"Expanding the Human Economy through Off-Planet Resources"

Moon Miners' Manifesto - Pleiades

MMM Classics
The First Fifteen Years

Year 14: MMM #s131-140
December 1999 - November 2000

Several topics and articles stood out this year. We have long pointed out that if we are to build a resource-using industrial frontier civilization on the Moon, our major sites will need to be along highland/mare "coasts." The north coast of Mare Frigoris, Sea of Cold, is closer than any to potential coldtrap water ice reserves, just 200 some miles to the north. Roads will follow the path of easiest traverse and thus help determine where towns are built The Lunar Developer will be essential, giving barren "unimproved" land real value. Cast Basalt is likely to be among the first industries.

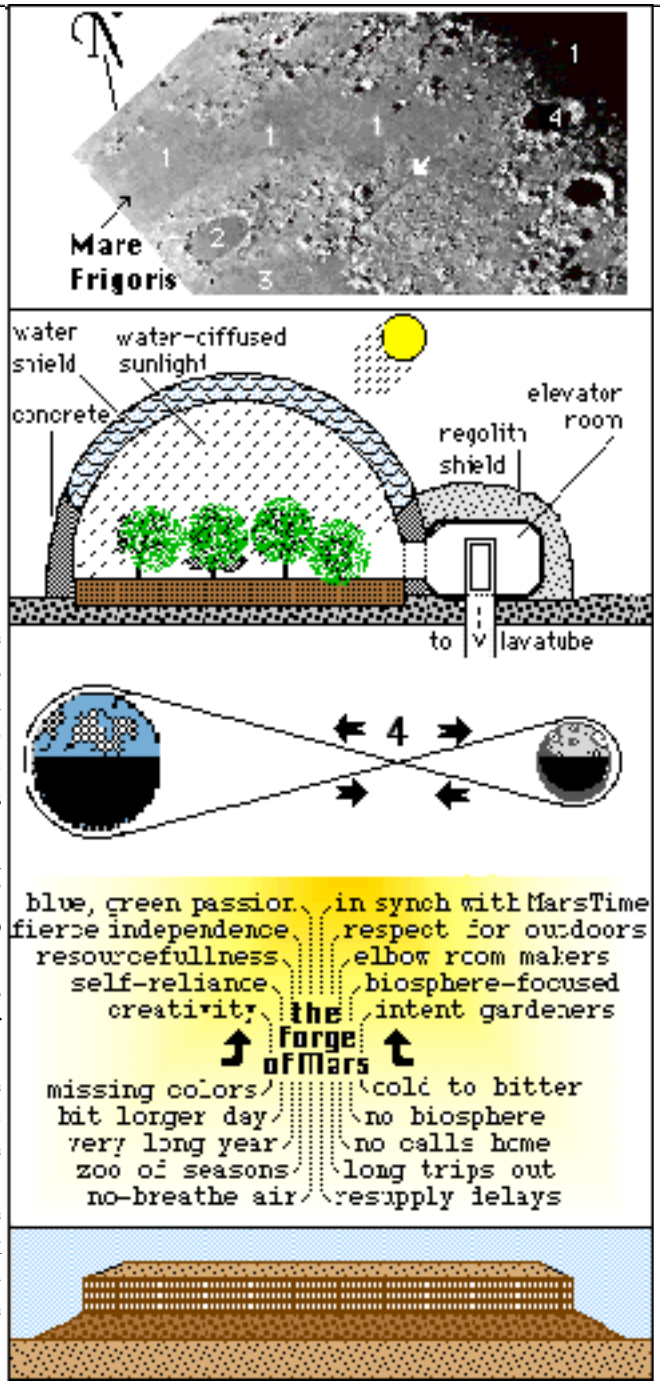
The evolution of home rule and pioneer rights receives added attention. The Moon will be attractive to those who want to set up "Intentional Communities." Several people discuss lunar currency.

Other Moon-focused topics are "postage" and "mail" (not email), golfing, and "tramp art" as a likely development.

Sulfur lamps emerge as a most efficient contender for nightspan lighting needs.

Lavatubes may also be made more attractive by developers. Skylight domes above them are an attractive option.

Lunar tourism will be upon us sooner than we think with early "loop the Moon" non-landing tours. Eventually surface resorts will follow.



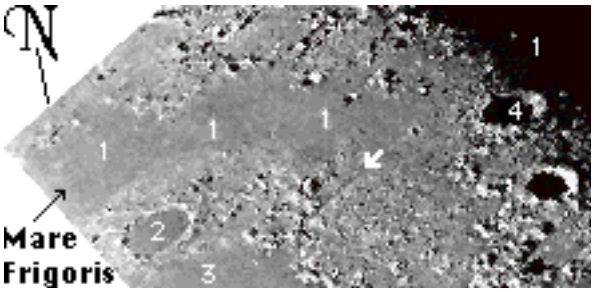
This year, we take an in depth look at the wellsprings of Martian Culture. The severe climate, the monotonous color scheme, minor and greater differences in the pace of time, and the remoteness of Mars will have a profound effect. Those who survive and thrive will be among the best.

Here too, the developer will play a vital role in creation of "improved" real estate, but we can do more now to "make Mars more valuable and attrac-tive to prospective pioneers.

The sight of Utah's San Rafael Swell, on a Greyhound trip to the Moon Society's Founding Convention in Las Vegas, gave us an idea of how regolith shielding mounds on the Moon and Mars, could be "architecturally sculpted" to have a much more attractive presence, adding to the beauty of the lunar or Martian terrain.

MMM did not neglect the rest of the Solar System this year: we took up again the potential for balloon-exploration of Venus, Titan, Jupiter.

In July, this year, the new more broadly based Moon Society took over chapters and member services from Artemis Society International, and thus became MMM's largest client. A lot was happening with other space organizations this year. The new Mars Arctic Research Station was erected.



Site for a Major Settlement fed by Polar Ice

WANTED: "a Mare/Highlands coastal site, with access to both major suites of lunar materials, with proximity to abundant sheltered volume in lavatubes, and within easy reach of polar icefields." Seems like a tall order, but Mare Frigoris (1) at 60° N, central nearside, may fill the bill. Mare Imbrium (3) lies to the south, with easy access through the Alpine Valley (arrow). The craters Plato (2) and Aristotle (4) are prominent. See below.

Where to Set up Shop?

Moonbase Site Selection Considerations

by Peter Kokh

It matters very much where and how we begin. We need to deliberately pick a site and an outpost systems architecture that is pregnant with a broad, open-ended future.

Of Apples and Oranges

People who discuss and debate where on the Moon is the most propitious place to set up a manned outpost risk talking apples and oranges. Agreement on what we mean by "moonbase" is assumed without any justification. In fact, different people have very different dreams for the Moon, and different visions of how a first lunar outpost will develop. They have differing appraisals of the uses for which the Moon is suitable. Participants in this debate also differ in the esteem in which they hold science, industry, enterprise, tourism, government, and eeks! - the common man, the stuff of settlers, alas. Academics and scientists, NASA bureaucrats, and development entrepreneurs are likely each to have widely incongruous views of what a moonbase should entail.

But if this is so, it should be clear that a consensus on an appropriate site is impossible. One site might be perfect for a "Kilroy-type outpost". We put an outpost on the Moon just to say we are there and not to do anything special except, of course, whatever science to which the location lends itself. So we pick the place easiest and cheapest to set up.

The geologist could care less whether the site is "easy" to erect or maintain. He wants to be in the very center of the greatest variety of Selenological enigmas awaiting investigation.

The radio astronomer and those engaging in S.E.T.I. search programs will want a base in central farside to listen to the star-whispers in silence.

The power beaming company wants a pair of east and west limb sites taking turns in the untempered sunlight. The helium-3 miner wants to be in the middle of the largest of the richer he-3 fields.

Those fixated on water-ice, as if industry could be built on that commodity alone, or who could care less about industry so long as they can burn the ice all up as cryogenic rocket fuels, will want a lunar polar site, as will those apparently intimidated by the Moon's surface temperature swings or its 14.75 day long nightspans.

With both Clementine and Lunar Prospector targeting the poles, we have seen a few pontifical announcements of late of "the" site being identified first at the South, then at the North Pole of the Moon. All such announcements presuppose unexamined and very questionable assumptions, however common.

The Pregnant Moonbase

It is impossible to reach consensus on this point as the debate is controlled largely by temperament. Those who look for a single lunar outpost and do not see the sense or feasibility of further development can quit reading now. So can those who see lunar outposts as a government affair, in the mold of what we have in Antarctica, or functioning as a university-government "National Lab" like Fermilab or Argonne or Los Alamos. For these persons, such a tomorrow is a daring, ambitious undertaking.

We choose instead to look beyond beginnings, to a global human presence on the Moon engaged in all kinds of activity: scientific research; industry and commerce; tourism and recreation; and just plain living. From this point of view, it matters very much where and how we begin. We need to deliberately pick a site and an outpost systems architecture that is pregnant with this broader open-ended future.

Nearly seventy years after Little America, we are still very "stuck" in the same sterile paradigm in Antarctica. And there is little reason for optimism that we will outgrow the present self-limiting goals to our Antarctic presence anytime soon. Scientific research IS important, but it hardly exhausts the potential of a genuine human community. If we don't want such a restricted future for the Moon, we need to start with a different kind of beginning.

- *We need to locate where we can learn to deal with the Moon on its own terms*. We need to resist establishing ourselves in a thermal and diurnal ghetto in which we will be unable to learn how to survive on the rest of the globe.
- We need to establish the main site *where the bulk of the materials that we need are located*, not near a small however essential fraction.
- We need to locate *where protected expansion volume is readily accessible*.
- We need to locate at *a natural crossroads site from which a large part of the lunar surface is easily accessible*.

We need to be many places on the Moon doing many things. We cannot, must not think of "a" or "the" moonbase or lunar outpost, only of "the first", second, and third or many. If

we want to establish a lunar economy, trade between a number of outposts and settlements will be necessary.

It is urgent that those who agree in general with the above philosophy part company with those who do not. We cannot win them over, we must leave them behind. The limits of their visions would be a millstone around our necks. Collaboration with fellow travelers can only set us on a road with an abundance of false turns and detours. Sometimes, there is not strength in numbers. It is better not to dilute the right vision in search of quick gains.

(1) "where we can learn to deal with the Moon on its own terms"

The polar sites are very non-typical areas of the Moon. 99.9% of the lunar globe experiences a dayspan/nightspan cycle twenty nine and a half Earth days long, in which surface temperatures swing between 200+ degrees below and 200+ degrees above zero Fahrenheit. We need to learn how to deal with these conditions, and to cope with them "as if by second nature". If we start in an atypical "thermally benign" "oasis", we may never venture further.

We *must face* dealing with the Moon's thermal swings. We *must face* learning how to operate in the energy desert-time of the lunar nightspan. [see MMM #126 JUN '99, p 3. POTENTIATION: A Strategy for Getting through the Nightspan on the Moon's Own Terms] Only if we do these two things, will we have earned the right to say we have "established" an "honest" and hopefully permanent presence on the Moon. Only then will our the capabilities of our presence be truly global.

(2) "where the bulk of needed materials are"

If we are going to the Moon only to refine cryogenic rocket fuel, then it makes sense to set up shop at one of the lunar poles. But if water is just one, and, by tonnage ratio, a minor feedstock for industries needed to support widespread settlement and a strong export market, then it makes more sense to place the major outpost where the other materials are to be found.

> Both lunar poles are in "highland" terrain rich in aluminum, calcium and magnesium. In contrast, sites along the "shores" of the lunar lava plain seas give access to iron and titanium rich soils as well as highland soils.

We'll need a polar outpost to tap the water ice and ship it to the main outpost. But the relationship of polar to mare/highland coastal site should be more like that of Prudhoe Bay to Los Angeles. It would be far less efficient to ship much greater tonnages of mare materials to the poles.

(3) "where protected expansion volume is readily accessible"

Lunar lavatubes offer spacious volumes protected from thermal swings of the surface, from micrometerorites, from cosmic radiation and solar flares, and from the otherwise omnipresent insidious moondust. These lee vacuum "hidden valleys" are a formation feature of the lunar maria, and they are happily more common near the "coasts". Setting up the main outpost handy to a lavatube entrance will provide ready expansion volume for warehousing, industry, and other needs. They are the ideal situation for fabric inflatables likely to carry the brunt of early expansion prior to the development of lunar building materials and components. It is possible that lunar lavatubes have been breached without being destroyed by comet fragments and will be found coated with usable water ice deposits far from the poles. Lavatubes are just as cold and as thermally inviting as the polar permashade cold traps. They are large enough to serve as ideal placement for heat radiators. There is more to the Moon than its surface.
[see MMM #130 NOV '99, pp. 1-4 "The Lunar Rock Pile: Behind Door #1, Door #2, Door #3, etc."; p. 5, "Of Coasts, Harbors, and Lighthouses"]

(4) "at a natural crossroads site"

There are "intercrater plains" that are not too difficult to traverse. But in general, highland terrain is more tortuous than mare terrain. Happily, most of the Moon's maria are on the nearside and interconnected in a "chain of maria." Mare Crisium and Mare Nectaris stand alone but nearby. Most any mare coastal site will put the pioneers within reach of a very large area of the lunar surface by easy traverse.

(5) "the first, second, and third or many"

We ought to look for a site that is prime for industrial expansion and a diversified economy. Yet no single site offers good access to all kinds of lunar resources. To succeed on the Moon, we will need to tap all the resources the Moon has to offer: highland and mare regolith soils; polar water ice reserves; KREEP deposits rich in potassium and thorium (key to a lunar nuclear fuels industry) around the fringes of mare Imbrium; possible upthrust mantle materials in some crater central peaks; possible atypically strategic-metal-rich Sudbury type deposits of asteroidal origin, laden with copper and nickel and other metals genuinely very scarce on the Moon.

If we start with one general well-placed site, we will still need a plethora of additional mining outposts. As tourism comes of age, more outposts will be established for scenic and other reasons. Such a wide-ranging nearside network of settlements will support geological investigations over a major portion of the Moon. *Science does much better piggybacking on settlement than alone.*

(6) "parting company with lesser visions"

Those whose goal is a single science research outpost see the government as its logical partner. The rest of us see industry and enterprise and tourism as our partners. While the government *can* have an enabling role, we must be careful not to give it a lead role. That we would inevitably find to be quite suffocating and preemptive with respect to all other activities, as it has been in Antarctica.

Our goals differ, our means differ, our logical partners differ. We need a friendly parting of the ways. Let's wish each other good luck, and for them, a safer return home. For us, home is out there. Let's not waste our time trying to sell others on a vision that by temperament they are not capable of sharing.

Unexamined drawbacks of a lunar polar site

We most definitely DO need a polar outpost and ice-harvesting and volatiles-shipping operation. We can ship ice and or water. Or we can electrolyze the water into its

components, combine the hydrogen with carbon from the carbon oxide ices likely to be intermixed if this stuff is truly cometary in origin, and ship instead liquid or gaseous methane. Methane, much easier to handle and ship than hydrogen, can to be combined with local oxygen at the various non-polar destinations, via fuel cells at night, to produce water and recovery energy. If we ship water, which is 89% oxygen, to areas rich in oxygen, we are in effect shipping "coal to Newcastle."

A polar outpost will not be the piece of cake it is being painted to be. The poles are inclined 1.4°, enough so that one must be at least 2,000 feet above the mean surrounding terrain within the horizon for the sun to be visible month around.

Even at those rare sites where sunlight is available for a majority of the month, it is coming in parallel to the ground. This creates a permanent "break of dawn" lighting condition, which combined with ink black shadows means the visible terrain will change unrecognizably from day to day. These are hardly easy conditions in which to operate at all safely. We predict that even with extensive artificial lighting, the poles will soon be found to be an alien, hostile, "extreme" environment , just by virtue of the angle of sunlight. Remember, while the Apollo missions all avoided the lunar nightspan, they also avoided both dawn and dusk for their unfavorable shadow-distorted lighting conditions.

Solar power taps at the poles will require vertical stacking. You cannot just array them all over the surface as you can anywhere else on the Moon. They would eclipse one another.

Some see a lunar polar outpost as an "easy do" with full time sunlight and "mild" temperatures, and expect a polar base would be a tourist favorite. But they are dreaming. They have miscalculated. *We will need people at the poles. But* lunar polar duty will be at the bottom of the list for volunteers. The two-week long lunar nights notwithstanding, life elsewhere will be better, safer, and more tolerable.

The Two Outpost Gambit - A Possible Synthesis

Let us set adrift this trial balloon. A number of robotic precursor missions to the poles better quantify the lunar ice deposits, and qualify them. Just how deep are they, and how continuous are the various fields.

- How much of these reserves are within reach of proposed outpost sites?
- How much moondust is mixed in, and on top of, the water ice layer?
- How much carbon and nitrogen ices are mixed in? (That'd be a great positive as we need these two volatiles every bit as much as we need water or hydrogen.)
- How hard is the stuff to chop up?
- How much energy does it take to melt, vaporize, and collect the vapor?

Then we have to field test demonstration pilot equipment. If we'll be preferably shipping methane and/or ammonia, we'll need pilot refinery equipment.

Assuming all this works, we need to find the ideal location, *not just for sunlight access, but central to* the various icefields for refining and shipping purposes and also handy to topographically easy shipping routes to destinations equatorwards.

At the same time, if the "Radar Flashbulb" project has been (privately) funded and the Lunar Lavatube Locator mission flown, perhaps as a NASA Discovery Mission opportunity, and suitable lavatubes are found in a number of highland/mare "coastal" areas, a short list of sites suitable for a main industrially diversified lunar settlement can be drawn up and a decision made.

If polar volatiles are to be shuttled to more equatorial sites by suborbital hoppers, any of these sites will do. But if a methane pipeline is indicated, a terminal in Mare Frigoris, the closest mare unit to either pole by far, would be the logical choice, and especially so, if intact lavatubes are confirmed there. [see "What do Lavatubes Look Like?" at http://www.lunar-reclamation.org/papers//lavatube_pix.htm]

Then what?

Then both outposts need to be set up almost simultaneously, or at least in quick succession. It's fine to lead with the polar base, so long as the lunar opening does not end there. An ice operation will support industry, agriculture, and the functioning of mini-biospheres. Yet a lunar polar operation without a mare coastal industrial settlement would be like male without female. Both need each other. Neither makes economic sense or will be viable alone.

The biggest pitfall is to think of "a" moonbase (read "any" or "Kilroy was here") or "the" moonbase as if the "beginning" is the whole thing, and not an overture to something that will grow beyond any forecast. This is the kind of thinking that is bringing us "the" space station instead of a whole flotilla of them.

It is impossible to sell an open-ended venture to public pockets. People in general are interested in the near term. We look at the far term. Their support is good for is a jump start of exceptionally colorful and/or easy to understand parts of the whole puzzle. It is tilting at windmills to think otherwise.

The very last thing we need is a stillborn premature moonbaselet. Let not our impatience to see something happen in our lifetime lure is into settling for a fake. We have made one false start already. The only option we can afford is the right one with a "pregnant beginning". Let search accordingly. **<MMM>**

The "Colloquipause"

The Moon is in Earth's "Conversational Space"
But how much further out does that go?

By Mark Kaehny and Peter Kokh

The speed of light, and of radio, is 300,000 km per second. **The Moon** averages 384,400 kms from Earth. That's one way at the speed of light in 1.28 seconds. Round Trip "ask-a-question-get-an-answer" time is 2.56 seconds - theoretically! Allow a few nanoseconds for the person on the other end to think of a response. Call it **3 seconds**. You can hold a

conversation under those conditions, with a bit of hesitation, of course, but not really enough lag to discourage anyone.

Mars at its "very closest" approach to Earth is some 56 million kilometers away. At its very farthest retreat from Earth, when both planets are on opposite sides of the Sun from one another, Mars can be as far away as 400 million kilometers. That means a radio time delay ranging from a bit over **6 minutes** minimum, to as much as **44 minutes**. That kind of wait to get a response to a statement or question is more than enough time to go to the bathroom, make a snack, even do the dishes and vacuum the living room rug, and maybe even walk the dog. Under such conditions, conversation cannot really exist as a dynamic human intercourse. Rather, we will trade monologues. And these will tend to be long, for efficiency's sake.

The Limits of Conversational Space

As you go out further into space than the Moon's orbit, say to a passing asteroid, conversation will become increasingly more awkward as the time delay increases steadily. Some people will be more patient in waiting for a response than others. But there will come a time when most will either take up knitting to pass the moments while waiting, or just give up the exercise and proceed to trade monologues, or just send prerecorded messages, email fashion.

There are in fact targets of opportunity such as passing near Earth asteroids where human crews may someday be sent. It would be nice to know how far conversational space extends and where radio and video mail space begins. For crews outbound for Mars, it would be helpful to know (rather than guess) for how many days we can expect to keep in touch by "conversation" as opposed to video email?

An inexpensive chapter project

This is one thing we don't have to wait to find out. We can simulate delays by electronic means, by recording, and then delaying transmission for an ever increasing "time delay" period before reception by a second party. To better determine the distance out to the "colloquipause" where fluent conversation becomes impractical, we propose two simulations.

Setting up the Simulation

For very little money and equipment, local groups (to avoid toll charges) could undertake one or all of the following simulations. (Teams should be chosen with a range of backgrounds and ages to avoid spurious results from too small a sample.)

1. Begin with a period of familiarization with the lunar distance 3 second delay. Everyone should perhaps have an hour's experience at this level.
2. Up the delay to 4 seconds - 20 minutes
3. Up the delay to 5 seconds - 20 minutes
4. Up the delay to 7 seconds - 20 minutes
5. Then 10 seconds, 15, 20, 25, 30, 45, one minute

If everyone is still comfortable with a one minute delay representing a conversation over a span of 9 million kilometers of 6 million miles, then try 1.5 minutes, 2 minutes, 2.5 etc.

Simulation Exercise One

At some point individual players will, upon receiving the response, start having trouble remembering what they said, to which the other has replied. Different people have different attention spans, and differing susceptibilities to distraction. The point is to find at what level of delay each person says "enough! This no longer feels like conversation!"

Whether background has any influence would not be discernible without a lot of repeat tests with a much larger sample. The "scorekeeper" tallies the point of first drop out, and the last, and calculates the median and the average. This exercise gives us our first set of data points.

Simulation Exercise Two

1. Begin with a Mars-minimal 6 minutes. If no one feels they are "conversing" with this length,
2. Try 5 minutes, 4, 3
3. As soon as someone feels comfortable "conversing" at the current level of delay, start going slower in the reductions. a half minute less, etc.
4. Note the point at which the first person came to feel he/she was conversing and the point where the last remaining team member felt so. Calculate the median and the average. This gives us our second set of data points.

The expectation is that the second delay range will be further out, involving a greater range of delay, than the first set, and will give some indication of how far the Colloquipause can be pushed with training and dedication.

Then switch positions, Group 1 repeating the descent from 7 minutes, Group 2 starting with 3 seconds and increasing the delay. This will further refine both sets of results.

Jack Benny was the master of time delay. But even he could not push it more than a few seconds. But if we expect a delay, everything should change - to an extent. To what extent? That is the question.

Simulation Enhancements

- Use television or web cams instead of radios. This will allow visual clues. As the delay grows longer, you will detect that the other party is waiting for your response. Starting with the first phase of Simulation One, you will not see a change in expression indicating the other has heard what you said for three seconds after you have spoken.
- A TV on each side could be programed with the delay so you can see yourself speaking at the same time as the other party is hearing you. That reminds you of what you just said, and helps to anchor the other's response. Use of such devices would help over longer range delays. Over short lunar-like distances, they would interfere, as you would start to hear yourself talking before you were finished with the first sentence. So this device might help in a repeat of Simulation Two
- Alternately or additionally, a warning light on your side gives you a set warning when your message is about to be seen/heard. That would stir you out of any reverie or daydream you had fallen into in the long wait for a reply.

How do either of these aids extend the tolerable distance to which the Colloquipause can be pushed? Are they helpful over clearly different and distinct ranges? At which ranges do they interfere?

Practical Applications

We might end up with protocols whereby we normally engage in conversational mode while the two parties remain within a standard range - the limits of each party's conversational space - the "Colloquipause". Beyond that we may automatically switch to radio or video email mode, with "you have mail" chirpers alerting us to an incoming message to be saved until we "pick up".

