere of Earth would face the Moon.) When the Moon is "new," the side facing Earth is totally dark and observers on the Moon would see a full Earth.

What would be the logical place to start a sunth from a lunar viewpoint? That depends on the chauvinism that comes with where on the Moon you happen to have settled. For Farsiders, any consideration of the "phase" of Earth would be moot -- Earth will never be above their horizons. Perhaps most settlers will live on Nearside where most of the mare plains are located.

Sunrise on the eastern limb (Mare Smythii - Mare Marginis - Mare Australe) at 90 °E would seem as good a starting point as any. That would coincide with "new moon" on Earth. If you wanted to mark the sunth from sunset at that point, the start of the sunth would coincide with what we experience as Full Moon. The settlers must make the decision, and pick up the sunth count reckoned back to the last new Moon or full Moon (whichever standard they pick) that occurred on a January 1st.

To follow or avoid Jewish or Islamic Practice?

Now in both lunar calendars in wide usage on Earth, the Jewish and the Muslim, the start of the month is reckoned from the first observable crescent moon, i.e. a couple of days after the new moon. The settlers can opt either to go with that precedent or break with it (by using the lunar standard suggested above) to avoid any confusion or appearance of religious considerations.

However, if they want a lunar calendar that is ready to go, has a fixed tradition of calculation, and still tries to keep apace with the year count, they could simply adopt the Jewish Calendar with or without its month names, and with or without its feasts and festivals. The one advantage of such a choice would be that calculators to translate Jewish and Gregorian dates into one another already exist, both on paper, and online. But similar calculators could easily be devised for any calendar setup the settlers choose to adopt. It's only a software matter.

Calendars on the Wall

In plain practice, physical Lunan calendars would give the equivalent standard Earth date and day of the week (and/or day count #s 1-365) in fine print alongside the lunar sunth day number and day of the week name. It's simply a layout problem, with a number of good solutions. One great advantage of the Sunth Calendar is that it won't change every year. Lunar Calendars can be made of durable materials.

Relevant articles from MMM issues past:

#7 JUL '87, "M" is for Month or *Sunth*; "Moon Calendar" [MMMC #1]
#43 MAR '91 p. 4 "Dayspan"; "Nightspan"
p. 5 The "Sunth" [MMMC #5]
#92 FEB '96, p. 6 "Pioneer Holidays"
#95 MAY '96, p. 8 "Moon Calendar Revisited"
[both in MMMC #10]

<MMM>

The "LCCJC"

Luna City Cyclers & Joggers Club

by Peter Kokh

Cycling and Jogging in Middoor Spaces

"MIDDOORS": In Lunar & Martian Settlements, the Middoors are public commons spaces, including paths and roads as well as parks and squares, *within the pressurized envelope* of the community, *fully shielded* from the Out-Vac (outside surface vacuum) beyond the airlocks, but distinct from private "indoor" spaces.

For many people, exercise in a necessary fountainhead of their sense of well-being -- vital for physical and mental health alike. To avid joggers and cyclists, in-place exercise in fitness centers, or at home with compact fitness equipment is "not the same thing." Thus it is important for the general well being and morale level of the settlement to attempt to provide for this form of recreational exercise. That means providing fully shielded and pressurized safe pathways reserved for joggers and cyclists.

Cycling & Jogging Paths

In laying out our settlements, it should be easy enough to provide for dedicated pathways, time-shared between cyclists and joggers if too narrow for both. There could be time set aside for walkers as well. Given the need for an abundant area for growing plants which could border such pathways, this set aside should not be difficult to justify.

There could also be special reserved lanes on city pressurized arterial streets and open use on residential lanes - again with abundant landscape vegetation to increase the total biomass, spread, and diversity of the settlement biosphere.

Middoor Cycles

Will cycles for use in pressurized areas be recumbents, bicycles, tricycles, leaners? We have to design for lower gravity and lower traction for maneuvering and braking as well as for unreduced momentum and impact vulnerability. An ideal challenge for a Design Competition!

Protective Equipment: Helmets & Knee Pads

Even in low lunar "sixthweight", a cyclist's (and his cycle's) inertia and momentum are the same as they would be on Earth. Inertia and momentum are cosmically constant. If you are catapulted *forward* into some obstacle, you will hit it *as hard as* you would on Earth. The lighter lunar gravity one-sixth that of Earth's will save you only in a downward fall in which no forward velocity is involved. This lesson is one that each fresh settler will quickly, and probably painfully, learn for him/herself.