You might think NASA knows all this by now. Not unless they have done a similar round of simulations. The furthest human beings have been from Earth is over the farside of the Moon, when they were in radio shadow anyway. Those of you who remember the Apollo missions live, will remember that those minutes out of touch with Earth seemed interminable.

Knowing how far out we can push the edge of the Colloquipause could be helpful to crews bound for Mars, or returning. As to asteroid-bound crews.

Outreach Potential

Why not run such simulations in a school, or with volunteers from the public at large? One doesn't have to be a space expert to take part. One just might become a space fanatic in the process.

Meanwhile we would appreciate letters or email <KokhMMM@aol.com> about the right kind of equipment for these various simulation exercises. If there is enough interest, we could put up a web page or an online discuss group. Engage! **<MK/PK>**

[Space Frontier Home Rule Series Cont.]

For "Strangers in a Strange Land", A "Right" of Repatriation?

by Peter Kokh

Does anyone know him/herself truly well enough to volunteer to be a "one-way" space pioneer? Should immigrants have **a right of repatriation** with guaranteed free passage back to Earth, should it become clear that they just can't handle frontier life? How would reserves to pay for this be set aside?

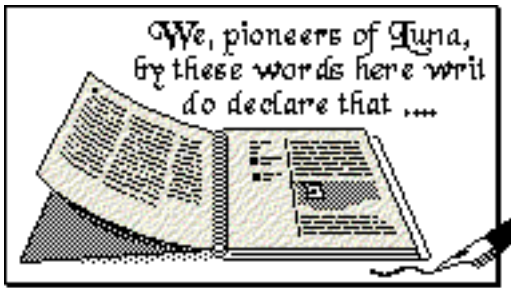
Every effort must be made to exclude those likely to fail; to be sure those still willing enter into this with eyes wide open. On past frontiers, the immigrants gave up the old country, relatives, friends, property, etc. They did not give up Earth, its blue skies, the green grass and forests, the fresh air, outdoor activities - in short they have never before given up life in the Mothering Earth Biosphere.

There is much "romance" in the notion of pioneering new worlds. We must do everything possible to minimize this romance if we are not going to end up with a lot of disillusioned and mutinous settlers. People have to know what they're giving up. And they have to be confident that what they are gaining is worth it; to believe that they will have every opportunity to make steady improvements in harsh living conditions. Would the right to return home, prepaid be an effective safety valve to diffuse trouble? Or would this safety valve work instead to encourage people to try, when really they are not suited?

The likeliest scenario is that the first space pioneers will be persons who have gone out to work, with no intention of staying. Among those who agree to stay on will be some who have fallen in love with the frontier, eventually becoming so comfortable with their new life that they are ready to give up the right of return for a "buy-in" into the frontier as a citizen. But should the Earth-based employer decide to pull up stakes, leaving the starter community high and dry and unviable, they might be required to offer free repatriation as an "ultimate assurance".

Once a settlement is begun with former on site temporary employees, the opportunity for direct immigration from Earth will arise. Here, volunteers, job contracts in hand, will be making "for keeps" decisions without actual experience of frontier life, even if they have passed their "frontier orientation simulations" with flying colors. If hiring companies are involved in the orientation and simulation as "assurance" against recruiting unsuitable persons, then they should be able to purchase "insurance" to pay the cost of return of the hopefully few pioneers who will fail despite all their best intentions.

Now for Lunan pioneers, this cost will be modest relative to the cost of repatriating Martian pioneers. This is a plus for having frontier opening experience under our belt on the Moon first. **<MMM>**



The Settlement as an Intentional Community

by Peter Kokh

We know the origins of some of Earth's cities and towns. For most others, their origins are lost in the myths of time. Yet with few exceptions (planned capital cities like Washington, Brasilia, Islamabad, Canberra, etc.) cities have grown haphazardly, with no force shaping them other than topography (coasts and rivers, mountains, etc.) and the fortuitous conjunction of economic forces and fortunes.

Of "Xities" and "Reclamation"

In our series on extraterrestrial settlements MMM's #s 52-60, we coined a new word for communities that do not arise in a preexisting global biospheres, but which have to provide, and maintain, mini-biospheres of their own, with no forgiving "sinks" to act as buffers for environmental irresponsibilities. The word we offered was "Xity", "X" standing for "exo", of course, but pronounced hard: KSIH tee, *not* ek sih tee. We

want the word pronounced in two syllables, like city, not three. The hard sound is a clue to the unprecedentedly difficult task that any/all settlements beyond Earth's cradling and coddling planet-wide biosphere must face.

Dutch towns below sea level come closest as a model. Their protective dikes holding back the tides and surges of the sea must be religiously maintained. The dike is an analog of the seamless pressure hulls of space settlements (modular or megastructure). The pressure hulls in effect "reclaim" from the seas of space, vacuum, and cosmic radiation, formerly "inundated lands" that are now made fertile, capable of supporting life. As we've said before, "reclamation" is job one for any space frontier settlement, a job that never ends. With eternal maintenance and vigilance, the reclaimed area hopefully will increase in size, fertility, productivity, and population.

Education Responsibilities in Fragile Biospheres

This "defining" "task one", means that the settlement cannot take a *laissez faire* attitude about the environmental education of its citizens, when it comes to awareness of their shared vulnerability and the responsibilities that each must assume as his or her own. The critical difference between the global biosphere that terrestrial cities take for granted, and the local mini-biospheres that space frontier settle-ment *cannot ever* take for granted, is that the latter have no massive "sinks" to buffer the effects of environmental sins and episodes of carelessness. On Earth, we mess up and it affects our grandchildren. Out there, we mess up and it's all over. The pioneers will live immediately downwind and downstream from themselves. Everyone, not just some, must care.

Whatever other educational freedoms are guaranteed, all citizens must know, and understand, how their biospheres work: how the air is kept fresh and recycled, how the water is kept free of pollutants and recycled, how vegetation is to be cherished and cultivated, and more. A part of this common education will be to provide a menu of chores suitable for children, with some degree of rotation, so that everyone has basic familiarity with *all* the biosphere's systems. And when they come of age, a year or two of universal service running the air and water plants and the agriculture areas would instill an even deeper sense of "ownership" and better citizenship.

And that is what each settlement must seek to instill: a sense of ownership of the systems and the fragile balances that make community life possible beyond Earth. The test of this appreciation is the degree to which it appropriately affects individual microeconomic decisions as well as environment-relevant housekeeping habits, public and domestic.

Economic Health of Citizens

Space frontier towns will be hard pressed to survive unless a much higher fraction of their populations are productive than seems acceptable on Earth. Health priorities must be turned around with emphasis on expectant mothers, infants, children, and seniors with good years left in them. It will not work to take a hands off attitude on prevention and then plow inappropriate resources into remediation.

For economic productivity, the same is true. Every effort must be made to equip every citizen with all the tools and knowledge each can use to become as productive and creative as their individual talents and aptitudes will allow. Being relaxed about education and then having to plow major resources into welfare etc. will not work. The settlement cannot thrive unless each citizen is offered the best individually tailored education, not just a basic one.

The University system especially must be geared to work with would-be entrepreneurs in development of new products for domestic consumption and/or the export trade, to maximize the economic self-sufficiency of the settlement.

Just "retiring" seniors will make no sense. Putting them to work on new tasks such as educating the young and taking care of much of the administrative load will prolong their usefulness and self-satisfaction, while relieving those in the prime of life for tasks related to production and trade.

Conclusion

On the space frontier, many things we have always taken for granted on Earth, must become the object of concerted "Intentional" Communal Effort. The upshot is **a linkage of citizen rights**, on the one hand, and of **duties and responsibilities** on the other The former must be guaranteed, the latter must be mandated, by the Settlement charter. **<MMM>**

The "Developer's" Role:

Putting together a package to attract anchor tenants and a "viable mix" of other clients, splitting costs & burdens, may be just the "accelerant" needed to start Lunar Development in earnest.

by Peter Kokh

Improved Real Estate

Most readers will be aware of the distinction between "improved" and "unimproved" real estate. "Improved" real estate has on site or boundary access to utilities like water, gas, and electric. The lot may or may not have other "improvements" e.g. drainage grading. "Unimproved" real estate is just raw ground, with no utility access, perhaps not even road access, the kind of stuff Florida an Nevada fly-by-night "developers" want to sell you in the middle of a swamp or desert for a "bargain of a lifetime" price/ Lot's of luck doing anything with it!

All lunar real estate is "unimproved"

That does not mean that some locations are not better advantaged than others. Polar sites may have access to water-ice reserves. Highland/Mare Coastal sites have access to both major suites of pre-pulverized (read "pre-mined") regolith. Sites along the Mare Imbrium rim are richer in Potassium and Thorium and KREEP elements. And so on. But these are natural assets. No land on the Moon is man-improved, i.e. with

utility access, or with any other kind of loacation-location-location traffic generating engineered "improvements." This is a daunting, if not intimidating fact facing anyone who has a free enterprise idea for a lunar location. The same can be said of Mars, of course.

Allen Wasser has proposed a lunar "land grant" program to attract lunar development. But perhaps the only ideal customer for such a real estate regime is the "developer" who will go into the prospect site and make improvements that will render it especially attractive to specialized mining, processing, manufacturing, and other types of private enterprise. The first such developer to "improve" a resource-rich well-situated site, may, in the process be founding the first genuine lunar settlement. Even if there is already a scientific outpost on location, without improvements the "settlement" will not come.

The perspective of other interested parties

The mining company, the manufacturing company, the hotel operator, do not want to have to do such unaccustomed preliminary work as setting up power supplies, providing water, building a space port, providing communication relays, etc. If these things were already in place, ready to "plug into" and ready for "hook up", the location would be immensely more attractive. Industrial and commercial enterprise would not have to assume *the extra burden of paying for these improvement costs up front,* but would merely tap in, and pay a monthly or annual usage charge: utility bills. This drastically cuts their financing costs as well as the time between arrival on the Moon and first returns on investment. It makes their job in closing a deal at a bank that much easier, more realistic.

The Lunar Site Developer's tasks:

(1) Picking a Site for Improvement:

The first task is to analyze candidate sites on the basis of "strengths & weaknesses". The developer should draw up an "Existing Conditions Map." This will include the topography within the area, noting potential obstacles and assets for construction. If there is a science outpost already established, any sharable assets (power, communications, roadways, launch pad) should be noted.

Do assets outweigh liabilities? Are there any "targets of opportunity" such as proximity to uncommon but valuable resources, passages through topographical obstacles such as passes through nearby ridges, natural bridges over nearby rilles? Are there known intact lavatubes in the vicinity? What is the ratio of highland-derived to mare-derived soil in the local regolith? Are there scenic highlights in the area? Is there enough flat terrain for emplacement of large solar arrays? Is there a logical location for a spaceport?

What are the liabilities? Lack of easy access to neighboring areas of the Moon? Uneven terrain? A large number of inconveniently placed boulders? Rilles or ridges that are not easily negotiated? Such liabilities must be weighed along with assets.

Next the developer needs to brainstorm this mix of assets and come up with a winning strategy to attract enterprises to buy in the development.

(2) The Site Development Plan

Site development plans should work with the lay of the land, develop topography suggested transportation corridors in the vicinity. The location must be picked for the spaceport with adjacent surface warehousing and shipping/receiving areas. Will the spaceport provide loading and unloading equipment so that incoming freighters do not have to carry the extra mass of self-unloading equipment? Developing the Port Facility will be part of Phase One.

A graded Road Network linking identified industrial park properties and residential and commercial areas and other special identified use areas must be provided. Easily gradable roadways to important nearby off-location resource-rich areas should be identified and marked. Care must be taken that all such identified sites are easily serviceable both by road and by utility providers.

3) Financial Considerations:

The proposed development must be

- **market supportable**
- **physically doable**
- **financially viable**

To this end, the developer needs to take on "natural partners" in order to subdivide the task and conquer the load. "Natural Partners" will include:

- a power generation company (solar &/or nuclear)
- an oxygen production facility. Among potentially competing proposals, one that employs processes that produce enriched tailings especially attractive to other potential manufacturers should be given the nod. Such beneficiated byproducts will help identify and attract other clients.
- a water production facility. If the site is not proximate to polar ice fields, and the developer does not wish to co-develop such icefields along with a means of transporting water, or hydrogen produced from it, to the development site, then, if hydrogen produced by heat-scavenging of any and all regolith moved in development of the site does not produce enough to be reacted with locally produced oxygen to meet needs, the balance must be brought from Earth

  The only rational way to meet primary water recovery and waste treatment needs is on the spot where the water is grayed. This will be a burden each tenant-client of the development must assume. The development's shared mini-biosphere must be modular both in construction and in maintenance. This means primary treatment at the source of the problem for both water and air.
- a mining processing-building component manufacturer to turn out prefab modular building components to fit customer needs, in order to defray the cost of bringing additional pressurized volume from Earth at much greater expense.
- Such a partner building component manufacturer could then enter into a joint venture with the developer to produce "turnkey" factories, warehouses, commercial and residential properties for other clients on the basis of need and request.

- ◇ Additionally, such a company could construct "hanger sheds" or space-frames constructed of glass composites or steel, covered with plates of the same material, then over-blanketed with regolith to provide "improved" radiation proof "lee vacuum" for easy set up of modular habitat structures, especially less expensive, lighter, cheaper to ship inflatables and hybrid rigid-core inflatables (on the TransHab model). Such hangers or ramadas might be built as rille-spanning vaults: virtual man-made or more exactly, man-restored lavatubes, which is what most sinuous rilles originally were.
- ◇ Another joint venture would be to provide improved access (graded ramps and elevators) to any buildable lavatubes in the area. Shafts drilled through the lavatube ceiling/roof filled with fiber optic cables, with sun collector on top and light defuser within the lavatube, would be an immensely attractive improvement, as would be a lavatube floor topographic map. No enterprise will buy space within a lavatube, no matter how many theoretical advantages it offers, without solid concrete information, and prepared access and minimal lighting.

These "Natural Partners" will be the "anchor" tenants" necessary to attract other partners, clients, and tenants to the development. These latter must be identified with special care to create a viable mix of enterprises that will both provide a healthy balance of diversified exports and meet a major portion of the physical needs of the growing community of people locating in the development to run and operate the various enterprises:

- **modular housing, other pressurized structures**
- **furniture and furnishings**
- **food**
- **other basic products**

Summary

This is a plan in which costs are identified and shared in a manner that makes the development

- **physically doable**
- **financially viable**
- **environmentally compatible**
- **politically feasible**

It is a prescription for a rational plan to share both equity and debt, to remediate any waste problems, and to share the costs of further improvements useful for all or most parties.

Reader comments and suggestions to further improve this general approach to lunar industrial development are welcome. For contact information, see the box below the front page masthead.

<MMM>

Updated 3-D Renderings of
Io, Europa, Ganymede, and Callisto:

http://www.mmedia.is/~bjj/jupsys_rend.html

Towards an Interplanetary Internet
earth.sol, moon.sol, mars.sol superdomains

Or "On Putting the Cart before the Horse"

via Curtis Snow <curtis@baloney.com>

A recent written inquiry sent to the International Organization for Standardization in Geneva, asked what it would take to set up "superdomains" on the World Wide Web for each planet.

In a classic testimony to the obtuse intelligense of beaurocrats, the reply was essentially this:

"Have the sovereign representatives
of the Moon, Earth, and Mars write us a letter."

MMM #132 - FEB 2000

In Focus "Spinning-up" Frontier Enterprises Profitable for both Earth & Space

The outlook for Space Enterprise would seem to be grim in the wake of the Motorola Iridium bankruptcy. We beg to differ. Yes, investors will be wary of big space enterprise proposals after this major collapse. But how, in truth, would the success of Motorola's effort or of any similar effort help open the space frontier? It would have helped build the market for small payload launchers. Our point is that small satellites and small payload launchers, while they may make money for individuals who may *also* happen to be interested in opening space as a human frontier, do not in any direct way remove any of the considerable hurdles confronting those who would open space to human beings on any truly non-vicarious, non-virtual level. Small payload CATS, certainly good in itself, is probably not much more than an energy-sucking detour.

We need cheap access to the threshold of space, LEO, *for large payloads* and *for people*. AND we need *cheap, fast transit "in" space itself.* AND, once we can get cheaply and quickly to places where we can tap the vast resources of space, we need the industrial tools to do so. Alas, no one seems to be working on any of this home(planet)work backlog.

The "rocket science" portion of this agenda, we must leave to those with expertise in those areas. What we'd like to talk about is the vast, unexplored potential for making *real money now,* developing processes and industries to meet the common unexplored resource challenges of good old *terra firma* Earth and of sundry worlds in space alike.

The considerable *"bricks & mortar"* portion of Earth's economy, which will *never* disappear or become irrelevant, has been built entirely upon the tapping of "enriched" resources. It is obvious that it will be cheaper to mine rich veins of ore than more homogenized concentrations of the elements vital to industry. It is obvious, too, that if we are to have self-reliant settlements on space, that they must also be able to "produce" economically, the elements needed for

their own industries. The hitch is, that concentrated ore bodies are a terrestrial asset which we are unlikely to find elsewhere in the solar system. No where else has there been billions of year of geological processing of a world's crust and mantel in the presence of water. Not even on Mars, where such processing may have started only to be nipped in the bud much too early.

Poor Ore Mining Technologies

For accessing necessary resources on the Moon, on Mars, and even on the asteroids (where there is an unsubstantiated widely held belief that concentrated ores may indeed be found), we need to develop mining, beneficiation, and processing technologies that are economical in unenriched deposits. Talk to a mining engineer, and it is likely that if you bring up the subject of "mining the Moon" or Mars, you will be greeted with a contemptuous, condescending put down. No one knows with confidence, how to "produce" metals or other elements from such "poor" ores economically on industrial production scales. To point to lab-verified pathways of getting oxygen, for example, is not helpful or useful.

We will see no self-reliant resource-using lunar or Martian settlements until we have such technologies. Give us CATS and we will still have nothing! Nor would a political turnaround of unrealistic proportions that would make a lunar or Martian "outpost" a confirmed agenda item change this situation. "Local Industry" beyond a few relatively easy and simple symbolic things, will not be necessary for the token outposts such a political miracle might put on the agenda. We must not assume that if NASA (i.e. Congress) did indeed reverse itself, it would undertake crash programs to develop such technologies.

There is another way, a very mundane way to get the job done. Sadly, space-enthusiasts in general are too much too impatient to sidetrack their efforts to indirect methods that may in fact be much more powerful. These very same "Poor Ore Mining Technologies" would be very useful on Earth, whether we ever do go on to open up the space frontier or not.

Consider Earth's economic geography. The distribution of iron ore, copper, bauxite (aluminum), uranium, and other elements vital to industry has in large measure predetermined which nations have thrived and which have not. Of course, other factors play vital roles: arable fertile soil, access to the sea, forests, and the enterprise quotient of the people.

Poor Ore Mining Technologies would usher a substantial equalizing force into the world economy. Soils everywhere contain abundant aluminum and iron, *but not* necessarily in the concentrations and in the mineral forms we "know how to" work with cost-effectively. Chemical engineers must blaze new pathways that balance favorably energy inputs, secondary marketable byproducts, and environmental impacts. Concrete specific proposals tailored to the mineralogical circumstances of the various candidate locations need to be made to local or non-local investors and partners that stand to profit. Some of these poor ore mining technologies may have direct or indirect application to the situation we will find on the Moon or Mars or elsewhere. But even where this is not the case, we will be building up a pool of people with a "can do" attitude to supplant the present unhelpful crowd of "can't do" mining experts.

Molecular technologies under exploration by people like Steve Gillette of the Univ. of Nevada-Reno offer some real revolutionary promise of an end run around present mineral-cracking hurdles. When it comes to producing strategic elements that are much less abundant, like copper, zinc, silver, platinum, gold, etc. where a 1% ore is considered rich, bio-extraction technologies need to be pushed. Without concentrated ore bodies, such elements are often present in only parts per million [ppm], or even parts per billion [ppb]. Bioengineered bacterial cultures may be able to greatly beneficiate or enrich these ambient concentrations. Here on Earth, such technologies would make many nations less dependent on others, less subject to political blackmail.

Novel Building Materials

On the Moon, there are neither forests to supply us with wood, nor petroleum reserves to supply us with chemical feedstocks for the host of synthetic materials to which we are addicted. Even on Mars, with a carbon and nitrogen rich atmosphere and plenty of hydrogen at least in polar ice, bringing such traditional building materials and manufacturing stuffs on line will be a trick. But is the situation any different for scores of countries on Earth that do not have appreciable forests, or who cannot afford to make further inroads into those they still have, and without native oil reserves?

Glass-glass composites have been proposed, and lab-researched, as a promising option for lunar settlement industry. But if we learned to produce a versatile array of glass composite building products and manufacturing stuffs, that could be an immense aid to the economies of countries that must presently import vast quantities of lumber and other products. There would seem to be ample economic incentive for taking this exotic stuff out of the labs, make fortunes in doing so right here on Earth, and in the process develop, debug, and put "on the shelf" a ready-to-go industrial technology that could be a backbone of early lunar and Martian industrial settlements. We developed this idea in more detail in MMM # 16, June 1988. But while glass fibers are finding their way into new concrete formulations, no one has bothered to try to earn a buck by taking glass composites themselves beyond the laboratory curiosity stage.

Metal alloys are another area deserving more research. Most pure metals have poor performance characteristics and benefit greatly from inclusion of varying amounts of "alloying" ingredients. Yet it does not seem to dawn on most space supporters that the Moon's considerable "on Paper" wealth in iron, aluminum, magnesium, and titanium - the four "engineering metals" - does not guarantee the easy and economic production of the various alloying elements we are used to using to improve the performance characteristics of each. Steel needs carbon, in poor supply on the Moon. Aluminum alloys generally are rich in copper, a ppb trace on the Moon. Metallurgists who step in to research more "frontier-feasible" alloys which are still "serviceable" may end up producing alloys with considerable marketability here on Earth.

Synthetic Chemical Feedstocks

Mars enthusiasts never tire of pointing out that the ocher planet is richly endowed with the elements that are the

basic organic and synthetic building blocks: hydrogen, carbon, and nitrogen (oxygen being taken for granted as ubiquitous). But in fact, most plastics and other synthetic materials are normally not "made from scratch" but from nature-preprocessed cooking ingredients more or less easily refined from oil and other complex petroleum reserves (tar, shale, etc.) We are spoiled. But at the same time, countries not blessed with such reserves are at the economic mercy of those who do have them. If economical "from scratch" methods of meeting such synthetic materials needs could be developed by chemical engineers of the organic-persuasion, this would be of great economic value for many nations. And, as always, the power to equalize is the power to make money.

Bob Zubrin showed the world that methane could be easily made from carbon dioxide by using a totally automated "Sabatier reactor". Apparently, the chemical pathways exist to make other simple organic molecules that could serve as synthetic feedstocks by a similar or adapted sabatier process. Applying such techniques here on Earth might prove profitable. If countries blessed with natural gas, but not with oil reserves per se, could build the equivalent of a petrochemicals industry upon the simpler rudimentary assets of air and natural gas, this could prove a powerful economic equalizer for them. And anything additional to methane that we can learn to produce by these techniques, will also have the happy effect of putting "on the shelf" pre-developed and pre-debugged technologies ready to go on Mars at a much lower cost to the frontier.

In the original oil crisis, research began into using certain plants to produce oils and other petrochemical-like feed stocks. There is money to be made here on Earth by pursuing such agricultural alternatives. And happily, many such advances will be useful to opening the Martian and lunar frontiers. We *can* learn to be much less dependent on wood, paper, and synthetic organic products. But if we are not to be confined to a the constraints of a "New Stone Age" on the space frontier, alternatives to conventional petrochemicals must be developed. And we can make money here and now doing so.

"Biospheric" Technologies

Biosphere II was an attempt to come up with a centralized solution for biological life support. Though the specific experiment "succeeded" only by "cheating", in fact we learned much. The only thing that can be dismissed as a failure, is an effort from which we learn nothing. It is much easier to dismiss than to criticize constructively, and when reading such negative reports, one should always discount for the temperament of the reporter.

Beyond Earth, settlements must reencradle themselves in mini-biospheres that each settlement must establish, grow, and maintain. This will entail the unprecedented challenge of "living immediately downstream and downwind" of oneself. Pioneers in space *will not pollute* because, unlike us spoiled terrestrials, they cannot "get away with it," putting off pollution problems to the next generation.

But to attempt to do this in a centralized way is just as ineffective as are centralized methods of growing and controlling economies. Modular "market" techniques must be the basis of any effort to establish, grow, and maintain space frontier biospheres. Systems that treat human wastes at the origin and greatly reduce any residual problem that must be handled on a larger scale, are much better suited for non-ivory tower communities of non-static size.

In fact, many people are experimenting with "living machines" and other techniques to integrate plants, air quality maintenance, and waste treatment in unit-sized systems. Such an approach will not only make city-size biospheres a more practical prospect, but will also enable appropriate-size life support systems for spacecraft on long deep-space journeys. We need technologies that are "scalable." In contrast, solutions addressing fixed, static size situations are not helpful at all.

The terrestrial profit prospectus of modular biospheric technologies is immense. In the last few decades we have seen the emergence of gargantuan urban complexes in the third world. For the most part, such cities have grown and continue to grow faster than urban utilities can add capacity to keep up with them. The pressure on centralized water treatment facilities is unreal, and the loser is public health. Inexpensive ways to tackle human wastes home by home, unit by unit, that freshen interior air, and provide additional sources of food, would do much to make such monster "blob" cities more livable. There is a market! Let's make money now, and learn how to do space right in the process.

The Gospel of "Spin-up"

The traditional fare of the space faithful is what has long been known as "spin-off." NASA spends hundreds of millions or even billions of dollars developing new materials and technologies that the agency needs for use in space, all at taxpayer expense. Then these technologies are made available to industry at large, providing the usual litany of "benefits for the public" of space research.

"Spin-up" would take the opposite path. Enterprise would brainstorm technologies deemed vital down the road in space for their potential Earth-market applications, so as to make money now. The frosting on the cake is that technologies also needed on the space frontier, would be predeveloped now at the expense of the consumer, rather than the taxpayer (YES, there is a world of difference in this distinction), and would be ready in time "ready to go" and at relatively low cost to those who will in due course attempt to open the space frontier to genuine self-reliant local resource-using communities beyond Earth's biosphere and atmosphere.

"Spin-up" is a more economical and efficient way to get the research done in a timely fashion. It is the only path not dependent on uncontrollably fickle political tides. And in so far as it is consumer-user financed rather than tax-payer-forced, it is a more moral way to achieve "minority goals" such as ours.

But above all, the "spin-up" route is the only sure way to get the job done. *To rely on the traditional route means putting all our eggs under a hen that is not motivated by instinct or any other reliable force to hatch them.* We have complained before that those who want to open space by political coercion are abdicating the responsibility for the fulfillment of OUR dreams to those who do not share them, *and cannot be made to share them.*

If you are blessed with the talent to be an

entrepreneur, consider that getting involved in pioneering some of the terrestrially useful technologies needed also in space may do more to guarantee the timely opening of the real space frontier than any amount of seemingly more direct involvement in micro-satellites and micro-launchers.

We do not expect those with electronics and propulsion expertise to get into totally different fields. Each of us must do our thing. Rather, we want to encourage and set loose the untapped talents of others who have not realized that they have a potentially powerful role to play, however indirect. The important thing in opening space is not instant gratification. It is well-targeted patient hard work.

If you are a young person not yet established in a career, consider chemical engineering, poor ore mining technologies, new materials science, "from scratch" synthetics production, bioextraction technologies, molecular mining technologies, experimental agriculture, and modular environmental systems as rewarding fields in which you can make a difference, both down here and out there.

Rocket science can take us to other worlds. It cannot enable us to do anything useful once we get there. Iridium may have failed. It was a detour. There are other, ultimately more powerful and profitable ways to build up to a space frontier economy. Do not waste a moment wallowing in discouragement at recent setbacks. In the end, they won't matter. **<PK>**

Collapsed Lavatube Make-Overs

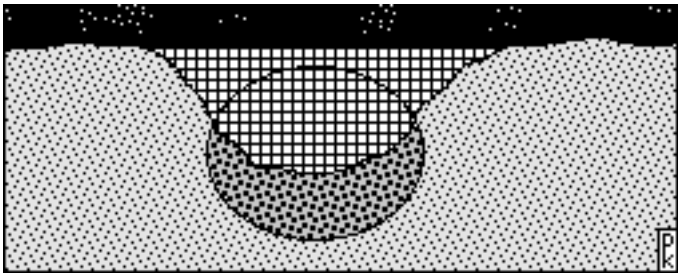
Recreating Shelter Space inside Rille Valleys

by Peter Kokh

We've talked a lot about the use of lavatubes with their ready made shelter from both the harsh cosmic elements and the harsh surface conditions of extreme temperature swings and insidious moondust. But what about "ex-lavatubes", the collapsed lavatubes whose ceilings were evidently too thin or too weak to stand the test of time? Are these no more than fascinating, scenic, geological ruins? After all, some areas may have rilles but no handy intact Lavatube sections? And even if a site offers both, as is likely, can anything useful be done with rilles?

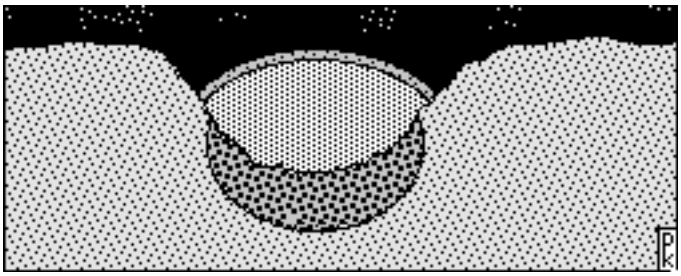
We got our first and only up close look at a sinuous rille valley when the Apollo 15 crew visited Hadley Rille at the foot of the northern Apennine Mts. which form the SE ramparts of Mare Imbrium and separate that great "sea" from Mare Serenitatis. Hadley is about 150 km SE of the rim of the prominent 75 km wide crater Archimedes. The rille itself is about 135 km [c. 85 mi] long and 1-2 km wide from rim to rim [1,000-2,000 meters or yards]. The small section actually visited was 370 m [c. 1200 ft] deep. We can assume this as typical, with rilles that are both narrower and shallower, and wider and deeper. These dimensions give us a fairly accurate way of reconstructing the size of the original tube.

The whole report referred to at right is online at: http://www.lunar-reclamation.org/papers/rille_paper1.htm



In the illustration above, the current cross-section profile of the surviving rille is cross-checked. The oval represents the size and location of the original tube. The cross-checked area above the lavatube ceiling has collapsed onto the lavatube floor and is represented by the heavily checked area below the current rille floor.

If the mission plan for the chosen site calls for the establishment of a sizable surface shelter, any rille valleys within the site boundaries should be seen as substantial pre-excavated areas that need only be spanned with regolith covered arched roof spans to provide the same protection from the cosmic elements as did the once intact lavatube. A plate-covered space frame arch, extending from one wall to the other, partly down both slopes, could then easily be blanketed with regolith by dragging material down on top of the arch from the rille shoulders above. The arch could be of any length, with an original section extended in either or both directions at a later date.



In the illustration above, a strong, lightweight arch of space frame construction (lunar glass composites) spans the rille valley from one wall to the other, and has been covered with 4-6 meters of loose regolith using drag lines to pull loose material down from the rille shoulders above. The lightly shaded area below, represents the space, still vacuum, that is now in the lee of the cosmic elements: cosmic rays, solar flares, and the micrometeorite rain that still washes the exposed space above the blanketed arch. The floor of the protected space lays above the rubble of the collapsed ceiling of the old lavatube.

Previous Treatment of the Concept

During the winter of 1988-89, in response to NSS' Space Habitat Design Competition, an eight person team used the idea of spanning a rille valley as the keystone of the Lunar Reclamation Society's second place entry in the category: advanced lunar base for 1,000-5,000 people. We were looking far into the future, as the competition guidelines asked, and designed a pressurized two-tiered arched shelter. We published a serialized report under the title "Ventures of the Rille People" in MMM "s 26, 27, 28, 29, 31`, and 32. [Reedited, reillustrated and republished in MMM Classics #s 3 and 4]

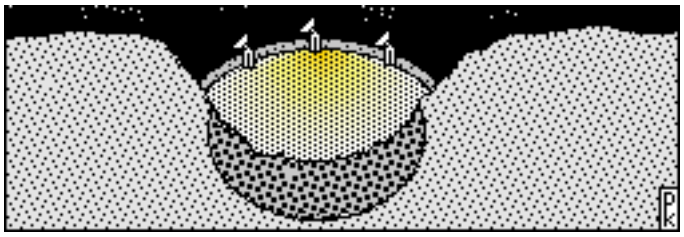
Here we are taking a more modest, near term look at the possible utility of rille valleys and are proposing a simple shielding arch, open at both ends, providing shielding but not pressurization. What we get from this is a spacious calm, lee space anchorage, ideal volume for the erection of a modular base or outpost complex of either hard shell or inflatable shell modules or both, that will not need further protection. Such a protected site, within which construction workers and others need only wear simple unhardened pressure suits, is very attractive.

This idea is similar to the concept of a hanger shed outpost such as we described in MMM # 89)CT '95, p. 3 "Shelter on the Moon" [text only at: http:// www.asi.org/adb/06/09/03/02/089/shelter.html] In comparison, rille valley structures would be both larger and easier to cover with shielding moondust.

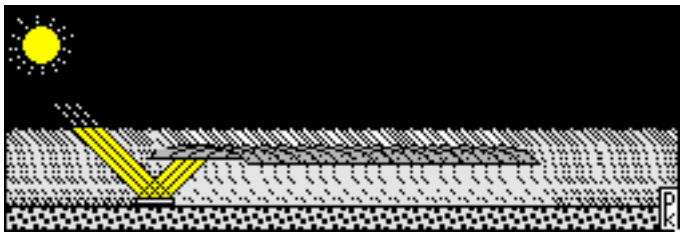
Improving the Lee Space Underneath

While the space underneath such shielding arch-hanger would be environmentally benign in comparison to the exposed lunar surface, without further modification, it would be pitch black even during lunar dayspan. There are a number of ways to channel diffused ambient sunlight to the sheltered space below, making it much more attractive.

Banks of sun-following mirrors on top of the vault shield could channel concentrated sunlight via fiber optic shafts into the space below.



Similar banks on the rille valley floor, fore and aft of the hanger area, could bounce channeled sunlight off the underside of the vault for diffuse ambient lighting. During nightspan, large electric lamps could use the same light delivery systems.



The result would be a benign, construction-friendly, softly lit environment with moderate temperatures. The cost of constructing a vault shield can be balanced against the costs of excavation and unit by unit shielding of alternative surface methods.

That undertaking such an effort implies the establishment of a prior glass composites building materials industry can only be seen as a welcome foundation for an eventually much more diverse lunar industrialization. The time to take such a committing plunge is at the outset. Delay in crossing the industrial threshold only extends the period of vulnerability to program cancellation.

Future Upgrades

The initial vault shield can be extended up and down the rille as the outpost-settlement complex grows underneath. "IF" care is taken to secure cables crisscrossed over the top of the structure to bedrock deep into the rille walls, the ends could be closed and the volume within pressurized.

Sinuous rilles are to be found in mare areas around the Moon, in the same haunts as suspected lavatubes, their surviving sibling features. Why did some tubes collapse? Thin, relatively weak ceilings could easily have been compromised by modest meteorite bombardment. But the rilles' very large size leads this writer to suspect that they may be the ruins of unusually large lavatubes forming from unusually wide and rapid flows of lava, leading to ceilings too thin in proportion to the width spanned. If so, it suggests that most surviving intact tubes will be somewhat smaller in cross-section. For whatever the reason or reasons, these features are there. We might take advantage of some of them, preserving the rest for scenic and geological enjoyment. **<MMM>**

Liquid Airlocks

for Cargo in & out of Lavatube Habitats

By Peter Kokh

In MMM # 17, July 1988, we introduced the concept of liquid airlocks, not for people but for small and export items. The aim is to cut air losses through repeated cycling of conventional airlocks.

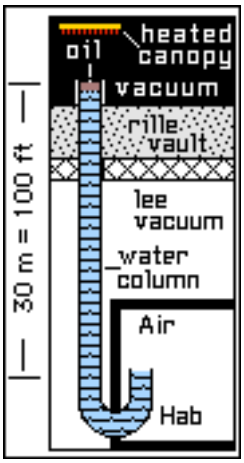
- every effort should be made to preserve the high external vacuum of the Moon - priceless both for science and industry
- even though oxygen can easily be replaced, nitrogen is rare on the Moon

The idea is not hard to explain to anyone who is familiar with a barometer, a common device used to measure fluctuations in air pressure as a clue to coming weather changes. A barometer is a bent glass tube, closed at one end, open to the atmosphere at the other end filled with a set amount of a liquid, commonly mercury. Sea level air pressure supports a column of mercury 76 cm or 29.92 inches high.

If you were to make such a device large enough in cross-section, you could run a conveyor belt through it to carry properly sized items out of the pressurized habitat into the surface vacuum, or vice versa. For some situations, this might be ideal

Mercury is very dense, 13.5 times as heavy as water. This keeps the size of the device compact. For a liquid airlock on the Moon, we would need to import considerable amounts of this liquid metal at great expense. If we use water instead, relatively much easier to source locally, the column needed to keep vacuum out of a sea-level pressurized habitat in one sixth gravity would be significantly higher: over 61 meters or 200 ft. But it is more likely, to minimize both the amount of nitrogen needed and stress on the hull(s), that we would use half that

pressure level. That's still 30 meters, 100 ft of water. This height is impractical for conventional subsurface facilities. It seems just right, however, for use with lavatube facilities and rille vault shielded outposts.



The weight of column of water 30 meters or 100 feet high exerts enough counter-pressure to keep habitat atmosphere at 0.5 Earth normal (42% O_2, 58% N_2) pressure from flowing out the open ended J-shaped tube. A layer of oil, lighter than the water, keeps the water from boiling away into the vacuum while a heated hood keeps the surface warm enough so that neither oil nor water will freeze.

Water has a relatively low boiling point and a high vapor pressure, but both seem tractable. At the surface, a heated hood would greatly reduce the propensity of water to loose temperature to the cold of space, as well as shading the exposed liquids from the heat of the dayspan sun. A layer of oil would minimize sublimation into the vacuum. Goods in transit must be able to tolerate and shed this oil.

Of course, the conveyor belt must not snag, not ever! So the real "invention" here is not the barometric airlock itself to keep habitat air pressure safely inside, but the features that make it work as an avenue for bringing goods from the vacuum above into the atmosphere below and vice versa: the snag-free conveyor system that works well in four media: vacuum, oil, water, and air, and which has to be able to convey a variety of items in some useful range of sizes if it is going to be useful. This "invention" waits to be developed.

Other Liquids? - Gallium & NaK

Could other liquids be used? Gallium, 6 times as dense as water, would allow a much shorter column of liquid to do the trick and make liquid airlocks practical to use in conventional surface habitats that are shielded with just 2-4 meters of regolith. It is and liquid from 30 to 1983 °C (86 to 3600 °F) and that is very attractive. But on the Moon Gallium is a trace element not economically feasible to produce, so the amount needed (plus loss-make-up-surplus) would have to be imported.

NaK (pronounced knack) is a eutectic alloy of sodium (Na) and potassium (K) at 23% and 77% respectively. It is liquid just a little bit above room temperature up to about 800° C, a very serviceable range, and it has a high thermal capacity. Both sodium and potassium are sufficiently abundant on the Moon. in parts per thousand, to make local production eventually feasible. Discounting polar ice reserves, NaK is potentially the most abundant liquid producible from lunar regolith. But it has a density comparable to that of water so there is no advantage if shortening that 30 meter column is the goal. More importantly, it is nasty corrosive stuff.

Conclusions & Spin-up Opportunities

Twelve years ago, when we first broached this novel idea, it seemed impractical. The density of the working liquid right to fit the needs of surface-shielded habitats was offered only by Gallium. Polar ice seemed unlikely, and NaK did not behave well.

But for the elevation difference between the lunar surface and a lavatube or rille-bottom outpost, polar ice water now seems ideal. Are their spin-up applications on Earth that could drive profitable predevelopment of this technology? Perhaps as a clean conveyor system between the outside atmosphere and closed rooms with special, even toxic atmospheres for special industrial use? **<MMM>**

"Skylight Domes" for Lavatube Towns & Vaulted Rilleplexes

Like so many "mushrooms" sprouting from underground fungal mats, floral gardens, arboreta, picnic park areas, and restaurants could grace domes capping elevator shafts from below.

By Peter Kokh, with thanks to Uffe Jon Plug
at uffe@ploug.dk for his suggestion

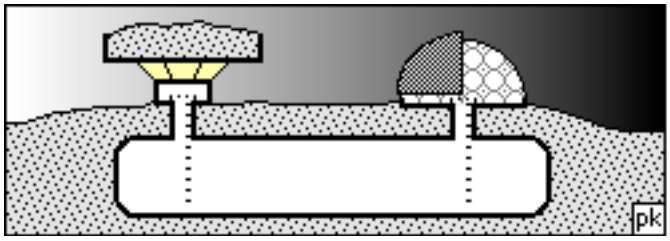
We have talked several times about solar and visual access for Lunan pioneers who must live under a blanket of moondust to enjoy the same protection from the cosmic elements that we Terrans take for granted from our blanket of air. Periscopic windows, fiber optic shafts for sunlight are one thing for habitats immediately (2-4 meters) below the surface. But what about providing solar and visual access for those living much deeper below within lavatubes or under rille-spanning regolith covered vaults?

There will be elevator access for both goods and people as a matter of course. So why not add a few more elevators, at intervals, that open up on the surface within pressurized domes, more generously flooded with sunlight and affording expansive views of the surface. Cosmic ray shielding afforded by such domes would be minimal, so no one could live there, or even habitually frequent such delightful places.

What about operating personnel - gardeners, restaurant waiters, and others? What might work is for each exposed surface facility to be "sistered" with several other places offering similar employment down in the lavatube or under the rille shield. For example a surface restaurant could be part of a chain, the others all being in fully shielded surroundings. Waiters and other personnel would then take turns - for example working one day a week up above, and even that on a volunteer basis. That way, accumulated exposure could be managed. But even then, one would want to limit the years spent in such a pattern.

Even if one visited such surface facilities on the same frequency that city dwellers on Earth may go to the local arboretum or a botanical gardens or to a tower top special occasion restaurant, just having such places to go to would relieve the psychological pressures of living below surface.

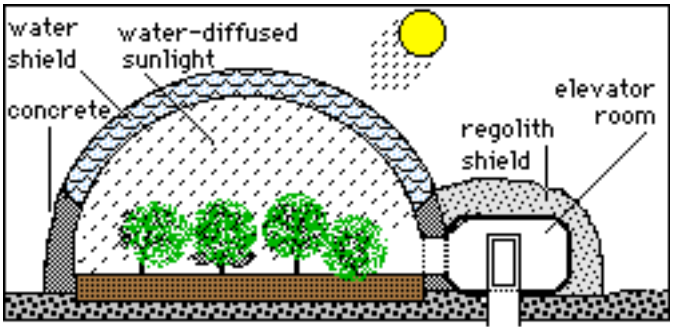
As glass is much stronger under compression than tension, geodesic domes will have convex panes, curved inwards, to help manage the considerable forces of pressurization. If the facility serves mainly as an observation area, it could be built more like an airport control tower than a dome. a row of windows with panes sloping outwards at the top could be covered with a generously shielded roof with wide eaves. This would reduce exposure to cosmic radiation to the few degrees hugging the horizon. A movable shield could protect windows facing the sun when it was near the horizon, as on the day of dawn or the day of sunset or very near to the poles.



On the right, a glass dome, with a rotating half shield facing the Sun. On the left, a top-shielded observation tower, reminiscent of an airport control tower. Exposure to radiation coming from all directions of the sky is minimized by the shielded top cap. The base of the tower could have a pedestrian EVA airlock.

Non-public areas in which personnel spent any appreciable percentage of their time might be fully shielded: the kitchen or the access area to the dumbwaiter if food is prepared and dishes washed below; bathrooms, utility rooms.

The ultimate would be a dome within a dome, with the space between filled with 2 meters of water. The "hydrodome" would provide soft filtered glare-reduced ambient light and considerable radiation protection. The "devil lies in the details" of all the plumbing and water circulation tricks needed to keep the water between freezing and boiling at all times.



Such "escape valve" facilities must complement, not replace, more conventional ways to channel abundant dayspan sunlight, via mirrored shafts or fiber optic cable bundles, into the general habitat areas, to provide warm ambient light, accent-focus light, or both. Access to sunlight should be provided not just on special occasions, but as a matter of course. Yet lush surface dome gardens, picnic spots, and moonscape observation perches can provide more special treats. Lunans, and Martians as well, will have given up very much to earn a chance to pioneer new worlds. Every effort must be made to keep them as comfortable as possible and their lives as full as possible, and to minimize the sense of loss of Earth's incomparable outdoors. **<MMM>**

Meeting Our Way to Failure vs. Let's Just Do It!

"If you had to identify, in one word, the reason why the human race has not achieved, and never will achieve, its full potential, that word would be "meetings."

- anonymous.

[Time out for some upbeat fiction from Dick Steffens!]

An e-mail home from the Moon

Dear kids,

Well, here we are! We're in our room at the Luna City Hotel, after a wonder filled, full day. The rest of the flight was pretty much as I described in my last e-mail, sent from our ship, the Melva Gay. It was thrilling to watch the Earth disappear as we went around the Moon in preparation for landing. We had watched the Earth get smaller each day, and then it was like watching the sun go down!

The landing was smooth as can be. We hardly felt a bump! The flight attendant asked us to remain in our seats until the spacecraft came to a full and complete stop, and the disembarkation tube had been attached. It's funny. I thought it would be an unusual looking contraption, but it's not much different from the ones at the airport, just taller. That's because we tend to bounce when we walk up here, and we need the extra ceiling height! Your father wasn't paying attention at first, and nearly put a dent in the roof! I told him, "Bob, you've got to watch your step. Just because you can, doesn't mean you have to act like a spring chicken." Well, it didn't take too long to get used to it. It was a bit strange at first. I'm glad we took that trampoline class at the gym before the trip. It was good practice for bouncing!

Anyway, we went down the walkway into an area that wasn't very different from the boarding area at the airport. There was a shuttle bus docked at an airlock, just waiting for us. It looked like a big tube with rounded ends, sitting up on enormous tires, only the tires were hollow, just like the ones on the old Apollo Moon rovers. I noticed out the window that there were a couple of flatbed trucks over on the other side of our space ship. They were similar to the shuttle bus, except instead of looking like a tube, they looked like spheres with a flat trailer bed behind them. We could see the drivers operating

small cranes, loading containers from the ship onto their truck beds. I think that's how they get the luggage over to the hotel.

It didn't take any time at all to get on the bus, and then we were rolling over to the entrance portal to the elevator that takes us to Luna City. There was another air lock, and another airport like waiting area. Luna City is built on the floor of a lava tube. Dick, our tour director, explained that the lava tube is a kind of gum drop shaped cave about a half of a mile wide and a quarter of a mile tall, with the roof being about forty feet thick. He said that there were all sorts of benefits to be had by building inside the cave, but I think I'll let your father tell you about that later.

The elevators are made with big windows. They give a marvelous view of Luna City. We could see the city laid out before us, and we could see the sides of the cave, too. What impressed me was the comparison of these lava tube caves to the ones we visited in Hawaii. The shape is similar, but the scale is quite different. As our tour director told us, they'd have to take the antenna off the top, but the Empire State Building would fit inside this cave! Your father just can't wait to go on the behind the scenes tour and see how this place works. I think I might go along, too!

On the bus ride over, Dick, handed out the key cards for our rooms. They work like credit cards at the gift shop, too. He also gave us brochures with a map of the hotel and of Luna City. It looks like it will be pretty easy to find our way around, but having the map is comforting. I wouldn't want to get lost on the Moon, and you know how your father is about asking directions!

The elevator deposited us in a central plaza, and after a short walk through a delightful park, we entered the lobby of the Luna City Hotel. Just like everywhere here, the ceilings are taller, but other than that, it's pretty much like any of the nice hotels we've stayed in. Actually, there is one thing that's a little different. There are more plants here than you'd find in a typical hotel. Something to do with keeping the air clean. They must know what they're doing because the air here is as fresh as at a mountain resort.