On the other hand, while imported terrestrial cycling head gear will work quite well on the Moon, cyclists will be up against the prohibitive cost of importing it. It will be a priority to try to invent a homegrown "lunar-sourceable" alternative. Given that there are no "soft" materials easily made from the elements common in the lunar regolith, we may have to do with metal helmets with fabric inserts that suspend them outwards from the cranium. Ideas from readers are welcome!

Jogging Shoes:

On the Moon, one might expect that "impact" injuries from running and jogging would be much less of a problem, in proportion to the lower gravity. Unfortunately, that will be true only if we learn by practice to bound no higher than we do on Earth. If each running step takes us six times higher than on Earth because we have not learned to restrain the bounding energy we put into it, the impact on footfall will be just as great on the Moon as here. But I predict that new arrivals will quickly learn to adjust their strides. If so, the incidence of impact injuries to the feet and spine could be reduced. But until we have a chance to practice jogging on the Moon in a pressurized environment without spacesuits, we can't be positive about that.

People say "The Moon? Been there, done that!" When you stop to think that no human has walked or ran on the Moon except in a space suit, or within the sardine can confines of the Lunar Lander, you see the absurdity of that dismissal. There is much that we would consider ordinary activity (sleeping in a bed, for heavens' sake, staying overnight, etc. etc. etc.) that no one has had the chance to do on on the Moon. "Been there, done that? - *NOT!"*

The LCCJC

While jogging and cycling are activities that individuals can do each on his/her own, we can expect that jogging and cycling clubs will arise and appeal to many if not all. Social sports are more fun and self-discipline in a social context is easier. By joining clubs, one gets social as well as physical exercise, to the benefit of the whole person. Health is a mental as well as physical state. Club activities could include dances and dinners etc. It is important for people to socialize in non-work-related contexts and social hobby and sport outlets will be valuable.

Conclusion

In the process of getting to feel "at Home" on the Moon, satisfying perks will be very important. The physiological-psychological highs that come from good hard exercise will certainly help those who take part. So many of the "outdoor" activities we have been used to on Earth will be hard to duplicate on the Moon for some time to come. Those that we can accommodate fairly easily deserve to be high on the list of things to provide for in settlement design and growth. All work and no play makes ... ***<MMM>***

The Parable of "Stone Soup"

by Peter Kokh

There are undoubtedly many versions of this story, as I have met others who knew of the parable and got it from very different sources. I heard it from an African missionary priest.

> One day while, making a call on villagers that they had never visited before, a pair of missionaries was seized by warriors, their hands bound behind them. Meanwhile, other villagers were gathering kindling to put under a giant pot.
>
> Growing worried, one missionary asked what was going on. "Why we are getting ready to have you for dinner," the chief said. "You look healthy! You will make good soup!'
>
> Thinking quickly on his feet, the other missionary spoke out saying, "if it is good soup you want, we have a much better recipe!" The chief, his interest piqued, demanded that the missionaries tell him about this splendid recipe.
>
> "Well first, you must free us so we can help you find just the right stones to put in the pot first. The right stones are the secret ingredient that makes our soup so good."
>
> There bonds loosened, the missionaries led a group of young warriors into the forest where they pointed out the stones that the warriors should pick up and put in the pot.
>
> Now, they said to the women who were watching with much curiosity, "we need to add vegetables. Let's add all the various kinds of vegetables you have on hand." After that the missionaries supervised the adding of spices.
>
> The soup, it turns out, was very good, and happily did not include themselves as a special ingredient.

The morale of the story is that sometimes we have none of the ingredients needed for a project, nothing, that is, except the idea itself. But if you leverage that idea wisely, and play your cards right, others will contribute the things you can't. Can we apply this lesson to space enthusiast efforts to get pet projects started and see them through to completion?

Why we already have! *Space enthusiasts* had the idea of a Lunar Polar Orbiter that would look for lunar polar ice. And back at ISDC 1988, that's all we had. An idea and a few hundred dollars. But we called a conference in the spring of 1989 in Houston, and as a result of that, Al Binder was "hired," Lockheed picking up his salary, to design a probe, which *we* named *Lunar Prospector*. Now you know the rest of the story.

The Lunar Reclamation Society and the Moon Society are small organizations with big ideas but without the resources to make those ideas real. *Not quite!* Ideas can be powerful. But it does take some work to articulate them well enough to attract the attention of others who can contribute other needed resources. It takes leveraging connections, diligent networking, and not missing too many tricks. But if we did it once, we can do it again, and again, and again.

The Stone Soup route to the Stone Moon!. Never underestimate the power of an idea! **<MMMC #15>**