Well, we decided to go right to our room and check it out before going exploring. I really like what they've done with the hallways. Remember I told you about plants being everywhere? On the walls of the hallways, they have murals made with plants. It's kind of like the floats in the Rose parade, only instead of being glued on petals, these are live plants, growing on the wall. They give off a nice fragrance, too.

Our room is quite comfortable. It has a huge canopy bed, with wisteria growing on top! How heavenly. There's a balcony with a view of the gardens in the atrium of the hotel. The bathroom is complete with a shower and a spa-tub, although I don't know when we'll find time to relax in that. Your father teased me about it, though. He said, "Jean, now don't you go spending the whole afternoon in a bubble bath. We've got places to go, things to do." He knows I haven't used bubble bath in years, but he does like to tease! That's ok. I just remind him about the yellow duck soap on a rope incident and it quiets him right down.

There are lots of plants in our room, too. One wall is completely covered in English Ivy. I've noticed gardeners working on the rooms right along with the maids! They say it's all for the oxygen. So, I guess that's a good thing.

After seeing our room and dropping our carry-on bags we decided to have a look around the hotel. Just in case we'd need it, I picked up the brochure with the map on it from the credenza where your father had left it. ;-)

We had taken the elevator up to our floor, but we decided to try the stairs on the way down, just so we'd know where to find them. Imagine my surprise when, instead of stairs, we found ramps! As I think about it, I haven't seen a stairway since we got here. Since we are on the fifth floor, there were five flights of ramps to hop down. They have big arrows on the floor, showing us which ramp is for up and which is for down. You get to going pretty fast, and it would be quite a jolt to run into someone, so it just makes sense to have one way ramps.

There's another interesting feature of the ramps; they have banked curves. If you can imagine a typical multi storied stairwell, with the stairs switching back and forth, that's the way these ramps are built. You go half way down to the next floor in one direction, and then switch back to the other direction for the second half. Instead of a flat landing at the half way point, they have banked curves. Your father said it reminded him of the indoor track in the balcony around the basketball court at his high school.

The surface of the ramp is different, too. Do you remember the time we went up to Mt. St. Helens and stopped at the visitor center about half way up, the one run by the highway department and one of the lumber companies? Do you remember the playground that you ran over to before I could stop you? I watched you trip and fall on what looked like hard blacktop, but you jumped right back up as if nothing had ever happened. I remember, when I got over to that playground, how amazed I was to find that this stuff that looked like blacktop from a distance was actually kind of bouncy, like the bottoms of your sneakers. Well, they use a similar stuff for the floors of these ramps. I suppose they are taking pity on us newcomers – they have new folks up here every week, so I guess it's just good planning.

Before we knew it, we were back at the lobby level and headed out into the garden. We could see this garden from our balcony, but it was amazing that even though we knew how big it was from up there, we couldn't tell that from inside it. You can look up a path and see it curve away, and you never see the end. The plants are beautiful. It's a tropical paradise with more varieties than I can begin to name. And birds, too! What lovely songs they sing. There's a little brook that winds through the garden. The path crosses it many times with little bridges. Every so often, there's a short little stub of a path

leading into a little area with either a bench, or a few chairs. The garden was obviously designed for relaxation.

Somewhere near the middle of the garden is a fountain with a dedication plaque attached to it. It explains how Luna City grew out of the dreams of a group of space pioneers calling themselves Artemis Society International, and that the city is the outcome of The Artemis Project. There are bas relief sculptures of several of the founders of the organization and a brief history. And sitting on a pedestal is a computer running an Internet web browser. You can use it to look at anything on the net, but if you leave it unattended, it always returns to http://www.asi.org, the home page of the Artemis Project. They tell us we'll hear more about the Artemis Society and the project on the behind the scenes tour, tomorrow.

We strolled around the garden for a while, every so often encountering some of the other folks we met on the flight out. Then it was time to go to the welcome dinner in the hotel's banquet room. All the folks on the tour were there. After a nice meal, our tour director introduced the hotel staff and then spent about 10 minutes telling us about the things we'd be doing for the rest of the trip.

Tomorrow we have the behind the scenes tour and the rest of the day to explore Luna City. Then the next day we start a six day excursion to visit two of the Apollo landing sites. I was a bit concerned about people trampling all over the historic footprints, but they told me that we will be inside looking at the sites through big windows. That made me feel better. It would be a real shame if someone were to add their footprints to the historic ones. But then, you know me and historic preservation. We can have a photo of ourselves e-mailed from the site with certification encoded in it to prove we were there. I'll tell you more about that when we get to the little hotel they have there. Since it's a good distance away from here, we'll have another bus ride. They showed us pictures of the "motor coach" as they called it. It's a lot bigger looking than any bus I've ever been on. It reminds me of a Pullman car from the railroads, but longer and taller. The one in the picture even had a name on the side, just like the railroad cars do. It was called the Neil Armstrong. I'll let your father describe that to you, after we've seen it first hand.

After the welcome talk from Dick, our tour director, there was a drum roll and fanfare while the hotel staff folded back a wall revealing a dance floor and an orchestra! We spent the rest of the evening dancing in one sixth gravity. What an enchanted evening! We waltzed, we danced to swing era music, we danced to rock music. We lost track of the time! Eventually we could tell that the orchestra was getting a little sleepy, so we thanked them for a wonderful evening and let them go home to bed. Then we realized that we were getting sleepy and came on back to the room.

So, while your father's in the shower, I decided to sit down and write you this e-mail. We'll send you another one tomorrow night. We're having a wonderful time. I know you'll enjoy it when you come, too.

Good night.

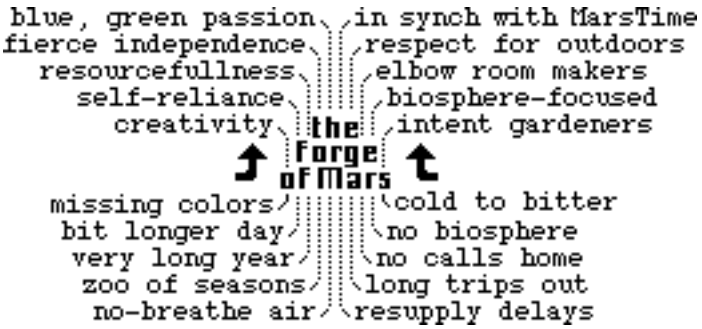
Love, Mom.

Dick Steffens is a member of the Artemis Society, and of the Oregon L5 Society, who is pretested in tourism in outer space. He has been a tour guide and a tour director, and wishes to travel to the Moon as a tour director. His web site is:

http://members.home.net/rsteff/

MMM #133 - MAR 2000 - MARS

Mars will Forge those who Pioneer it



Alien beauty, endless monochrome horizons, thin breathless air, trans-Siberian cold, a tad longer day, doubly long year, irregular seasons, remote from Earth. Mars! Here is a world that will take its pioneers and reshape them to the core. In the end Mars will tolerate only "its own kind of people." Mars will make them "the best." The Seeds and Wellsprings of Martian Culture are our topic this month

In Focus Making Mars More Valuable

Commentary by Peter Kokh

I have seen many a proposal of how to jump start a frontier with land grants and land sales. Maybe I don't understand them. To me, they seem like so many pyramid schemes based on nothing. Yes, Mars (and the Moon) are more than nothing. The ingredients for "stone soup" are all there. But it takes more than the right elements in sufficient quantity to make a land valuable. They have to be present in a form we know how to mine and produce. And on neither the Moon or Mars is that the case. The land has theoretical value only. What can one do with it when the tools to do anything do not exist?

That is our point. In last month's IN FOCUS essay, we outlined how entrepreneurs could make a tidy bundle here and now by developing technologies needed on the space frontier that *also* would have a real market on Earth. Poor Ore Mining Technologies, for one. Not only could one make money selling such technologies to "resource poor" nations on Earth, not only would you end up putting "on the shelf' technologies needed on the frontier, but even more important, *just by doing so,* you would make that land on the Moon or Mars much more valuable. For the R&D being done, the

resources on these worlds will become more than "theoretical" - they will become real. They will become something we know how to work with. Then, only then, is any talk of land grants and land purchases something more than wild-eyed pie-in-the-sky.

To make Mars more valuable, we have to do much more work on its global resource map, on Mars' Economic Geography, using probes with instruments that tell us what we need to know, not just what scratches the intellectual itches of investigators who have no interest in what Mars could be. We need to map the larger enriched deposits of all the major chemical suites, locate potential energy sources like thorium, ferret out near surface lavatube networks, produce a heat flow and retention map that may tell us if there are any tappable deep geothermal pockets, and map permafrost deposits detectable from orbit.

So much for NASA's job. But it won't get done if we leave the priorities up to academia and ivory tower curiosity. A a community, it is not enough for us to vigorously defend the science mission portion of the NASA budget.

We must start getting involved in the choice of missions and in the selection of mission goals and of the appropriate instrumentation. As a backup, we have to beef up legislative efforts to supply "carrots" for entrepreneurial prospecting missions.

In addition to guaranteeing that the prospecting "homework" is done, entrepreneurs must tackle the new technologies needed to economically develop these resources: poor ore mining technologies, glass composite production and fabrication, and other new materials suited to the resources available. Very deep drilling technologies may be needed if we can detect deep, still active geothermal pockets. Permafrost tapping experiments could be tried on Devon island (the Nunavut authorities willing), in Alaska, or elsewhere along with a concerted effort to test the abil ity of various methods of orbital detection of known permafrost fields.

It is time to develop a terrestrial alternate nuclear fuels industry built on conversion of abundant Thorium 232 into fissionable Uranium 233. Earth's thorium reserves exceed the combined total of all other known sources of power.

Both for use on trackless parts of our home planet and on other worlds, entrepreneurs might develop marketable vehicles able to negotiate boulder strewn fields "as if they were paved", and other minimum infrastructure transportation methods.

Metallurgists can develop alloys that serve well enough without the rarer alloying ingredients in strategic short supply. Those working on sabatier reactor research can look for pathways to produce a more versatile stable of synthetic feedstocks.

Experimental agriculturalists can continue development of plants that provide petrochemical-like feedstocks from which to make a whole host of useful synthetics. All these technologies, pursued to make money here and now on Earth, will by their very applicability to the Moon and or Mars, make these raw worlds more valuable.

And of course, if we could get there faster, cheaper, sooner, that would up the value of land on Mars even more. Now, when NASA has begun to look more to commercial partners than to "contractors", truly commercial development of hardware like inflatable habitats, lower cost launch vehicles, and even nuclear rockets start to make sense. NASA has tossed the ball to industry.

Yes, after all this, Mars (and the Moon) will still be "undeveloped real estate." But technologies like these available, the prospects for actual development efforts will be much more realistic. We will have taken the settlement of Mars (and the Moon) from the pages of science fiction and put it into the working projects folder of corporate boardrooms.

It is futile to agitate for the opening of Mars until *we* have made it more *valuable* to open. - **PK.**

Seeds & Wellsprings of Mars Frontier Culture

By Peter Kokh

Forward

The Culture of the Martian Frontier? That's something to be developed, evolved, and decided by the pioneers themselves! Yes, when it comes to language and literature, sports and fashion, laws and government institutions. And as much as some people would like to put constraints on how such culture should develop, lest we repeat any of the many sorry mistakes that have been made here on Earth, those cultural facets are not really within our power to predict or control.

At the same time, while we will be settling a brand new world, we *won't* be doing it with brand new pioneers. The pioneers will be *people from Earth,* people with cultural baggage. That may be neutral in itself, neither bad nor good. Personally, I think that the pioneers will find much worth taking with them in this regard, while in other respects they might choose to begin with a fresh slate.

But this essay is not about what the pioneers may or may not choose to take to Mars. We do not want to talk about those seeds of Martian Culture that may come from Earth. We propose instead to outline the Seeds of Martian Culture that will come from Mars itself. We want to try to trace the outline of the *character* that the Martian settlers will assume, *because Mars will impose it on them.* That character will *filter and transform* whatever cultural seeds the immigrants bring with them from Earth.

The One-Sided Mars Palette

The Given

On July 20th, 1976, two weeks after the 200th anniversary of American Independence, many of us were glued to our TV sets awaiting transmission of the first color pictures from the surface of Mars! At last the first frame came in, one line at a time, and the oohs and ahs were audible as we saw that beautiful blue sky above those beautiful ocher sands! Yes. blue! But it was a teasing mis-calibration. Once the computers corrected to match the color chart on the leg of the Viking I

lander, the blue sky was gone, gone forever, to be replaced with the true salmon.

That Mars' skies might not be blue was an idea that had escaped most writers and visionary painters, including the great Chesley Bonestel who had inspired us all for the past quarter century. Oh well, we were used to being disappointed by Mars.

The planet named after the god of war for its ruddy blood-suggestive coloration, was more consistently "red" than we had hoped. Long gone were once popular visions of canals wide-fringed with green vegetation and farms. Now gone was the blue sky, too. Except for the white polar caps of ice, snow and frost, Mars is one global play of colors bunched up on one small quadrant of the color wheel: salmons, rusts, ochers, tans. The scenery has all of the lifeless geological beauty of the canyonlands of Utah and Arizona - without Utah's and Arizona's blue skies.

Now as much as we may miss those blue skies and as much as we may find ourselves hoping to catch sight of a green forest or prairie on the other side of the horizon, "Mars As Is" has a very real, otherworldly beauty all its own.

However, human eyes are *made to sense* the whole rainbow of colors, most of which are nowhere to be found on Mars. As captivatingly beautiful as Mars is in its own way, we suspect that long term exposure to just these few colors, with no relief, could lead to a state of "sensory deprivation" and low morale.

Now some will say, "Wait a minute! We'll *green* Mars with vegetation, then *blue* it with new lakes and seas and oceans - "terraforming". Wait a minute, my foot. That's "wait a few centuries"! The problem needs to be looked at from the point of view of how we can address it near term.

The Mars Missing Colors Project

We missed the blue and green right away. And while there are other colors not present, true yellow and red, hues that would bracket the Mars-tone palette, it is the blues and greens of Earth that we miss the most. And in fact, if you make a computer inverse, or color-negative of any marsscape photo, what you will see is an image of bright green shades (inverse of the rusts and ochers) and bright blues (inverse of the more golden shades). For those of you who can get online, I have put this illustration at:

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

Blues and Greens will be our primary "antidotes" to sensory deprivation from the unrelieved consistency of the Mars-tone palette with which all of Mars apart from the icecaps is colored - as much rusty land as in all of the continents of Earth put together. There is no escape from the one-sided palette unless we provide it ourselves. Finding ways to "restore the rainbow" and especially the missing blues and greens will "terraform" Mars virtually.

How to do this is the goal of our Mars Missing Colors Project. Outdoors, for safety and visibility, even more than for sensory relief, pressure suits and vehicles bodies will need to have colors that make them stand out from the background. This coloration must be at least partial - prominent stripes or bars.

Inside, part of the solution will be automatic. Green house plants and food garden plants will be needed in abundance both to clean and refresh the air and to provide at least occasional fresh food. By our standards, even in comparison to the homes and apartments of the green thumbs amongst us (count me out - not even artificial plants are safe from me), Martian habitats will be luxuriant with vegetation. That will bring a rich variation of greens, and even other colors. There is pink and purple and yellow foliage, plus, of course, the riot of accent colors from blossoms, flowers, fruit, berries, peppers, etc.

Internal surfaces of habitats build on Earth can also bring relief. Even the off-white walls that are in vogue here will bring welcome contrast and complement to the late, late, late show repeat outside the windows. Fabrics and accessories can be chosen to fill in the rest of the Mars "Missing Colors."

More important in the long run is how the early pioneers can provide color using locally derived materials from the soil, and from garden byproducts. For if we are to settle Mars, we must begin at the earliest possible to produce modular expansion shelter using locally produced building materials. And we must decorate, furnish, and accessorize them, as well as clothe ourselves with locally produced inorganic or organic substances.

Right away we can pretty much cross off the list the very bright vivid colors we have come to take for granted but which are fairly new historically, as they are derived from refined petroleum products (e.g. aniline dyes. The mainstays on Mars in the early period will be metal oxide pigments (stained glass, vitreous ceramic glazes, simple paints) and organic vegetable dyes (fabrics and homemade paper). Just as on the Moon, there will be "periods" of Martian Frontier Arts & Crafts and clothing fashions marked by the variety, or lack of it, of the metal oxides that pioneers have learned to extract from the minerals in the soil and from the dye stuffs they have succeeded in producing from garden and farm plants.

The oxides will produce whites (titanium dioxide, aluminum and calcium oxides) and blacks (ferrous iron oxide, manganese dioxide) fairly easily. There will be less call for rust (ferric iron oxide) of course (camouflage, marsscape paintings). If one wants inorganic greens, there is chromium oxide. Sulfur produces a pale yellow. Cobaltous aluminate gives the prettiest blue one could ever want, but it may be a while before the settlers can produce it. Inorganic reds will be out of the question until the settlements can produce lead or mercury.

Without lead, the ceramic glazes will be soft like those now very much in vogue at arts & crafts shows. The vivid very glossy glazes formerly valued won't be easily produced (and good riddance! - but one shouldn't argue about tastes.)

As for vegetable dyes, we think saffron yellow and indigo (denim) blue will be popular. But natural vegetable dyes are available in many softer shades. Tea, onion, beat - many plants produce usable fabric stains - not all of them stable.

Mars Time

Mars Time - the "slightly longer" day

On the Moon, where the dayspan-nightspan cycle (sol) is 29 and a half standard days long, this can be conveniently ignored. Explorers and pioneers will pace their daily lives by the 24 hour clock of nearby Earth.

Mars day is about 40 minutes longer than our own, and ever since this was discovered, writers have treated this as a very happy coincidence. We've never heard or seen anyone suggest that this slight difference will pose any kind of problem. In fact, explorers and pioneers on Mars may be plagued by a mild jet lag effect that never goes away, ever. For those forty extra minutes will be like traveling west at a rate of two time zones every three days - for the rest of your life. The body, adjusted by evolution to a 24 hour pace, will want to go to bed 40 minutes earlier every night, and get up 40 minutes earlier every morning. This may pose different problems for "morning people" like myself, and for "night people."

Depending on their individual temperaments, some may adjust easily while others may be in some permanent can't-put-your-finger-on-it 'fog'. Nothing can be done about the length of the Martian day. We will just have to see how it plays out.

How do we handle this clock wise? One way is to use slightly slowed down traditional 24:60:60 clocks with all the units 1.00275 as long as standard ones. This would be the easiest solution to adjust to, but poses the problem of confusion with intervals quoted in standard versus Martian units. Will all the science textbooks have to be rewritten? A simple fix would be to give the Martian units new names so that their would be no misunderstanding. As by this system, there would be the familiar 24 time zones around the globe, our own suggestion is "zonal" for 'hour', "moment" for 'minute', and "tic" for 'second'.

To avoid confusion over "day", scientists have been using "sol" (Latin for "Sun") to designate the day-night cycle on Mars. But sol should be reserved for generic use for the day-night cycle on any world. Preemptively assigning it to the specific Martian cycle is a clear example of how shortsighted scientists can sometimes be. A better solution is to find a word specific just to Mars. Edgar Rice Burroughs' fictional Barsoomian word for day, "padan" is ideal.

Another approach to rendering the slightly longer day in clock time, would be to retain the standard second and minute, use digital clocks only, and have the hour change every 61.65 minutes. If we kept the standard hour also, letting the day reset at 24:40 (round numbers), that would mess up the very practical arrangement of time zones (we like our broadcasts on the hour or half hour no matter in which part of the globe they originate.)

Then there are those who would scrap our traditional clock entirely, and come up with some decimal system. It may take a long time for many newcomers on Mars to be comfortable with this. Of course, for native born children, it would be natural.

Yet another problem of the longer day is that it does not, *cannot* keep pace with the days of the week on Earth. We hate to say this, but we predict that their will be some fundamentalist religious leaders who believe Earth days are cosmically significant, and will demand that their followers on Mars follow Earth time, so that the sabbath, be it Friday (Muslims), Saturday (Jews and some Christians), or Sunday (most Christians) will fall when it should. In fact, even on Earth these days are not cosmic. When it is the sabbath on one side of the International date line, it is either the day after or the day before on the other side. Hopefully, common sense will prevail.

In fact, by the time 37 days on Mars have elapsed, Earth will have seen 38 days. As a result, it would be very confusing to continue using the same familiar weekday names. Some Mars calendar makers seize this opportunity to establish weeks of other lengths" 6, 8, 9, 10, 11 day lengths have all been suggested. On Earth, throughout all of history, no part of timekeeping has been more resistant to change than the number of days in the week. In the French Revolution, the establishment of a ten day week met with victorious public resistance. After the Bolshevik Revolution in Russia, communist efforts to establish a five day week, also were doomed.

A major source of resistance to playing with the seven day week is rooted in the pace of religious observance of the sabbath. We think that calendars that would institute weeks of other lengths will be "dead on arrival" but some will be proposed to the Mars Convention, all the same. They will learn.

The best all-around approach is to pick all new names not based on heavenly bodies (Tiw, Woden, Thor, and Fria being Nordic Mars, Mercury, Jupiter, and Venus, respectively). Now you can think of many sets of seven names: the seven largest moons in the solar system for example, or more playfully, the seven dwarfs, or the seven stars of the Pleiades. We have another suggestion: a set of seven very short names, which has a very unique asset - the 7th immediately begs to be followed by the 1st, that is the sequence immediately resets itself in the mind.

We are thinking of something everyone knows by heart: the notes of the diatonic scale: do, re, mi, fa, so[l], la, ti, *do, re, mi,* etc. Now combine this with the obvious anchor point by which days should be determined - noon when the Sun is overhead (we'd still count days from midnight to midnight) and we get these names: donoon, renoon, minoon, fanoon, sonoon, lanoon, tinoon, *donoon* etc.

As to which is the sabbath? Picking different days for the sabbath is much more about distinguishing one religious tradition from obvious infidels than about any cosmic significance. Sorry to say it, but Muslims, Jews, and Christians all need to "get over it" and grow up. Days of the week are not cosmic facts. Everyone can start a new leaf on Mars and all observe the same day. It is in no way a respectable thing to argue about. Making something like this a point of "dogma" just discredits one and all alike.

Mars Time - the much longer year

Mars orbits the Sun in 687 Earth days, or 668.60 "padans". That translates to 22 months. It is a long "year". Most Mars calendar makers do not try to find any way of making the marsyear seem less never ending. Most proposed

Mars calendars have 20, 22, or 24 "months". Zubrin's very innovative calendar has 12 months, a familiar number, but they vary from 46 to 66 days in length to keep pace with Mars' seasons whose lengths vary considerably, three apiece.

Two other calendar efforts that try to address the length of the year's psychological ramifications are Mike Kretch's suggestion to "split the blame" - instead of many more months of familiar length, he suggested 16 months of 42 days length. Our own suggestion is a "split-year" calendar, in which their are two fairly year-like halves each 334 padans long, either 11 or 12 months each. Martians could choose to celebrate "versaries" and "holidays" by the split-year or the full year. But most religious leaders would probably prefer to repeat their religious calendar and its succession of feasts and holy day observances by the 334 padan long half-year.

Even and odd half-years would feel quite different, of course, consisting of different pairs of seasons. They might be distinguished as "even-odd", "out[bound] -in[bound], fore- and aft- "splits". The new Martians would still observe nature's rhythm of the seasons by the long year, of course, reckoning full calendar years as a full once-around-the-Sun. To avoid any confusion with Earth years, the term "marsyear", "annum", or "circuit" might be used.

Mars Time - the diverse season lengths

Another familiar feature that Earth and Mars have in common is a very similar axial tilt: 23.5 ° for Earth, and 24 ° for Mars. Thus Mars has a similar set of seasons: Winter, Spring, Summer, Fall. Of course, with this big difference - they are all cold! Now some Mars calendarsmiths seize on this fact to ignore them. Doing so allows one to come up with a calendar maximized for rationality: 24 months, 4 seven day weeks each - you would need only one calendar page a each month would start on the first day of the week and end on the last. There would have to be *some* adjustment at the end of the year because 668.60 padans is 3.4 days shy of 24x3=96 weeks. Out of every five years, in two years there would have to be one week with only four says, and three years with one week with just three days. How can you call it a week? Okay, a short week - call it a "wek".

But that makes a perfect calendar for a textbook world with 668.6 pairs of sunsets and sunrises. It is nor a perfect calendar for Mars. For in fact the seasons will be just as intrusive, if not more so, in the daily life of Martian pioneers, as our own seasons are in our lives. How so?

To address the first "put down", that Mars' seasons differ only in the degree of coldness, that is so superficial a remark as to be undeserving of any one calling him/herself a Mars enthusiast. Consider that slight differences in the temperature could have very critical effects. On Earth, for example, liquid propane gels at minus 54° F, a very salient fact in the central northern areas of my native Wisconsin. Happily, the thermometer rarely plunges that low. We remember that in last year's rescue attempt of a doctor stationed at the South Pole in Antarctic was dependent on the temperature affecting the hydraulic systems on the rescue plane. On Mars, such seasonal temperature differences will be extremely crucial for outdoor activities.

Further, whenever it is winter in one hemisphere or the other on Mars, about 30% of the carbon dioxide in the atmosphere freezes out over the winter pole. And carbon dioxide makes up 97% of Mars' air!

It is not only seasonal activities which will be affected. The daily pace of life will also differ with the seasons, for just as on Earth, winter daylight hours will be shorter, summer daylight hours longer - in very similar proportions latitude by latitude.

Where the pattern takes an unfamiliar turn is with the length of the seasons. Our seasons on Earth are pretty even in length - 91-92 days each. On Mars we can't just scale this up lengthwise to 167 days each. Whereas Earth's orbit is fairly circular, Mars is much more elliptical. At its furthest from the Sun. Earth is 3.4% further out than at its closest. Mars ranges 20.5% further out at aphelion from its closest approach at perihelion. This has a drastic effect on the length of the seasons, further complicated by the fact that both perihelion and aphelion occur part way into a season:

154 Northern Winter = Southern Summer = **Winsum**
193 Northern Spring = Southern Autumn = **Vertum** *
179 Northern Summer = Southern Winter = **Sumwin**
143 Northern Autumn = Southern Spring = **Tumver** *
[* taking "ver" from "vernal" (Latin vernis = spring)]

Note the proposed hemisphere-neutral words for the seasons. On Earth most of the population lives in the continent-packed northern hemisphere. On Mars we do not know where the bulk of the pioneers will live. That is a pattern that may be tentative and shifting for a long time. These neutral name suggestions, proposed to my fellows on the Mars Calendar discuss-list at <time-sig@lists.marssociety.org> are my own but have been informally adopted by everyone participating, as have hemisphere-neutral names for the solstices and equinoxes (new terms first):

Southern Solstice = N winter / S summer solstice
Northward Equinox = N Spring / S Autumn equinox
Northern Solstice = N summer / S winter solstice
Southward Equinox = N Autumn / S Spring equinox

These terms trace the position and movement of the sun relative to the equator without referring to the consequent seasons, reverse in one hemisphere from the other. This was the suggestion of another writer, not a member of the group, whose identity I do not remember. We just passed the idea on.

Getting back to our subtopic, you will notice that northern winter is much shorter than southern winter (154 vs. 179 padans) and similarly northern summer is much longer than southern summer (same figures). But the reason that some seasons are much shorter is that they occur when Mars is closer to the Sun in its orbit and moving much faster, covering more degrees of orbit in any given amount of time, than it does when furthest from the Sun. Because of this orbital eccentricity, the long southern winter will be much colder than the short northern one, and the short southern summer much warmer than the long northern one. So the climate will tend to be more extreme in middle and high southern latitudes.

These very different season lengths are quite inconvenient for calendar makers to reflect. it is much easier to ignore them when laying out the calendar and be content to

simply note the days on which the solstices and equinoxes occur. Most Mars calendar makers in the group follow this route, as does James Graham, inventor and publisher of the well-illustrated and widely published Mars Millennium Calendar with its totally out-of-the-clear-blue-sky choice of month names without any natural significance for Mars. (Pretty, but "thumbs down").

In the past [MMM # 19, NOV '88], we have suggested a 24x28 calendar but we've been unhappy that it did not pay homage to the pulse of Mars, to the seasons. Then in 1993 Bob Zubrin suggested a novel approach: pinning the months to equal 30° sweeps of Mars' orbit. That results in twelve months, three to a season, with varying lengths to fit the varying orbital speed. The months that resulted varied from 46 to 66 days. You can find the details of Zubrin's calendar along with our friendly amendments online at:

http://members.aol.com/Tanstaaflz/petesmars_calendar.htm

We have since been an ardent supporter of Bob's calendar (*with* our friendly amendments) since, as in our minds it will do a much better job of underpinning the culture of the Martian frontier. It is much "despised" by the "regularists," however, who dislike the wide variation in month lengths.

Since then, however, Richard Weidner has found another way to tie the months to the seasons.

http://cicero.jpl.nasa.gov/~richard/Calendar/index.html

The idea of twelve or twenty four months resonates well with experience (and convenient fractions), but Mars year is actually more like 22 of our months long. What Weidner noticed is that the two longer Martian seasons (Vertum and Sumwin - remember the first part of the word is a clue to the northern hemisphere season, the second part of the word to the southern) are more like 5/22nds of a Mars year, while the two shorter seasons (Tumver and Winsum) are more like 4/22nds of a Mars year. So he proposed a calendar of 22 months, with the seasons being 4, 5, 5, 4 months long (Winsum, Vertum, Sumwin, Tumver). In his calendar, it is still necessary to vary the length of the months from a low of 28 to a high of 32, only one day more difference than in our own calendar. While this is a very creative compromise, the regularists who want months of unvarying lengths, dislike it too.

But that seemed a great effort in the right direction, so we have been playing with the "22-month solution" ever since. Our own "designer goals" have been ambitious: the Mars Pulse calendar should pay close homage to the seasons, be conveniently divisible into same-length half-years or 'splits", and offer some degree of perpetualism - one printed calendar does the trick for all years (on Earth we need fourteen, one starting on each of the seven days of the week, both for regular length years and for leap years). Now it would be handy if both of the shorter seasons (Winsum and Tumver) were the same length, and both of the longer seasons (Vertum and Sumwin) were the same. You could then start the year either with Winsum or Sumwin, have one short and one long season in each "split". But that produces half years of 347 and 322 padans each, not as equal as we'd like, a problem for those who would schedule religious and other observances two cycles per year.

But we've come up with some creative ways to meet all these demanding designer constraints, a way to "fully develop" Mars Time. We'll omit the details here because these issues may bore many. Those that want to take a look at our "Mars Pulse" calendar will find it on the web at:

http://members.aol.com/Tanstaaflz/marspulse_cal2.htm

Of courses, the regularists in the group hate it, calling it "bumpy". We call it curved to fit the double curve of real Mars Time: curved by the eccentricity of Mars orbit and by the way the vector of Mars' axial tilt is askew of the line between the point of perihelion and aphelion. Our calendar is designed to fit the Martian frontier experience and to best underpin Martian frontier culture. Calendar makers need to use mathematics. But they need to remember that calendars are not only ivory tower timekeeping instruments, they are also institutions of cultural infrastructure. That may not suit over-disciplined minds, but, hey!

Outdoor Mars

Mars' Thin Unbreathable Atmosphere

Mars' atmosphere does some attractive things for those interested in making this planet a second human homeworld. If burns up the bulk of incoming meteorites, it diffuses sunlight to produce a bright sky, it helps moderate temperatures that would be more severe without it, it provides a source of invaluable chemical feedstocks, it enables incoming space craft to shed momentum by using aerobrakes and parachutes, and it makes global reach possible by specially designed aircraft. That's quite a lot!

BUT! You can't breath it. Not so much because it is so thin, barely one percent (and seasonally less than that) of Earth normal sea-level air pressure (about the same as at 125,000 feet or 24 miles up) - but because it is made of the wrong mixture of gases, 97% of it breath-suffocating carbon dioxide. Those who dream of terraforming, predict that there are probably much larger quantities of carbon dioxide absorbed in the surface rocks that could be released if we could but raise the planet's temperature a bit. And probably, even if we don't decide to out and out "terraform" the place, we will attempt to increase the air pressure. It would help to moderate the climate, better support aviation, and better shield against radiation (which it does very poorly at present.) It might even be enough to support specially bred or bioengineered Mars-hardy vegetation out in the open - the first National Lichen-Forests!

All of which would also support an increased amount and variety of outdoor surface recreational activities. But you still won't be able to breath it and still need your own oxygen supply. But someday, just maybe, you won't need a pressure suit, only warm clothing and backpacked bottled oxygen with a breather tube held lightly in the mouth. Now that would be something to dream about. Someday. Maybe.

Mars: from cold to cold beyond bitter

One thing that never ceases to perplex me is that so many self-styled Mars-enthusiasts have made life-style choices to live in warmer, not colder, climates here on Earth. Many may be wearing rose-colored glasses. They look at photos of Mars and see Utah or Arizona. Photos do not feel cold.

For the Latest Martian Weather Readings
http://nova.stanford.edu/projects/mgs/late.html

Yet this is not a fair assessment. On Earth, we are used to enjoying the outdoors without outerwear, for at least part of the year. Thus it comes as a rude awakening, year after year, when we start having to wear extra clothing, and pile on the layers. Even worse, for many of us, is the snow. It's great with skis and snowmobiles, but it doesn't mix well with our automobiles. And not too many of us, even avid winter sports advocates, truly enjoy shoveling snow.

Mars, in contrast, is snow free , except at the poles. And as to outerwear, we'll need it all the time, not just to protect from the cold, but heavy duty outer wear - pressure suits - to protect from the near vacuum of Mars' thin atmosphere. Mars suits must be well-insulated - *and heated,* something new.

Not only could a tear or rip in the suit, or a crack in the helmet, soon be fatal, but a failure of the heating system could also lead to the slow onset of hypothermia and eventual death. In pre-terraformed Mars (we do not wish to imply that Mars will, in fact, ever be terraformed - that is another issue, and anther article), explorers and settlers will always be within the warm comfort of their Mars suits when interfacing with Mars Outdoors.

So in fact, except for system failure, Martian pioneers will experience the cold of *their* outdoors *less* than we feel the seasonal cold of our own. On Earth, we feel the penetrating cold most, when, as we frequently do, we misjudge the temperature or the wind and go outdoors with inadequate wrap or wraps with inadequate defense against the wind or driving snow or chilling rain. On Mars pioneers are much less likely to let themselves get into such situations.

Martians will take the cold for granted, and deal with it by "second nature." It won't be something to complain about. They will know how to keep themselves warm. They will know the consequences of failing to do so, or of systems failures.

It is not the "cold" that will be the "issue" so much as always having to wear a pressurized suit and helmet - never being able to feel the air and wind on one's face and breath in its freshness and enjoy the breezes. It is not so much the cold, but the thinness of the air, and its unbreathable mix, that will shape the Martian character.

Of course, as we have said, it will be a practical matter to them when certain fuels and lubricants gel or freeze. But they are likely to rely on those that work under all conditions found on Mars. Fuels and lubricants developed for the Antarctic winter will be of great service here.

But the cold of the Martian Outdoors will also affect the pioneers within their homes. They will have to be super-insulated. As fresh air cannot be brought in from the outside and noxious gasses cannot be exhausted, only solar or electric heating will work. Electric boilers running radiant-flooring systems will prove the most comfortable and not dry the air. But their will have to be stored electric backup within the home as well as backup communal generating capacity. For us, a power outage is "inconvenient", but seldom serious. On Mars, power failure is a condition that can ill be tolerated.

Mars Outdoors - no open water

While Mars is vastly wetter than the Moon, it is still one very arid world. No open surface water at all. Probably an appreciable amount of water lies yet to be detected, and mapped, as permafrost. You'll need your canteen, where ever you go. If you've seen or read "Dune", the classic novel by Frank Herbert, the image of the Fremen is suggestive.

Pioneers will learn to detect surface clues to hidden permafrost. And they may someday engineer pressurized aqueducts from the polar caps - "if the canals don't exist, we'll just have to build them!"

But perhaps the feature of "Red Mars" that could subconsciously affect the pioneers most is that no matter how far they range, they will never come upon a real shore. Land, land, everywhere! Most of us can look at a globe of Earth, even one without names and boundaries, and pick out where we live with the clues of shorelines and rivers. On Mars, especially away from the area of the great volcanoes and Valles Marineris, it will be harder to find those clues. We will miss the oceans for more than their water!

The pioneers will come across some places where the shoreline beeches of the ancient Boreal Ocean are clearly visible. Even if the water and waves are long gone, it will be a vista to whist over, a bottle of local ale in hand. Like the fisherman who clings to the memory of "the one that got away." On a world most of which will be monotonous, even such relics of interest will be precious and worthy of sharing.

No Biosphere Awaits Us

On Earth we take the life-coddling biosphere for granted. On Mars will have to make mini oases for life within pressurized interconnected complexes, deliberately planted to the rafters with vegetation, with scarcely any mishap-buffering margins. We'll have to live, as on the Moon, "immediately downwind and downstream of ourselves". We won't pollute - simply because we can't get away with it, as we still can, up to a point, on Earth.

Learning to grow and maintain these mini-biospheres, one for each outpost and settlement, will have to become common knowledge, second nature, ingrained duty - if the pioneers are to "make it." To the three "r"s will be added a 4th, "R" for recycling: recycling the air and water and waste biomass.

Even surface vehicles will have to be mini-biospheres of sorts, especially if they are in long term continuous use. By their docking directly with the habitats, people will be able to go most anywhere on Mars - from settlement to settlement, anyway - without donning a pressure suit. The biosphere will be virtually continuous in that sense. But make no mistake about it. Each settlement and outpost will really be on its own. That will provide some kind of quarantine protection against the spread of blight and crop failures. As the settlements grow, they will slowly reclaim more and more of hostile Mars. It will be an ongoing uphill battle that will deeply shape the character of all who come to Mars to stay.

The Remoteness of Mars

Beyond Conversational Reach

The Moon is 3 seconds away in round trip radio response time. It was no problem converse with the Apollo astronauts over that distance.

Mars orbits the Sun, not the Earth, and so its distance from Earth changes greatly, and with it the round trip radio response time - from a bit over 6 minutes to as much as 44. Just where "conversational space" ends awaits the results of some simple simulation exercises. [MMM #131 DEC '99, p6. "Colloquipause: end of conversational space"] But clearly, it will not be possible to carry on conversation by radio or any other means between the two planets. Instead, we'll be trading monologues, as we do in regular email (versus IM or ICQ). There will be no "Live, from New York" two-way interviews.

Being "beyond the colloquipause" may instill some sense of isolation. But we'll get used to it. After all, what's 6-44 minutes compared to communications prior to radio, telegraph, and the telephone!

The Long Trip out to Mars

Much more of a problem is the long trip times out to Mars: 6-9 months (depending on orbital alignments) by conventional chemical rockets. If NASA were to get the okay to dust off the NERVA nuclear rocket program and bring such vehicles on line, that could halve those times, reducing exposure to cosmic rays and solar flares while in transit.

Long trip times cooped up in a sardine can will be tolerated by trained crews, but the prospect may discourage would-be settlers. After all, we'll need people resistant to both cabin fever in transit and to agoraphobia on the open scapes of Mars!

Much attention must given to structuring the transit time. Inflatable elbow room would also help. We don't think the prospect of opening Mars "as a frontier" is realistic until trip times can be cut.

The Long Wait Between Launch Windows

The 25 month wait for the next Earth-Mars launch window to open will "separate the men from the boys. the women from the girls." The pioneers on Mars will have to operate sans "umbilical cord." A "Yolk Sac" strategy that stockpiles all likely needed items and replacement parts will be the way to go.

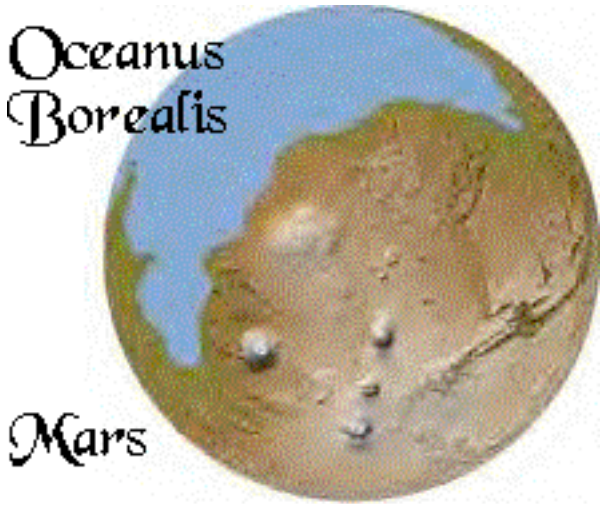
Nothing will serve to select would-be settlers for resourcefulness, independence and self-reliance so much as this single hard fact. There will be no speedy deliveries even in the case of life or death urgencies for the entire settlement!

This "fact of life" will also encourage speedy industrial diversification, cottage industries, and a high demand on local artists and craftsmen. All these results are positive, in our estimation. Mars will make its people "the best." **<MMM>**

In the end Mars will tolerate only "its own kind of people." Mars will make them "the best."

Evidence Found of Ancient Mars Ocean

http://www.brown.edu/Administration/News_Bureau/1999-00/99-060.html



The great Volcanoes and Valles Marineris are clearly visible to the south of the ocean.

Providence, RI, 12/10/99 - James Head, Brown Univ. planetary geologist, is the lead investigator on a team of scientists that has found evidence supporting the presence of an ancient ocean on Mars.

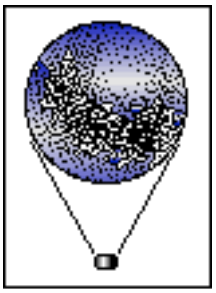
In an article published in Science magazine, Head and five colleagues presented topographical measurements consistent with an ocean that dried up hundreds of millions of years ago. The measurements were taken by the Mars Orbiter Laser Altimeter, MOLA, an instrument aboard Mars Global Surveyor.

To test the hypotheses of oceans on Mars, they used data from MOLA which beamed a pulsing laser to Mars surface. The return beam took less time from mountain peaks and longer from craters. MOLA is the first instrument to provide information to construct a topographic map of the entire surface of the planet.

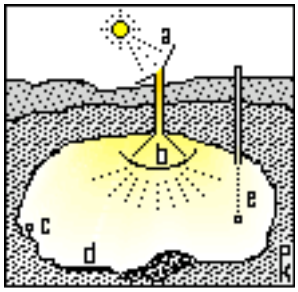
We have long known about channels in which water once flowed into the northern lowlands on the surface of Mars. But did it collect in large standing bodies. This was the first time we had instruments to comprehensively test these ideas. Four types of quantitative evidence point to the ancient ocean:

- The elevation of a particular contact border between two geological units, where one type of surface meets another, is nearly a level surface, which might indicate an ancient shoreline.
- The topography is smoother below this possible ancient shoreline than above it, consistent with smoothing by sedimentation.
- The volume of the area below this possible shoreline is within the range of previous estimates of water on Mars.
- A series of terraces exists parallel to the possible shoreline, consistent with the possibility of receding shorelines. **<BU>**

Planet Prep from Up Above to Down Below



LEFT: Bruce Moomaw describes something new in the air, "phase change balloons" that could be used to explore the surfaces of Venus and Titan, and the atmospheres of Jupiter and the other gas giants. See below



RIGHT: "Developers" can make lava-tubes attractive to potential clients with a row of solar collectors (a) filling interiors with diffused light (b); with line-of-sight communications relays (c); a graded road (d); and a suspended freight elevator (e). See below

In Focus Plenty for us to do while we wait for NASA

When will NASA return to the Moon? When will a manned NASA expedition land on Mars? Perhaps we should ask "when will we lend NASA a hand?"

There is no point getting discouraged when we are not doing our part. There *will be* delays and there *will be* setbacks. Meanwhile, there is much homework for us and others in NSS, ASI, and MS to do. *If NASA were ready* to take humans to the Moon or Mars tomorrow, *WE would not be ready*.

Homework needed for both Moon & Mars

We need to do much more R&D on the kinds of **building materials** we can produce from lunar and Martian regolith without a lot of capital equipment or sophisticated precursor technologies. Concrete, steel and other alloys, glass and glass composites, ceramics, and cast basalt are prospective appropriate technologies. *It is not enough to rest on paper studies and hit and miss laboratory trials*. It is also *up to us* to develop modular architectures that build on the characteristics of these new materials.

We need to do a lot more work on **biospheric systems** (they should be modular, growing as the settlement grows). In this regard, we urge that the Artemis Society and the National Space Society both lend support, talent, and resources to the efforts of the Mars Society Technical Task Force dealing with production of a workable modular system.

As much can be learned of value and applicability to early outpost operations on the Moon as well, we urge both the Artemis Society and the National Space Society to lend talent and resources to the Mars Society's Arctic **Simulation Base**.

Those of us with writing talents need to work harder to get the message across to the public. I urge you all to buy Marianne Dyson's new award-winning book for children, Space Station Science, available from either Amazon.com or B&N.com and donate it to a school library. We need to write for many markets, to hit as many people as possible.

Artists and CAD experts too can make their talents to brainstorming imagineers. **Speakers** can intensify their efforts to make themselves available.

Homework specifically for Mars

We must organize a **push for Mars missions that prospect for resources**, especially one designed to detect permafrost from orbit. We need a much more complete resource and asset map of Mars - **an economic geography of Mars** - as basis for settlement plans. It is up to us to have these missions ready, as Discovery Mission proposals by the time NASA gets back up to steam.

We have to **continue experimenting with what the Sabatier reactor can produce** out of the primary atmospheric gasses of carbon dioxide and nitrogen, and out of water vapor, a trace gas. These will be the feed stocks for synthetic chemicals to complement the inorganic elements and compounds we can derive from Mars' soils as foundations for early diversified industry.

Meanwhile, we need to encourage private industry to get involved. Enterprise can put in place the **Mars communications net** that NASA and other agencies can use to keep in touch with their craft.

We need to brainstorm and test **transportation and communications systems** that will allow a relatively small number of settlers keep in touch and trade over vast distances of a planet (Mars) without preexisting infrastructure. In March, there was a major discussion about setting up a Technical Task Force to examine **Meteorburst Communications** as a back up communications technology for the early frontier on Mars.

No time to rant, rave, or pout!

Yes, Washington has let us all down. Too many cutbacks on experienced personnel; too little money to build in reliability and redundancy; too much of the common clock-punching "who gives a damn" general culture. But NASA's crippling by Congress does not excuse us to do the same. Let's not worry about what NASA has been able to accomplish. Unless we do ours part, it won't matter how well they will or won't have done theirs.

Have faith. It will all sort itself out. But *only if we do our job*. Remember, NASA is not deeply interested in putting a permanent outpost on the Moon or in settling Mars or giving us the tools to do either. The agency wants to explore, and scratch some scientific itches. At best, NASA will give us something to hitchhike on, to piggyback upon - shoulders upon which to stand. ***But we have to be ready.***

We are the ones. ***Our dreams are the greater ones.*** What we are called upon to achieve is even more daring and stupendous than the boldest of NASA missions. So let's not get distracted. Let's dig in with even more fervor. - **PK**

Venus: Balloons & Aerobots

Bruce Moomaw <moomaw@jps.net>writes:

For [continued exploration of Venus], there has been [quite a bit] of work on exploring with what is called **phase-change variable-buoyancy balloons**. Let's suppose we

have a Venus balloon floating along in the clouds filled with two substances: a simple buoyant gas (helium), and a liquid that boils into gas above a certain temperature, increasing the balloon's buoyancy (plain water). As the balloon sinks to the hotter levels of Venus' atmosphere, the water starts evaporating into steam and the balloon goes back up -- and then, when it rises above the equilibrium level, the water condenses and the balloon goes back down. Moreover, since there's a delay between the time a substance absorbs or dumps enough heat to undergo a phase change and the time it actually completes that change, the balloon keeps perpetually oscillating several kilometers above and below the equilibrium altitude rather than settling down at that altitude -- like one of those bobbing mechanical drinking ducks.

What does that get us? Well, suppose that the balloon has a small water tank fastened to its bottom which the condensing water runs into. When the balloon is on the negative-buoyancy part of its cycle and headed down, you just shut a valve on the tank to trap the water -- and the balloon retains its negative buoyancy and keeps going down, all the way down to the surface of Venus. After an hour or so taking pictures and analyzing the surface, when the instrument gondola is starting to heat up dangerously, you open the valve, the water boils back into steam, and the balloon takes off for Venus' cloud layer again, where the gondola can cool off until Earth decides it's time for the next dive. (On the way down, you can open the valve part way to slow the balloon's descent -- or even stop it to hover in the lower atmosphere instead of going all the way to the surface.)

Neat, eh? And by taking into account the speed and direction of Venus' winds (which are 400 kph in the clouds but drop down to only 4 kph at the surface), you can land fairly near a specific location. (This is complicated by the fact that, while you can slow down the balloon's descent by opening the valve, you can't speed it up again -- so you have to deliberately "undershoot" your target and then slow down the balloon's descent by some extra amount later so it gets blown to the point you want.) Nice surface and aerial photos, weather data and surface composition analyses. The balloon would be made of a remarkable plastic film called "polybenzoxasole", several times tougher than steel, and which holds up beautifully to Venus' savage surface temperatures.

In another LPSC paper, Ronald Greeley details a simpler Venus mission called VEVA that he proposed as a candidate for the latest Discovery mission selection. Two balloons just blow along at a fixed altitude in Venus' clouds, with each one dropping four small mutispectral camera-equipped impact probes at appropriate locations. Anyway, both the Venus and the Titan phase-change aerobots are very high on NASA's intermediate-term Solar System wish list (with the giant-planet Montgolfier balloons being lower-priority).

Balloons vs Planes to Explore Titan

Bruce Moomaw <moomaw@jps.net> writes:

Exactly the same technique can be used for a Titan aerobot -- except, of course, that the phase-change material must be something that's still gaseous on Titan's -180 C. surface, but liquifies in its still colder stratosphere. Argon fills the bill perfectly. And this balloon, unlike the Venus one, can sit on Titan's surface indefinitely if we choose. (By the way, the tendency of such a phase-change balloon to oscillate up and down has already been tested on an Earth balloon, using ethylene chloride as the phase-change liquid.)

Ralph Lorenz, in an LPSC Conference paper last March, pointed out that a Titan balloon has one odd problem -- Titan's east-west winds are quite strong but its north-south winds are virtually nonexistent, so the balloon just keeps orbiting round and round Titan at the same latitude and looking at the same terrain. He suggested an airplane instead -- Titan's unique mixture of an atmosphere 1.6 times as dense as Earth's and a surface gravity actually slightly less than the Moon's (Titan's icy interior has a low density) means that a plane can stay aloft either with very small stubby wings or (better) with a very low-powered engine. But since one of a Titan aerial explorer's main goals is to keep landing and analyzing the surface organics, a dirigible with N-S pointing engines might be better.

Balloons over Jupiter

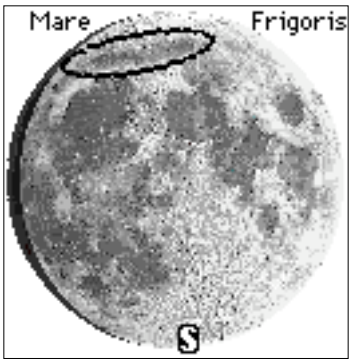
The problem of heating the hydrogen to keep a balloon aloft in the atmospheres of Jupiter and the other giant planets has been solved by using passive heating. You paint the upper half of the balloon black to absorb sunlight and thus heat the balloon's skin; and since all these planets emit a large excess of IR energy from their interiors, you also make the bottom half of the balloon IR-transparent and line the inside of the upper half with an IR-reflective coating so that the planet's IR radiation heats the balloon's gas directly. The technique is very weight-effective for all the giant planets but Neptune (too far from the Sun, but it works somewhat even there) **<BM>**

Cf. MMM #60 NOV '92 pp. 3-6 "Aerostat Xities "afloat" in the atmospheres of Venus, Jupiter, Saturn, Titan, Uranus and Neptune."

Site Selection for Flexibility or Expansion

by Larry Friesen

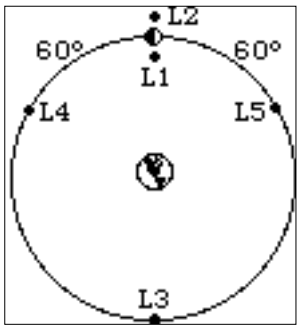
I applaud the approach in MMM #131 [pp 3-5, "Where to Set Up Shop?: Moonbase Site Selection Considerations"] about selecting the location for the first lunar base or settlement to maximize flexibility and to maximize opportunities for future expansion. At the very least, we should not make choices along the way (for short term advantage, perhaps) that make later expansion or building more settle-ments *more* difficult.



One of the areas to which I have given a great deal of thought, as a location for a lunar base/settlement, is one mentioned in that article: **the Mare Frigoris region.** Not that the "Sea of Cold" is the best place to start, but it is

one I've thought a lot about. I don't know whether this is a case of "great minds running in the same channels" or simple coinci-dence.

Flexibility, by the way, is one of the reasons I have advocated, and continue to advocate, that if we use a near-Moon staging base to support a lunar settlement, it would be better to locate it at the L1 Lagrange point of the Earth-Moon system than in low lunar orbit. That allows staging to any point on the lunar surface for nearly the same delta-V, and at any time. So an L1 station could support additional settlements or bases, not just the first one. It also maximizes the leverage of lunar propellants, by minimizing the need for terrestrial rocket fuels. If a lunar lander is designed and sized to use lunar-derived propellants to and from an orbital station, getting to L1 means you are almost at lunar escape, not just in low lunar orbit. Or to turn it around, terrestrial propellants do not have to be used on the way up from Earth to brake from lunar escape velocity to lunar orbital velocity.



<LF>

[The L1 Lagrange point is centered about 40,000 miles inward from the Moon. It is a semi-stable location that requires some station keeping fuel. Lunar-derived propellant combinations would then be used on both legs between the L1 station and either low lunar orbit or any place on the lunar surface. This arrangement will contribute to and hasten the achievement of lunar settlement economic break-even. - **Ed.**]

Ramps and Other Accommodations

for disabled individuals as architectural features of lunar/planetary settlements

["Universal Design"]

by Larry Friesen

I would like to comment on an article in MMM in which the author was advocating making lunar communities accessible to disabled individuals. Unfortunately, I am not able to identify the MMM issue nor the author. [Nor, for the moment, am I. -ED.]

One of the recommended features was the use of ramps as contrasted with stairways to get between levels of the community or a structure within the community.

If the author had in mind to include ramps *in addition to* stairways or ladders, I am in favor. I would like a lunar community to be accessible to as wide a variety of people as feasible. But if the author of that article meant that ramps should be used *in place of* stairs - that is, stairs and ladders would be forbidden - then I must disagree. There are going to be some situations where stairways or loaders will simple make more architectural sense. For one thing, there are many situations where stairs and ladders are more space efficient than ramps, and at least in the early days, I suspect that internal, pressurized space will be constrained.

I also take issue with another of the author's [points. The author appeared not only to want ramps to be required in public spaces - what you might term the 'Middoors" [my term - Ed.] but in the interior design of private homes as well. The author seemed to want to take very much a "one size fits all" to dwelling interior design. Now I am an individual who wants to live in a society which permits me a great deal of personal liberty. In particular, I want the right to customize the interior of my private home in whatever way and to whatever degree I like, so long as I don't put at risk the community's air, water, or power supplies, or create some other sort of hazard to the community. I suspect a lot of other people will want that right as well. And if I decide I want to put in a stairway to get from the first to the second floor in my home (if it is a multilevel dwelling), I don't feel I should be bound by *someone else's* limitations. If I choose to put in a ramp for the convenience of guests who ride in wheelchairs, that's my choice. But I don't feel anyone has the right to compel me to do so. And I am not likely to settle in a community that doesn't allow me that choice. I suspect that a community that too severely limits the choices people are allowed to make about their own private dwellings is not likely to attract many settlers. You may expect to read more about my aversion to coercion in the next settlement. **<LF>**

Editor's Note: Unless the editor is a victim of unsuspected early altzheimers, *MMM has never run such an article*. But there *was* an article about the principles of "Universal Design" in the first issue of Artemis Magazine. While I have a copy of this magazine, I have not yet read the article. In general, proponents of universal design find that many conveniences designed for the disabled are also easier for non-disabled persons to use. Now that would have to be an item by item assessment. Back to the point, there is no connection between MMM and Artemis Magazine, except that both editors are members of ASI.

We *have* commented that one NASA supported study recommended "bounding platforms" instead of stairs. But that is something quite different from "ramps." The idea behind bounding platforms is that in low lunar gravity, one could easily "bound" three feet at a time. We do object to that because while this may be so for those who still have their "earth legs" it may not be so for those whose musculature has become accustomed to lunar "sixthweight".

We *have* commented on ceiling height. Given that native born children may grow measurably taller, we have wondered if it would not be wise to build with 3 meter (10 ft.) ceilings. In general, it is in one's own economic self-interest to build with reasonable resale marketability in mind.

To my recollection, we have never written about the needs of the disabled although I am very sensitive to them. If I had written the article in question, then I would be a hypocrite because I do not have a wheelchair ramp to my own front door.

PK]

Political Independence for Lunar or Planetary Settlements:

by Larry Friesen

In much of the discussion about political arrangements for lunar, planetary, or asteroid communities in MMM, and in a lot of other literature of space-interest groups as well, it almost seems that many writers assume that political independence of the Moon (or Mars, or a settled asteroid) is both inevitable and desirable. Not that any writers expect that to happen immediately, but most writers seem to expect it to happen eventually.

I would like to put forward the idea that political independence is *not* inevitable. It *may* happen. But I'd like to get out of people's minds the idea that it necessarily *must* happen. Neither would it necessarily be preferable to political membership in or alliance with a larger entity (federation, coalition, or what have you).

I believe that what you described in MMM as "home rule". with the residents making decisions about *local* matters internal to their settlements *is* inevitable, or nearly so. While *communication* between Earth and the Moon or Mars or elsewhere in the solar system can be at the speed of light, the realities of travel time to the Moon or planets are likely to make trying to run local settlement affairs by "remote control" from Earth impractical.

I submit, however, that no one can predict how the political status of extraterrestrial settlements will evolve beyond the "home rule" stage. In particular, no one can predict whether the Moon or Mars or any other extraterrestrial body will become a fully independent nation-state ... or whether their inhabitants will even desire it. If and when that happens, it will happen in response to specific circumstances and events in a future history that has yet to unfold.

One thing that has influenced my recent thinking on this topic is a book I've been reading about the American Revolution by John R. Alden. The book was written in 1969, but I don't think his ideas are at all out of date. Mr. Alden points out that at the end of the French and Indian War,no one on either side of the Atlantic was expecting that only a dozen years later, an American war for independence would be starting. In 1763, Americans were pleased and proud to be British subjects. it was only after a long series of British policies and actions that the American colonists perceived as provocations, that a substantial number of Americans felt pushed to make a separation.

As one example of such a provocation: Most American history courses and textbooks note that the British claimed that many of the taxes they were attempting to levy in America were to support British troops stationed in North America, supposedly for the colonists' protection. Stated this way, the British argument sounds reasonable. What was *not* mentioned in the American history course I took in high school, but John Alden does mention, is that more British troops were stationed in North America on a permanent basis *after* the French and Indian War than *before*. This fact made many Americans suspicious of the reasons given by the British government for stationing the troops. They asked themselves: against whom are we needing so much protection? The French menace was gone; Britain now controlled Canada. The threat of Indian attack was no greater than before; it was probably less, since the French were no longer provoking tribes that had been allied with them to hostility. So why do the British need more troops than before the war, when there was a real threat? The Americans further asked themselves: With no more threat from the French, is the real reason for all those troops to begin establishing a tyrannical regime?

Whether or not that suspicion of British intentions was correct, it is an example of the suspicions and provocations that accumulated slowly, piece by piece, one by one over time. Although twelve or thirteen years is short on a historical scale, it was *not* a sudden process for those who lived it, and for many of the individuals who ultimately advocated independence, the choice was an agonizing one.

At this point it may be useful to distinguish between two kinds of freedom: one is personal liberty; the other is political independence. Personal liberty means being allowed to live your own life, to make your own choices about most things, to choose your friends, your occupation, your religion, and so forth; to speak or write your opinions freely; to live under a government and court system which protects your rights. Political independence means having your own nation, without being subject to some other [outside] power. The Americans in their War of Independence were choosing the tool of political indepen-dence to achieve the *goal* of personal liberty.

The two don't always go together. most Americans in the 1760's and early 1770's would have been perfectly happy if the British government had changed its course and respected their "rights as Englishmen". Mr. Alden points out that had the British government made a few fairly minor changes in policy at certain points, or had different groups of politicians succeeded in taking power in parliament at certain times which would have resulted in policy changes), the Americans might well have been satisfied, and a separation from Britain might never have taken place.

On the other hand, most of us can cite numerous examples in the 20th century where many nations in Africa or Southeast Asia achieved political independence but became rather nasty dictatorships. People living in many of those nations, especially if they were not allied with the ruling political party, found themselves with many few civil liberties than they had enjoyed under the colonial powers that hat formerly ruled those nations.

I propose that the kind of freedom that should always be our goal is personal liberty. Sometimes, in some situations in history, that goal is best served by political independence, as it was for Americans in 1776. At other times, in other historical situations, that goal may be better served by political *union*. For example, once Americans achieved independence from Great Britain, they concluded they could better keep their new-won freedom by facing the world as a federal union, than as thirteen separate nations.

In the same way, whether the personal liberties of people living on the Moon or Mars or anywhere else will be better served by political independence or by political union with other powers will depend on circumstances. Circum-

stances which cannot now be predicted, and circumstances which may change over time. <LF>

An Ardent Rebuttal

by Peter Kokh

When a child grows up, it is very often some specific concrete circumstance or event that triggers the decision to leave home. But in most cases, *if* it is not one thing, it *will* be another. If it is not now, it will be later. Independence is part of growing up. At first there may be some rebellion involved, some trying to distance oneself from home, parents, roots -- some trying to establish one's own sense of identity. This accomplished, in most cases, there is a happy rapprochement between offspring and parents, and a new appreciation on both sides for the other. And lo and behold, dependence is succeeded by mutual cooperation or interdependence.

We should hardly expect it to be otherwise with communities. Mr. Friesen makes the distinction between individual liberties and independence. This is not quite complete. Because *communities have individual liberties as well.* A settlement, every bit as much as an individual person, will value, in Friesen's own words, "being allowed to live your own life, to make your own choices about most things, to choose your friends (nations to collaborate with and trade with), your occupation (read industries and economic diversification plans). An Earth nation can *never* have the interests of an off-world dependency at the top of its list of concerns.

Domestic matters will always take precedent to the detriment of full support of settlement growth and industrial diversification and other needs. By withholding support for an expansion initiative sought by the settlement, the parent nation maintains a stranglehold upon it. This may not be deliberate, of course. It is simply a matter of other priorities. A settlement should then be free to seek support elsewhere. How can it do this if there is no "personal communal liberty" to make such approaches?

In the end, what happens will depend on the growth both in population and economic diversification and self-manufacturing of the off-world settlements. If there are never more than a few hundred people on the Moon or Mars, the question becomes moot. There will be too much economic dependence for political independence to be a viable venture.

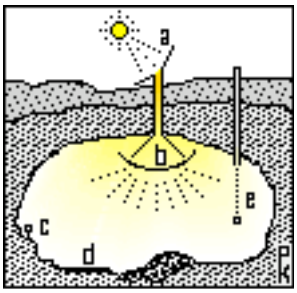
To lump the Moon, a 3 day trip from Earth virtually anytime, and Mars, a trip of many months possible only every two years, in the same basket when discussing possibilities and eventualities seems naive. It is possible to "do the Moon" at the end of an umbilical "cord". It is not possible to "do Mars" in that fashion. Independence or not, the Moon's effective collaboration and interdependence with Earth will always be much greater.

But I would agree, that settlements will have a much greater chance at economic viability and hence at effective equality with Earth, the more they work on their own interdependence. *United they will stand, divided they will fall.* If they let fears of "one worldism" stop them from collaborating, they will not have a chance. Neither in the end, will we on Earth. Independence, is, in last analysis a fiction. We are all interdependent and best glory in it. <PK>

Lava Tubes: the "Developers Role"

by Peter Kokh

In MMM #131, DEC, 1999, pp. 10-12, we considered the "Developer's Role" in "improving" a potential Moonbase-settlement site to make it more attractive and marketable to would-be entrepreneurs. In this issue, we want to take up the topic again with specific application to lava tube sites, something the first article touched on briefly.



"Another joint venture would be to provide improved access (graded ramps and elevators) to any buildable lavatubes in the area. Shafts drilled through the lavatube ceiling/roof filled with fiber optic cables, with sun collector on top and light defuser within the lavatube, would be an immensely attractive improvement, as would be a lavatube floor topographic map. No enterprise will buy space within a lavatube, no matter how many theoretical advantages it offers, without solid concrete information, and prepared access and minimal lighting."

Here we want to expand upon these points. In MMM #100 NOV '96, page 6, we wrote about remote mapping methods, with radar "flashbulb" impacting probes to detect subsurface voids and side-looking orbiting infrared detectors to spot exposed lavatube entrances. In the next article, pp. 6-7, we wrote about on site robotic exploration and surveying techniques.

A surface crawling drilling rig, using high resolution orbital radar lavatube location data, finds its initial drill point over an indicated tube site. Given the repetitive nature of the tasks involved, a highly automated remote monitored operation will be ideal. It would:

(1) *drill and stabilize* (a sleeve? side-wall fusing lasers?) a hole through the surface, penetrating the lavatube ceiling some tens of meters down. The *hol*e might be only *a few inches in diameter*.

(2) winch down through the shaft a radar-mapping instrument and/or CCD optical camera down to a height midway between lavatube ceiling and floor (determining that position is task one). A flare is released. The radar mapper and camera pan 360°, and from near vertical up (zenith) to near vertical down (nadir). The instrument pod is retrieved. A latitude/longitude/altitude benchmark is then lowered to the tube floor directly below.

(3) winch down to the same point a length of fiber optic cable, securing the top end to the collar of the shaft hole below a solar concentrator passively gathering available dayspan sunshine, channeling it into the optic fiber cable. At the bottom end a diffuser scatters this light, so future explorers can find their way with *night-vision goggles*.

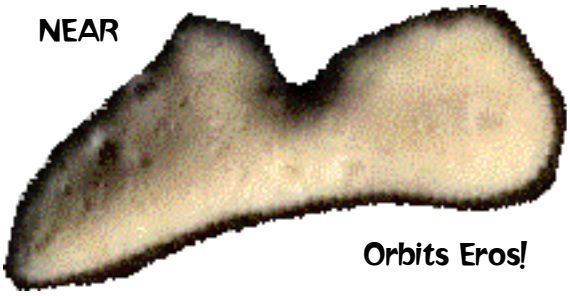
The drilling rig would then move on to the next position along the lavatube, guided by the data from the previous drill as to direction and distance to provide a continuous

overlapping mapping. Now both the internal topography maps produced and the minimal light shafts produced in this effort can be considered an improvement. This would enable future manned science expeditions but only tease would be users. What can be done to really "improve" the site?

- enlarge and multiply the number of light shafts to provide significant "naked eye" lighting
- feasibility and cost analysis of various ways to provide a high albedo "sky" within the lavatube for maximum eye relief and ambient lighting, e.g. with direct coatings or suspended grids.
- providing a graded vehicle-worthy ramp down an entrance talus slope, if there is one.
- providing a surface supported elevator shaft through the tube ceiling/roof, the cage lowerable to the floor by cable winches (no guide structure within the tube). The cage should be of freight capacity able to lower vehicles and modules.
- topographical maps of the floor with suggested grading using minimal (5-10%), moderate (15-30%) and major (above 40%) shifting of existing floor debris, and making use of "benches" and other features that may or may not be present. This would include recommended floor "road" corridors in each case. It would also locate recommended locations in each case for placement of modules and structures of various sizes.
- an engineering test of the ceiling at intervals to find its capacity to support suspended weight
- a minimal line of sight communications relay system, built into the "benchmarks" mentioned above using antenna when the benchmark is in a low spot, or into the light diffuser system.

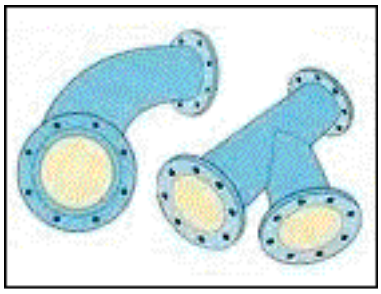
Some of these "improvements" would entail non-trivial investment in the site, especially the freight elevator. A developer might be able to market the site on the basis of the less expensive of the suggested improvements in the site, along with a contractual commitment to provide the rest upon receipt of good faith money/down payment by the proposed customer. These further improvements might include minimal floor grading to provide a continuous travel corridor through-out the length of the tube, further grading up to the user.

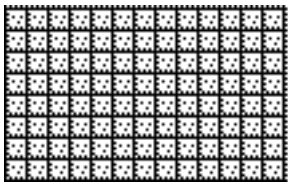
Lavatubes offer immense volumes safe from surface temperature extremes, sheltered from radiation and other hazards of cosmic weather, and relatively dust free. That said, they are raw assets that require basic "improvements" to be useful.



Cast Basalt: Startup Industry With Two Great Tricks

There is a growing, newly reinvented cast basalt industry in Germany, Spain, Britain, and the United States that is producing two types of products that will be very useful in the early lunar settlements: abrasion-resistant pipes & material handling (think regolith-handling) equipment





as well as countertops, and decorative wear-resistant floor and wall tiles [RIGHT]. These talents make a cast basalt industry a top priority. For more, see below.

An Industry Perfect for a Startup Lunar Outpost

by Peter Kokh

Perhaps a decade ago, I read a one-liner in an encyclopedia about a "cast-basalt industry in central Europe." Immediately the need of early Lunan settlements to hit the ground running with appropriate-technology industries came to mind.

Basalt! There is plenty of it on the Moon. The great flat lava flow sheets that fill the maria basins are essentially basalt. The regolith surface of these "Seas" is but meteorite-impact-pulverized basalt.

There is plenty of basalt on Mars as well. The whole Tharsis Uplift area (Arsia Mons, Ascraeus Mons, and Pavonis Mons) is basaltic, as is Olympus Mons. And there are other lava sheet and shield volcano areas on Mars rich in basalt.

The idea of just melting the stuff with a solar concentrator furnace and then pouring it into molds to make useful products seemed a no-brainer. Even if cast basalt had (an assumption) low performance characteristics, there would be plenty of things needing to be made in the Moon settlements for which high performance would not be an issue. Table tops, planters, paving slabs came to mind.

But for years, I could find nothing more than that teasing one liner. Five years ago, I asked friends in the basalt-rich Pacific Northwest if they knew of any such industry in their area. This did not turn up any new leads. That was then. Today we have the Internet, and I finally returned to the issue and did a simple web search. Voilà!

There is a thriving cast basalt industry here on Earth, and like most "materials" industries these days, it is vigorously reinventing itself. "And the envelope, please!"

Cast Basalt's Abrasion Resistance

Casting basalt in itself is not something new. People began to experiment with it in the 18th century. Industrial manufacturing with this material began in the 1920s when Cast Basalt began to be used as an Abrasion-resistant, Chemical-resistant lining. The material is crushed, and heated until it becomes molten at 1250°C [2280°F], then cast in molds (e.g. tiles), or centrifuged into pipe shapes. The cast items are then heat treated so that the material crystallizes to take on extreme hardness (720 on the Vickers scale where mild steel is 110; 8-9 on the Mohs scale where diamond is 10). The density is 2.9 g/cm^3.

Two companies in Europe produce abrasion-resistant items for use in material handling (think of handling abrasive regolith moondust on the Moon!): pipes, pipe fittings, cyclones, conveyor parts -- the list of applications is quite long. Both companies ship worldwide.

• Kalenborn Kalprotect, Vettelschoss, Germany
http://www.bulk-online.com/YD/Data/Co/09254.htm

This company's trade name for its cast basalt product is ABRESIST "one of the most tried-and-true materials for wear protection. It is high sliding, has a low coef-ficient of friction, good impact resistance, and very good chemical-resistance. More than 1 million of meters of pipe have been lined by Kalenborn with fused cast basalt." Kalenborn also makes specially resistant products out of other materials such as fused cast carborundum (a form of Alumina, Al_2O_3) and high alumina ceramics, both of which can also be derived from the lunar regolith.

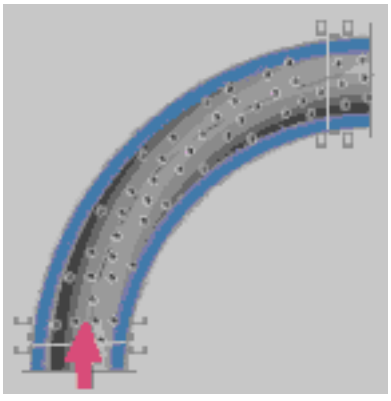
• Antidesgast, S.A. Barcelona, Spain
http://www.antidesgast.com/english/castbasalt.htm

This company makes a similar line of products under the trade name of Basramite, "the world standard for ash slurry pipe-work at fossil fuel power stations. An all round cost effective, adaptable lining material, extending the life of equipment subject to erosion."

Abrasion-Resistant Materials on the Moon

One of the strongest misgivings frequently expressed about the feasibility of industrial operations on the Moon is the very abrasive and "hard to handle" nature of regolith or moondust. Cast basalt as a material up to the job of handling moving rego-lith in industrial and construction operations seems a "lunar" solution made in heaven.

Are there any qualifications? The chemical analysis of the basalt used by Kalenborn includes the expected aluminum, silicon, iron, and titanium oxides, but a higher than typical percentage (on the Moon) of manganese, sodium, & potassium oxides. These elements *are* found on the Moon, however, in parts per thousand, not in parts per hundred.



What we need is a lab test of the performance characteristics of a similarly melted, cast, and annealed small Apollo sample of real lunar mare basalt regolith. This research would make a great *thesis* for a student majoring in inorganic materials.

An early lunar cast basalt industry produ-cing abrasion-resistent pipes, troughs, and other parts of sundry regolith-handling equipment would seem to take priority over everything else. We have to handle regolith to produce oxygen, to produce iron and steel, to produce aluminum, to produce ceramics, to produce glass. Regolith-handling equipment will be necessary to emplace shielding, to excavate, to build roads. It will be needed to handle regolith being heated to harvest its gas load of hydrogen, helium, nitrogen. Yes, we could use imported items for this purpose. Yes, we could use non-resistant items and keep replacing them as they break down and wear out. But that does not seem to be "logical."

If we are to diversify lunar industry in a logical progression, cast basalt seems the place to start, with an *in situ* demonstration as task # one.

Cast Basalt Flooring Tiles

Two companies, one in Britain, one in the U.S., use cast basalt to make "durable but decorative" flooring tiles in a variety of shapes.

• Greenbank Terotech Ltd., Derby, UK
http://www.greenbanktl.demon.co.uk/

•Decorative Cast Basalt Sales, Inc. Webster Springs, WV
http://www.decorativebasalt.com/

Greenbank Terotech and DCBS import Czech basalt to produce "Volceram [volcanic ceramic] Flooring Tiles" of "natural beauty and practicality." Cast Basalt is now being used extensively by archi-tects and designers for use both as a industrial floor covering in heavy industry and as decorative flooring in commercial, home and retail settings. The skillful 16-21 hr annealing process brings out all the natural beauty that gives the basalt tiles a unique appeal and a natural shine without added glazing.

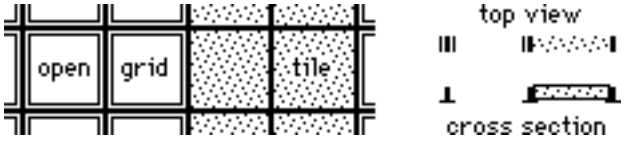
For commercial and industrial use, their hardness ("four times harder than rock, one of the hardest ceramic materials known") and impervious-ness to acid and chemical attack make the 25 mm (1") thick tiles very attractive. They "take a beating", retain their appearance, require little maintenance.

This nonporous "industrial strength" tile is nearly nearly indestructible, and chemical-resistant. Yet in the annealing process they acquires a natural beauty that rivals more common ceramic tiles that have to be glazed. This makes them equally perfect for kitchens, bathrooms, halls, patios, etc. Tiles are produced in standard squares, florentine, charlotte, hex and other shapes, and in several sizes to allow a great diversity of floor and patio patterns.

Role of Tiles in Lunar Settlements

Modular habitat structures, will have to have circular vertical cross-sections to distribute the stresses of pressurization equitably, whether their overall shape be that of a sphere, cylinder, or torus. This means a flat floor will have to be constructed over a bottom cavity. this dead space could be used for storage, water reservoirs, utilities, and utility runs, etc. -- an efficiently compacted "basement".

An open-spaced flanged-grid subfloor, of some no rust alloy or of glass composite, could rest on metal, concrete, or glass composite joists. The thick cast basalt tiles could then be set into the grid without mortar, as illustrateed below.

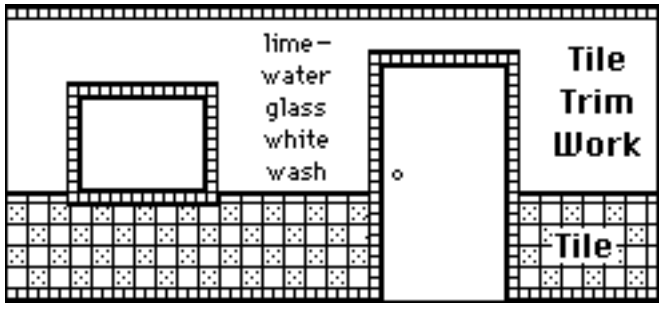


Larger cast basalt tiles could be used for floors of factories, commercial enterprises, schools, etc. And why not also outside, set upon a graded and compacted bed of sieved regolith, to serve as a sort of porch or deck at EVA airlocks, both personalizing such entrances and helping curb import of dust into the interior. One can think of many uses!

Cast Basalt Tiles for Walls and More

The floor tile possibilities and applications seem endless. But cast basalt tiles could be used for more than flooring. Without wood for the customary "woodwork", plain, textured, and/or decorative tiles could be used, in the role of jamb, casing, baseboard, ceiling cove moldings, even wainscoting. In MMM #76, June, 1994, we suggested the use of "ceramic" tiles for these applications:

> In the illustration below, ceramic tiles are used to provide trim borders. While the seemingly endless variety in color, pattern, and glazing now available on Earth could not easily be produced on the Moon, a variety of hues from the lunar palette (regolith grays, oxide colors, stained glass colors) should be available either unglazed or in soft satin glazes. Tile in contrasting sizes, and coor-dinated colors and patterns, would make a good companion wall finish, as would simple white-wash or waterglass-based paint.



Cast basalt then seems to be the right material with which to kick-start diversified lunar industries. On the Moon, where the regolith particles are quite sharply angular because they've never been subject to water- or wind-weathering, we will need a family of abrasion-resistant regolith handling items before we launch our lunar concrete, ceramics, metal alloy, our glass, and glass composite industries. Cast Basalt looms as a cornerstone of lunar industrializaion.

Once we have advanced to the processing and manufacturing of these other building materials, we will be able to start providing habitat expansion space from made-on-the Moon materials. Then once again, cast basalt, this time molded into durable and decorative tiles, will help in furnishing the interior spaces of these new "elbow room" modules. Cast basalt will be a cornerstone lunar industry. **<MMM>**

Currency for Lunar Settlements

[This discussion would apply to Mars as well.]

Edited by Peter Kokh

Artemis-List Discussion begun by Gregory Bennett in response to a question from George P. Masologites:

"Once the Moon base is set up, will there be a separate currency?"

Greg Bennett (3/26)

Dollars would probably work fine as the basis for the lunar economy, especially for trade between Luna and Earth, but I can think of a few reasons to have a separate currency for the internal lunar economy: fun, stabilizing the currency, and the effects of scrip.

1. It would be fun to invent a new currency.

Hey, we have a whole 'nother planet to play with. If we do the fun stuff, then the serious stuff will follow. Designing new currencies and figuring out how they'll work sounds like lots of fun to me. We might make some goofs, but as long as we have a way to recover without too much pain, we'll be fine.

Can we do better than the government agencies that control the currencies of Earth? Probably not; but if we don't even try, we'll never know.

2. People on the Moon might want to control their money supply locally.

Separate currency that floats with the dollar protects the lunar economy from swings in the dollar.

We've had some tremendous swings in the value of the dollar within my lifetime -- periods of stability and periods when Washington expanded the money supply so rapidly that we had inflation rates as high as 20%.

An infant economy driven by unknown factors will probably need to respond to rapidly changing economic conditions that do not parallel the U.S. economy. If the U.S. entered another period of currency devaluation during the early stages of lunar development, it could mean economic disaster for a lunar community that's operating close to its limits.

Some folks might want to tie the currency to a specific commodity. Until recently, the U.S. dollar was tied to the supply of gold and silver. (I grew up with real silver coins, and the value of the dollar was fixed at 1/35th of an ounce of gold.) Once the U.S. currency was debased (in 1971), it took a couple of decades for us to learn how to control this new kind of money, and the transition hurt.

Today, it seems that the value of the dollar is indirectly based on stabilizing the U.S. average city consumer price index (because that's the thing the Fed is most worried about keeping stable), which in turn is indirectly based on our gross national product.

A commodity-based currency worked well for many generations on Earth, but I don't know what the loonies would base their currency on.

Commodities that are precious in the early days of lunar development (almost everything) will become increa-

singly more commonplace as people develop the industrial infrastructure of the Moon.

Imagine a situation where that lunabuck in your pocket is tied to, say, the price of carbon. That's not a bad start; carbon is apparently quite scarce on the lunar surface.

For a few years, life is good. People earn good incomes; they can buy the stuff they want and still put back a bit for retirement. Then one day while he's out looking for a better grade of iron ore, Miner Joe hits a huge deposit of carbon-bearing compounds from a carbonaceous chondritic asteroid that got buried on the Moon a billion years ago. Suddenly, the value of carbon drops like a paralyzed falcon, in relation to other stuff people are trading on the Moon, and everybody holding lunabucks is broke.

3. Separate currencies could grow up from **scrip**.

[**scrip** n. **3.** Finance. **b.** a certificate to be exchanged for goods, as at a company store. **c.** a certificate indicating the right of the holder to receive payment later in the form of cash, goods, or land. (Random House Dictionary). For another definition
go to http://www.investorwords.com]

One way to finance some of the lunar development is to pay people in scrip. A scrip note is essentially a promissory note (an I.O.U.) that people exchange among themselves as currency, but it does not have any legal status. Several companies might do this, resulting in several different types of currencies being exchanged on the Moon.

Whether you accept scrip as payment depends on your confidence that the agency issuing the scrip will eventually be able to make good on the note. Or maybe you'd accept it because you know someone else will accept it from you in exchange for goods and services. [Some barter clubs operate on this basis: http://www.bbnetwork.com/members/index.html]

You might have experienced this yourself. Video arcades often have amusements that pay off in tickets or tokens, and a store that accepts only those tokens in payment for goods. [Scrip is also used for fundraisers

http://www.glscrip.com/

Scrip was a popular solution during the development of the American West, where companies had to pay their workers even when shipments of government currency lagged behind the development of the local economy.

The U.S. government uses it today for military field operations, to control the distribution of U.S. dollars and the impact that our soldiers have on the local economy.

For articles on *past* military use go to:

http://members.xoom.com/maturner/main4.htm

Food stamps are another example -- making it illegal to trade food stamps as money hasn't stopped people from doing it.

Remember Green Stamps and Top Value Stamps that they used to hand out at gas stations and grocery stores, and that you could exchange for goods through the stamp company's catalog? Scrip. Coupons and proof-of-purchase seals? Scrip.

(There are aesthetic reasons for accepting scrip. You might want it as a souvenir -- I still have some Renaissance Dollars from the Texas Renaissance Festival a few years back. Or you might want to make a philanthropic donation, not really caring whether you ever get your money back. But let's stick with basic economics at the moment.)

Perhaps the Bank of Luna City will accept deposits in scrip. You might have a bank statement that reports how many units of scrip you have deposited as well as how many dollars and euros and yen and whatevers.. If that happens, it's currency for all practical matters.

No battle plan ever survived contact with the enemy

I expect that there will be many cities on the Moon not too many years after the landing of the first exploration base. Each city might have its own local currency, or currencies, and people just might invent some new way of representing value earned. It really doesn't matter as long as it works.

That doesn't mean we shouldn't plan something and put it in operation -- solid foundations will get things started -- but we shouldn't worry too much if folks come up with better ideas once they've learned what things are really like on the Moon.

 Vik Oliver (3/26)

I'd recommend basing our currency on the kilowatt-hour. Even if we develop full-blown nanotechnology, power is going to be a key requirement. It's difficult to hoard, and universally defined.

 Dale Gray (3/26)

As a frontier historian, I heartily endorse the Kw/H monetary unit. Every frontier I ever studied has, during its original phases, a power shortage. Indeed, some say that the way new wealth is created on physical frontiers is by the application of energy to in situ resources. By connecting the currency directly to the creation of new wealth, you have set your economy on a solid foundation.

However, as civilization evolves out of the frontier, power systems will become a focus of human endeavor (think in terms of owning your own mint) much like gold dust in western America formed the basis of many mining town economies.

Once a strike was made, there was always a tendency to worry that all the available gold dust would be create dramatic drops in the price of gold. Similarly, a power-based economy must watch out for excess production of power devaluating the currency. The solution, of course, is to plug into the greater economy. During the western gold mining eras, gold dust was exported to eastern coffers so it was removed from local economies as fast as it was produced -- thus stabilizing the local price.

If there is a lunar economy based on energy, then those in charge of the system will eventually work up methods of exporting the excess power (doesn't have to be directly, can be used in value added production such as the aluminum plants of the Pacific Northwest utilizing the cheap hydropower.

In Idaho, the Trade Dollar mining company placed a dam across the Snake River in 1898. Excess power was sold to other mining concerns and to Silver City residents. Later when the mine closed, the company began to sell its power to local

farming communities. It is still active today as the Idaho Power Company. Montana Power has similar origins.

The first "Killer App(lication)" of the Moon will not last forever, but if the developers are wise, the infrastructure built for the first boom will pave the way for subsequent booms and the advent of civilization.

But to reiterate, frontiers typically suffer power shortages. Anything that promotes the development of local power supplies is a very good thing for the longevity of the system.

Eric Lowell (3/26)

Just putting in my two loonies...

I recommend that base our lunar money on one of three currencies: U.S. dollar, Euro, or Yen. Until the Moon has an economy the size of at least a respectable Developing World Country, who in their right mind would want to do business in a non-backed and untried currency? If the currency is backed by gold or silver or carbon, where would we keep the stores? The Moon? How do our debtors collect? Do we pay for transfer or do they? Same questions apply if we keep the stores on Earth, but then the additional question of why we would want to tie up our scarce capital in backing an unnecessary currency arises. (At least on the Moon we can mine the gold (or whatever) [Not gold! It is only present in unconcentrated parts per billion - Ed.] rather than having to buy it.)

Also, if the currency is thinly traded (which our "loonie" definitely would be for the foreseeable future), then the transaction costs of converting from any other currency to the Moon's currency would be excessive, thus raising the cost for others of doing business on the Moon. What we need to do is lower the cost of doing business on the Moon, therefore the dollar, the most easily traded currency, the most sense.

Also, if the majority of the companies that we do business with use the dollar, then currency fluctuations simply do not matter.

Greg Bennett (3/26)

(in response to Eric Lowell)

Yup. I was thinking in terms of what the lunar economy might be like after considerable industrial infrastructure had developed there. For the first few decades, I expect Luna will trade with Earth based on the dollar and probably use sundry kinds of scrip for local exchange.

For a currency backed by some hard commodity (gold or carbon), to be accepted on Earth, some clever folks will need to figure out how to document the concept of someone down here owning something up there. A pound of carbon on the Moon is worth a heck of a lot more than a pound of carbon on Earth. The same is true of all commodities; it's just that in our case the transportation costs are extreme.

Jeff Harr (3/26)

I would base the currency on helium-3. Even transporting a few pounds back to Earth (somehow) would pay off incredibly, and the only good place you can get the stuff is on the Moon or one of the gas giants. Personally, I think the gas giants are our key to the entire solar system, but until then the Moon will do, at least for helium-3 production. For those of you who don't know, helium-3 is supposed to be great for fusion reactors because it doesn't throw off any neutrons during fusion.

Dale Amon (3/27)

Modern currencies have almost no connection to one particular commodity. Many pine for the Gold standard and its' stability, but the return of single or even dual commodity standards is unlikely in this electronic age.

Money is a set of bits in world computers. The number of bits are set via money supply targets at central banks like the US Fed and are based on the underlying needs of the economy as a whole. In a sense modern semi-electronic money is based on a mix of all goods and services in an economy.

The same would be true of a lunar currency. We might want the physical representation to be something cultural unique, unifying and of course exportable and collectable, but the real money is the supply set by the Central Bank(s) of Luna. I use plural because there is no harm at all in having multiple competing currencies. It keeps everyone honest.

It seems highly likely to me that there will be some sort of lunar currency from very early days, even if it is just some sort of signed chit. e-Money will serve many purposes, people who are on short term contract will have money deposited in Earth currencies for their return... but that doesn't solve the problem of small private transactions. I don't think we are going to pay to transport bags of change and wads of bills to the Moon.

More likely is some form of local scrip, perhaps signed by Greg or some other senior member of TLRC [The Lunar Resources Company]. This is fairly common in military and industrial towns.

David New (3/27)

Before we speculate, I hope no one has any ideas about banning any non-legally specified currency. We should let the people decide what they want to use for currency. Sure they'll make mistakes but it is better to let them use what they value. Therefore I don't think the Moon should have an "official" currency, just the one(s) they value. With that said I have some ideas of my own.

As far as trade goes, the euro, dollar and yen would be your best shot but they unfortunately are not backed by anything and are subject to swings in the market. It would be a great entrepreneurial opportunity for a bank to exploit a free market in currency, and with the amount of backing asi needs, the Moon needs to be business friendly. I have been playing with some ideas of thin-client type electronic currency connected to a bank so maybe you guys have some ideas about that.

As far as backing I don't think commodities subject to major swings like carbon and helium-3, due to lack of knowledge about lunar minerals, would be that smart. Perhaps the "Loony" could be backed up by a sort of index of many commodities that are stable enough but worth enough to back up a good portion of the currency market. This index would ensure relative stability. Perhaps these Loonies (catchy ain't it?) would be the standard measurement of a piece of the commodities in the index and each bank would be able to reap the rewards of the free market by issuing currency at one Loony and they would be compatible with that of another

bank's.

The reason I like the idea of electronic currency is that unlike a bill or coin it would not rip or erode and all the exchange could be done at the bank site.

Paul Blaise (3/27)

I rather imagine that there will be no physical currency, merely notations in computer records. In an economy as computerized as the lunar one will be, not to mention as mass-sensitive, physical currency is not necessary. However, of course, that will not stop people from being able to set gems, precious metals, etc. aside as a safety mechanism. It's just that the currency won't be geared to them.

I imagine that basing the currency on, or simply using, the dollar will be the simplest mechanism. Throughout Europe, Asia, and South America - if the local currency isn't geared to the dollar directly, dollars are as acceptable, if not more so. It's rapidly becoming the universal currency anyways.

Vik Oliver (3/27) (reply to Paul Blaise)

The US Treasury is investigating ways of preventing external countries from using US dollars as their own currency.

Eric Lowell (3/27) (reply to Vik Oliver)

For a complete report on the benefits and disadvantages of dollarization, here is a link to a U.S. Congressional Subcommittee report on dollarization

http://www.senate.gov/~jec/bankingdollar.htm

Current Secretary of the Treasury, Lawrence Summers, testified before Congress last year and stated his general support for dollarization of other countries. In summary...

"If a country or countries decide to adopt the dollar, the United States can expect to benefit in a number of ways:

1. Most obvious, but perhaps least consequential over the long-term, by acquiring dollars for use in their domestic economies, dollarizing countries would be extending an interest- free loan to the United States. (Although the added revenues accruing as a result of any one country adopting the dollar would be extremely modest relative to the revenues earned globally already.)

2. Of potentially greater importance would be the increase in economic links that might be associated with the creation of a broader dollar area. The fact of sharing the same currency would reduce the cost of doing business with the dollarizing country and also reduce uncertainty about future exchange rate changes. There might be greater capacity for capital and trade flows in both directions as a result."

Secretary Summers did say, however, that the U.S. should limit its involvement in the internal running of another country's financial systems.

"Specifically, it would not, in our judgment, be appropriate for United States authorities to extend the net of bank supervision, to provide access to the Federal Reserve discount window, or to adjust bank supervisory responsibilities or the procedures or orientation of U.S. monetary policy in light of another country deciding to adopt the dollar."

Furthermore, Chairman Greenspan has testified that the possibility of people in dollarized countries blaming the United States for their problems should not much concern the U.S. He does not envision any particular problem with dollarization creating additional pressure on the Federal Reserve to adjust monetary policy to suit other countries' needs.

Peter Kokh (3/30)

It seems to me clear that until the lunar economy is very well established and diversified and until there is a fair sized population (at least some tens of thousands if not more), no meaningful independent "hard" currency could be established. On the other hand, use of dollars or any other hard currency may work for trade, but it will hardly work as the grease that lubricates the domestic lunar economy which should, per all examples, account for fully 90% of all economic activity on the Moon.

The reason for this is that, transportation costs being what they are, *even with dramatically reduced launch costs,* there will be no relationship at all between the local lunar "price" of a loaf of bread, and the price for a similar item anywhere on Earth. We have had such disparities before, for example prices in Alaska vs. the "lower Forty Eight" but the Earth Moon price ratio will be orders of magnitude higher. Scrip is clearly the way to go, evolving into a "soft" currency.

Now there are some possibilities. Pay on the Moon could be negotiated as X% in dollars (or some other hard currency) and Y% in lunar scrip. The purpose of splitting pay, or not splitting it, would be to encourage a desirable effect on Lunan customer import habits. The reason for a monetary policy that discouraged imports (e.g. most pay in lunar scrip) would be a no-tarrif non-protectionist way of encouraging local industry and enterprise to better meet pent up Lunan consumer demands.

At the same time, the Lunan Frontier government or "Authority" would do well to establish some criterion for valuation of its scrip currency, refrain from "printing money", and thus devaluating it, causing the often social dislocations of inflation as not all sectors of the Lunan population keep pace equally well. A market basket of commodities is one idea. (See the discussions above.) Vik Oliver's idea of basing it on the value of the kilowatt hour on the Moon bears consideration. I had previously favored pegging the currency to a scarce commodity like hydrogen, carbon, or nitrogen (actually, nitrogen is the scarcest of the three in relation to how much we will need just for plain "air".)

As to a name, scratch "loonies" or "crescents" -- Heinlein unwittingly gave us the ideal word, in his acronym for "there ain't no such thing as a free lunch" -- "**tanstaafl**". And I'll bet you a bushel of tanstaafls no one comes up with a better name!

As to the physical form, bills, coins, marbles, etc., that needs some brainstorming. The idea of an all electronic currency strikes me as idiotic. Not every entrepreneur is going to have a scanner! Doubt it? Let me throw some words at you: kid's lemonade stand, errand boy, neighborhood hooker. Get real, the Internet will NOT replace everything else! **<MMM>**

1st Moon Tours - the Farside "Loop"

by Peter Kokh

Then NASA Assistant Administrator, J. R. Thompson encouraged many of us at the 1988 ISDC in Denver nearly twelve years ago, when he told us about a dream close to his heart. All we have to do, he said, is to refuel the Space Shuttle in orbit, and it will have the capacity to head off for the Moon, loop it, and return to Earth orbit. Whether we'd have to bring an External Tank along for this effort, he didn't elaborate. But he did want to have the Shuttle make the flight with its payload bay doors wide open, and with a "conestoga-shaped" inflatable gym in the payload bay.

It never happened, perhaps because he could not infect the rest of the Agency or the government with the boldness of his vision. But the essential fact remains true. As Heinlein put it, "Once you are in Earth orbit, you're halfway to anywhere."

Hopefully, within the next five years, the first paying tourists will make it to orbit. Half a dozen enterprises are vying to be the first carrier. If the cost of going to orbit can be brought down to the same order of magnitude as round-the-world cruises, then we will have reached the price-level where a steady sustainable market will justify scheduled service.

And once we have the ships that can bring these jet-setters (and lottery winners!) to orbit, all we need to do is refuel them and provision them with a week's worth of consumables and then we can send the off (those who pay extra, of course) on a "loop-the-Moon: tour. No, they would not land, but they would swoop down fairly close over the crater-pocked surface, less than a hundred miles or so, for the other-wordly sight and experience of a lifetime.

Yes, get us to orbit, and looping the Moon is but a simple next step -- not something a decade or more further down the road! *Landing* on the Moon, however, either with enough fuel to take off again, or with enough equipment and provisions to stay, is quit e another matter. But given that breakthrough price, *you* (yes, *you*) could find yourself looking out that porthole on the Farside of the Moon *before the next human sets foot on the surface*. If the cost of a ticket to low Earth orbit comes down to a hundred grand, the price of a ticket round the Moon might be no more than a quarter million dollars. Not a few of u s would take a quick inventory of what assets we could liquefy, mortgage, or leverage for such a trip.

Even if the cost stays an order of a magnitude higher than that, there may still be lucky tourists who loop the Moon before the first outpost is established. Consider how many now pay big bucks add undergo considerable privation to go on "extreme" vacations to "untrodden" places. The market is there, and it is waiting. Markets create reality.

The Ship

We must now backtrack a bit. All that about "just refueling and having enough food, water and oxygen is true. But we'll be gone six or seven days and that means sleeping quarters and other space-using amenities we didn't need for a quick trip up from Earth to LEO. But we could do it with the same kind of craft, outfitted for fewer "overnight" guests than the cramped "coach" class shuttle to orbit.

To maximize the number of tourists that can go, we have to reduce the size of the crew. We have experience doing that on Windjammer cruises, for example. The passengers are pretrained to do the chores, and the permanent crew need be no more than two, qualified to replace one another. Those who want to go first class and just relax will end up paying the more dearly for the privilege. But that is as it should be.

We can double our capacity if we adopt two shifts, yes, hot-bunking, so to speak. Again, those who do not want to share berth space will pay more. Two shifts will also allow the same sardine-can "common" spaces to serve more people with seemingly greater elbow room. The eating area could double as a gaming area. A smaller common space could serve as a quiet room library and conversational audiovisual lounge. Breaking space up is important in cramped quarters so people can "get away from one another" if needed. None of this is necessary for a quick trip to orbit, but for a week long trip, there is no other way.

The Trip

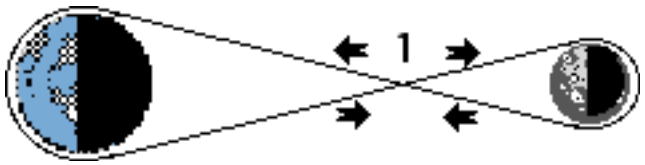
If we follow the Apollo itinerary, the trip out will take just three days, ditto the trip back, with the fast, low skim over Farside taking scarcely an hour. It would be nice if we had a ship that could separate into two tether-bound parts, then spin up to provide lunar-like one sixth (Earth normal) gravity. This would certainly add to the experience. But it would also create complications upon nearing the Moon, as we don't want to be spinning when we are trying to take in those stupendous crater-scapes. Yet this is an option that will come someday, as our cruise ships become ever larger and more elaborate.

The trip -- in both directions -- would be even more complete as a "lunar" experience if some of the spartan furnishings could be designed to simulate the sort of decor that early settlers might be able to produce for themselves from local raw materials. Food choices could also add to the "on the Moon" illusion, featuring grains, vegetables, fruit, herbs, and spices more likely to be part of an early frontier "harvest diet." [We did this at one ISDC '98 luncheon and it went over well!]

On the way out, passengers could learn about lunar geology, preparing themselves to recognize and understand the features they will see up close: craters of various types and sizes, the lava sheet seas of the maria, ridges, rille valleys, mountains. They could study the receding Earth and the approaching Moon through telescopes or with the naked eye.

Four basic itineraries are available:

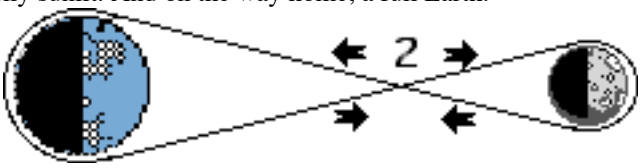
1. "Full Moon" loop: the Nearside is full, good for viewing on the way out and on the way back. But then the Farside, over which we would swoop more closely, would be in total darkness -- *total!* -- save for starlight. That doesn't mean there is nothing to see, as we'll learn just below. On the way home, the Sun would be behind the dark Earth with little to see there as well.



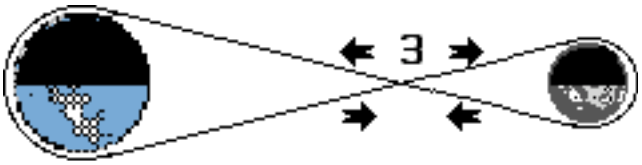
[These sketches are *not* to scale. In reality, the Moon is 30

"Earth diameters" distant from Earth (not 7, as shown) and Earth is proportionally larger than the Moon than shown.]

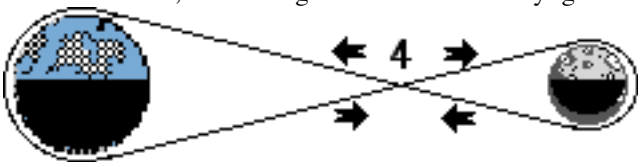
2. "New Moon" loop: the Nearside is dark except for the faint glow from Eartthshine (actually much brighter than Moonshine) so we will see some dim and eerie Nearside moonscapes on the way there and back, especially close to the Moon. But the Farside over which we loop up close and personal, will be fully sunlit. And on the way home, a full Earth.



3. "First Half Moon" loop: the eastern half of Nearside is sunlit. As we approach to the west, the lit area will become more and more a crescent, then disappear as we go behind the Moon in darkness to behold something stupendous. Unable to see the Farside surface below, and with no Earthlight to distract us, we will feast on the darkest skies ever seen by man -- and that will mean that the Milky Way will present itself with brightness, fine detail, and myriads of stars beyond all experience and comprehension. Halfway around the Farside, we will pass the terminator into the sunlight to feast on the rugged terrain below. A Half Earth would beacon u s home, but we will enter orbit on the dark side.



4. "Last Half Moon" loop: similar to the First Half loop but in the reverse order. We see the west half of the Nearside sunlit as we approach, then the first half of Farside in the sunlight also. Most memorable will be our pass over the great bullseye of the Moon -- Mare Orientalis. Half way around the Farside, we will cross the terminator into darkness and adjust our vision to behold the splendor and glory of the Milky Way without any distraction. We'll come around the limb to see the Earth rise over the dark moonscapes below, now feebly lit by Earthshine. As Mare Anguis, now redubbed Angus Bay, comes within range, will we see a flashing beacon that might have been placed there as a promise to all of our return? A Half Earth will welcome us home, and we'll go into orbit on the daylight side.



It's our guess that once we get live reports from our first tourists to make the loop, the Half Moon loops will be the most popular. Surely, they offer the greatest variety of experiences. If our prediction is on the money, the Full Moon and New Moon loop prices could be adjusted downward, and the Half Moon tour prices upwards, to reflect the weakness/ strength of market demand.

Looping the Moon

"Everyone up and at a window!" Hopefully the ship will have extra "ceiling" windows that can be "unshuttered" during the circumlunar phase of the trip. After all, wide windows would come in handy in low Earth orbit as well for looking at Earth.

One possible electronic enhancement for the up front coast around Farside would be goggles with a heads up display. They would automatically "follow" the focus of your eyes and "superimpose" the name of the crater, mountain peak, rille, or mare area that you were looking at. Use of such a device would help maintain silence by saving questions. Silence is essential lest the spell of this magic hour be broken. The craft's automated cameras will document the entire passage, not only for a precious "take home record" but allow answers to questions.

The Farside Club

As we fly around the Moon's limb, an anxious moment will be the LOS, loss of signal with Earth as we pass beyond line-of-sight. Unless there are relays in the Earth-Moon L4 and L5 Lagrange areas, some 60 ° ahead and behind the Moon in its orbit around Earth respectively. This would allow communications with Earth in all but the central Farside 60 ° wide section.

As we pass out of communication, we'll be on our own now, alone with an "Earthless Universe" -- and our Moon. Our tourists will join that exclusive "club" for those who have been on the "radio darkside" of the Moon, and for those who've seen the full glory of the Milky Way as it can never be enjoyed form Earth even in places most remote from city lights. Talk about "bragging rights!" A trio of toasts would be appropriate: "To the Moon!" "to the Universe!" "To Earth!"

The U.S. or U.N. Postal Service will have prepared a special "Farside of the Moon" cancellation and postmark for those who want to send letters or postcards, possibly with Farside photos they have taken, to loved ones at home. If we have put a simple relay in the L4 and/or L5 Lagrange point(s), tourists might even send "email" from "behind the Moon."

If the Moon happens to be at "apogee" at the moment, at the furthest point of its elliptical orbit about Earth, 248,000 miles (398,581 km) out, the tour company might arrange a higher loop of the Moon to a point 2,500 miles above Farside, so that all aboard could be the first humans to travel a full quarter million miles out from Earth. But this would be a very temporary record!

Could one pay extra for an EVA experience? To float free above Farside would be awesome, and a record, plus the first ever out of contact with Earth!

On the way Home

On the way home, there could be lectures on the economics of opening the lunar frontier, on settlement possibilities, on Farside radio astronomy and S.E.T.I. observatories, etc. Viewing Earth from afar would provide indelible memories,. On reaching Earth orbit, all would get a souvenir trip log and ship manifest. It's fun to speculate.

Idle musing? It may soon be quite real. For most of us, the chances of actually becoming a pioneer in the opening of the Moon to human occupation are very slim. But, the chances of such an up front preview trip in the fairly near future are much higher. If at least one seat is reserved for a lottery winner, that will greatly spur public interest.

To the Moon! (even if your name is not Alice!) ###

Springs Eternal

I heard the flute
The winds over the infinite sands
Of an empty soul
Its shutters askew
Shingles missing
Front door open to every violence
I looked upon Mars
And saw a fixer-upper
© 2000 by Richard Richardson

Frequently Audible Recurrent Uranus Signals

(Uranus Is Blowing Off Gas)

Uranus is blowing off gas
Was the report as the spaceship went past
No wonder they sped by so fast
Like bandits escaping with loot

In trying to get to the root
Of the cause of Uranus's toot
Many theories turned out to be moot
While others illumined the heart

So getting a pretty good start
Figuring out the hard part
And beginning to feel smug and smart
They decided that it was unique

That state went on for a week
Dissenters were more and more meek
And agreers clamored to speak
Until Uranus blew off another BIG flat...
...*Ulation*

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MMM #136 – JUN 2000

Progress on Mars Simulations Front

The new Flashline Mars Arctic Research Station [right] had been test-assembled in Denver, then disassembled for shipment 6/21/2000 to Devon Island in Canada's far north. After reassembly by 7/20 a crew is to begin simulating Mars operations.

Meanwhile, a "pressurized Mars Rover" Project [left] was begun.

In Focus Mir Rescue a Success & Other Upbeat Happenings

While many have been discouraged by such failed missions as Mars Climate Observer and Mars Polar Lander, the *news* overall continues to give us meliorists (optimism and pessimism are absurd) some real cheer. We *are* making progress, if to be sure, not as much as we would all like.

We couldn't have reported on the latest good news, if this issue hadn't been so late getting to press (*impacts happen*). Today, June 16th, as I finish this one last page, comes word that the world's first commercially funded astronauts have landed safely in Kazakhstan, after a totally successful stay of 73 days - extended from the 45 days planned. The infamous "leak" fixed, and other work completed, Mir has been declared ready for commercial activity "on a long term basis".

One of the seeming trivia of the mission was the first ever privately funded "spacewalk" on May 12th, for maintenance purposes. But the real mile stones lay ahead, and apparently not too far ahead.

On May 19th, in an statement in Turin Italy, MirCorp President Jeffrey Manber announced that the Company confirmed that discussions are taking place with the Italian company Itali-Mir to send "Citizen Explorer" Carlo Vibert to the Mir as a guest cosmonaut. Vibert has been with the European Space Agency, and already has Mir training experience. Itali-Mir brought together a wide range of Italian industry, media, banks and consumer companies to support the mission

And so it begins. Rick Tumlinson, Chairman of the Space Frontier Foundation and FINDS [Foundation for the Industrialization & Non-governmental Development of Space] promised at the Tucson 2000 ISDC last month, that we would see some exciting developments in the next few months.

In other upbeat developments, The Flashline **Mars Arctic Research Station** structure has been manufactured and test-assembled in Denver, and back in "kit" form, is ready for the flight up to Mars-reminiscent Haughton Crater on Devon Island in Canada's remote arctic north. The schedule is for it to be fully assembled on location by July 20th. The station is intended for simulation of "operations" on Mars: prospecting, collecting rocks, laboratory work, maintaining the agriculture unit, etc. To be sure, there have already been spinoff recommendations for the "Hardware" folks.

F.M.A.R.S. (we're grateful for Flashline's $175,000 contribution, but no one likes the acronym) is to be manned each short Arctic summer. What we learn from these "missions" will teach us much, not only about "how to do Mars" but also "how to do the Moon." We think this flagship project of the new Mars Society deserves everyone's support.

The 2nd "Annual" Lunar Development Conf. kicks off July 19th in Las Vegas. There is growing interest and enthusiasm in the business and industrial sectors about the possibilities. And NASA is ready to participate, not as a partner, but as an advisor and facilitator.

The Segue to this conference is a two day follow on -- The Moon Society Organizing Conference. Yes and No, it is and it isn't a brand new Org. The Moon Society is brand new in its structure and organization and in its toolbox (so to speak)

but it comes with 400 members - who will transfer from the more esoterically named (remember L5?) Artemis Society International, which found itself legally and organizationally encumbered in several ways. This is good news, because here is a group of ardent space enthusiasts who will now be able to be more productive and effective in helping bring about a permanent human "forprofit" return to the Moon, leading to the establishment of resource-using settlements and a true frontier.

News is upbeat in the National Space Society as well. An effort involving Ronnie Lajoie (Boeing, Huntsville L5, past chair, the Chapters Assembly), Board member Chris Pancratz and others, with the support of NSS Strategic Planning Committee and the blessings of the Board of Directors, are working on a document intended *always* to be a Work In Progress.

We're speaking about the "NSS Road Map to Space". This will be a chart (quite unrelated to the flow chart of future space achievements put together some years back by Ron Jones) that will keep track of the various "Roadblocks" and "Obstacles" to the opening of the Space Frontier and the settling of the Moon, Mars, and the asteroids. Some of these obstacles are organizational, some cultural, some political, some educational, some financial, some industrial - you get the picture. The idea is first to find the "State of the Road" and assess what trouble points are most amenable to action that it is within our powers to take. Each year, there'll be a fresh situation reassessment and fresh recommendations for action.

This is upbeat, because finally it gives NSS and its members a realistic and practical compass, and a many faceted menu of ways to get fruitfully involved. The "NSS Roadmap to Space" is promising.

Space is not for the impatient. We *will* lose those of that temperament along the way. For those of us "in" for the long haul, things are looking up! - **PK**

Nightspan Lighting

Sulfur Lamps & Light Pipes

by Peter Kokh

Getting through the 14.75 day long lunar nightspans *successfully* means having enough power to maintain both comfortable living conditions and productive activities. A *successful* "overnighting" program thus entails these elements:

- available nightspan power either from a power source that is not sunlight-dependent or one that involves a suite of ways to squirrel away overabundant dayspan sunshine for nightspan use.
- finding a way to separate out as much of the energy-intensive workload chores to undertake during the dayspan and as much of the energy-light, labor-intensive workload chores to get out of the way during the nightspan. This allows us to get through the nightspan productively with much less power than we use in dayspan.
- designing power-needing systems to be as energy-efficient as possible, thus lowering the threshold for success even further.

One of these "power-needing systems" is nightspan lighting. Using fluorescent bulbs instead of incandescent ones is the sort of thing we have in mind. But now, suddenly, in the past two years, a wholly new lighting technology has begun to come online that can cut the power demand for lighting to only a sixth as much as even fluorescents demand! It is an astonishing development, all by one Maryland company, and one that is ideally suited to a lunar application. Sulfur Lamps working in concert with Light Pipes. It is something to get excited about.

Sulfur Lamps - http://www.sulfurlamp.com/

- Full Spectrum, like the sun
- Very Stable, both in color and brightness
- Very low UV and minimal IR / heat in beam
- Very Efficient, most efficient source available
- Long-lived, with minimal service requirements
- Environmentally safe, just sulfur and argon
- Quick to start, 100% in 25 seconds
- Operable in any position
- Dimmable to 20%, and maintains color
- Very consistent in performance, from unit to unit

The light source is an electrodeless sulfur lamp, invented in 1990 by scientists working for Fusion Systems Corporation in Rockville, Maryland. This technology is now being developed exclusively by a new company, Fusion Lighting, also of Rockville. In the next two years, the lamp is expected to find its way into a wide variety of applications: large interior spaces (factories, warehouses, arenas, shopping malls) as well as for architectural and security lighting. Two lamps and a single light pipe at the Forrestal Building are replacing almost 300 conventional lamps, ballasts, and fixtures.

At the National Air & Space Museum, overall light level has been increased fivefold, unwanted ultraviolet cut to almost zero, shadowing reduced, and color improved -- all with a 5/6 ths reduction in energy consumption. Given their small size, sulfur lamps are ideal for use as "light engines" for special fiber-optic uses as well as general lighting.

The negatives appear to be low. The system uses sulfur rather than the mercury used in all other high-wattage lighting systems. The disposal of the bulbs will be no problem for the environment. The bulbs may never need to be changed. Because there is no filament or electrode, there is nothing to burn out or break. The magnetron used to power the lamp will need to be replaced after fifteen to twenty thousand hours of use. The lamp is designed to make this changing easy. But the expectation is that these will be superseded by solid state devices to give the lamps an almost indefinite useable life.

What about lunar agriculture applications? The lamp has been well received by Agriculture Dept. scientists looking for ways to use this energy-efficient source to grow plants in the laboratory. One big advantage here is that the sulfur lamp has bright, full-color characteristics just like the sun. Fluorescents and other high-intensity discharge lamps, emit only bits and pieces of the full color spectrum. In a graph of light output versus wavelength (color), the output from the sulfur lamp coincides closely to sunlight over most of the visible spectrum.

Truer sunlight quality may also be invaluable for frontier psychological health. Indeed, there has been high

interest in sulfur lamps from Scandinavia where the winters are long and dark.

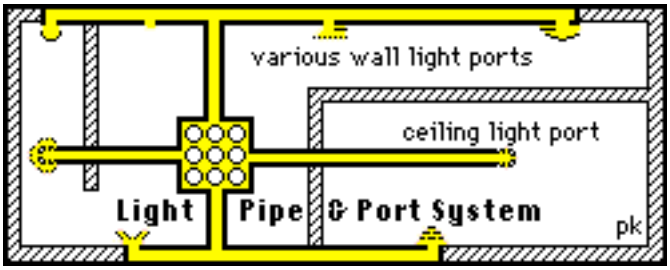
How do they work? Argon gas in the bulb is ionized by the microwave field and absorbs energy which is then transferred by collision to the sulfur molecules which, in turn, are heated, excited and emit light. Krypton would also work. The lamp is rotated to cool the bulb and also to mechanically stir or mix the plasma. The bulb weighs so little that only a very small motor with negligible power draw is required to spin the lamp. The argon and sulfur do not dissipate with time. Nor does the light deteriorate as with fluorescents or HIDs. The most popular fluorescence put out about 81 lumens per watt. The current sulfur lamp is at 95 LPW at the wall plug with new ones over 125 LPW available soon.

You can't go out and buy a sulfur lamp just now. The LightDrive 1000 and the Solar 1000 models used in tests to date have ceased production. The next model is still in R&D with no scheduled release date. According to Fusion Lighting, the future will bring even better all around performance.

Light Pipes

Light pipes are a delivery system not unlike "drip irrigation." Their whole function is to deliver light wherever needed, in the amount needed. Use of light pipes greatly reduces bulb replacement labor.

The 3M Corporation has taken the lead in developing and commercializing light pipe systems. We had reported on the usefulness of the new technology on the M (354 hours of guaranteed cloud-free dayspan sunshine) in MMM # 66 p.7 June 1993, "Let There Be Light: light delivery systems for lunar settlements need to be rethought."



The recent development of Light Pipe technology suggests an altogether different approach to indoor lighting on the Moon. Instead of a multiplicity of individual lamps and light fixtures, a network of Light Pipes whose rib-faceted inner surfaces channel light without appreciable loss to locations remote to the light source could be built into each building, ending in appropriately spaced and located Light Ports.

A central bank of efficient high-pressure lunar-appropriate sodium vapor lights could feed the network during nightspan, sunlight feeding it by dayspan, to form an integrated light delivery system, part of the architect's design chores. Delivery Light Ports could be concealed behind cove moldings to produce ambient ceiling illumination or end in wall ports that could be mechanically variably shuttered or dimmed from full "off" to full "on". If the reverse side of such shutters were mirrored, the 'refused' light would just go elsewhere and not be lost. A low voltage feedback loop could match supply, the number of central bank lamps "on", to the number of Light Ports open.

Wall and Ceiling Light Ports could then be fitted with any of a growing choice of consumer purchased and artist designed decorative plain, etched, or stained glass; pierced metal diffusers; or fiberglass fabric shades. Such a system might allow the number of types of bulbs that need to be manufactured to be minimized, allow the use of the most efficient bulb types, appreciably reduce the amount of wiring needed, and still allow wide decorator choices.

The exciting good news is that now, all of a sudden, we have a much better option than the "high-powered sodium lamps" suggested above. The sulfur lamp bulbs deliver much more light from a much more compact golf-ball sized source. The smaller the bulb, the easier it is to mate with light pipe distribution systems. Light pipes driven by sulfur lamps are suitable for low and high bay uses requiring high quality, low shadow light such as factory floors, sorting facilities, inspection bays, and limited access areas. The new sulfur lamps have been used with light pipe installations in post offices, train stations, clean rooms, large freezers, auto manufacturing plants, aircraft hangers, and highway signage. Advantages of light pipes are low maintenance cost and the nonintrusive nature of lamp maintenance. This is still a new technology and improvements in performance and lower price can be expected.

Other Useful Light Delivery Systems

Another way to deliver intense light evenly over a large area is to use a central kiosk under an arched ceiling or to a special overhead diffusive reflector which provides uniform illumination to the floor area. Other installations in Sweden use wall mounted lamps that direct light to specially placed specular reflectors for general and special lighting needs. Directing light toward a reflector is best for low maintenance, limited access installations that need good efficiency.

For us, the Bottom Line

Both sulfur and argon will be reasonably easy to process from lunar regolith, and that will make lunar self-manufacture possible when settlement growth makes it economic to do so in comparison to continuing importation.

The new sulfur bulbs have only very long lasting components and are so efficient that lunar nightspan sulfur lamp lighting systems will only need a fraction of the energy we had previously expected to have to devote to this purpose. As nightspan power generation is very much an "uphill" effort, the fortuitous development of these two well-matched systems is thus very encouraging. Men have never "overnighted" on the Moon. Now we have less reason to "fear the dark."

<MMM>

The World's Largest Sulfur Lamp

www.af.mil/news/Sep1998/n19980921_981433.html

Hill Air Force Base, Utah (AFNS) 21 Sep 1998**:** After years of planning, a demonstration of the world's largest sulfur lamp installation opened here. It features 288 energy efficient lamps with a 10 year life expectancy, covering a work area in a hangar the size of two football fields. The base expects to realize a savings of $57,000. The project's biggest benefit is expected to be a better quality of life for the employees who work in the hangar under the softer, more sun-like light.

An "All-In-One" Moon Resort

By Peter Kokh

You are a tycoon-entrepreneur, and you want to open a lunar resort-hotel for tourists *regardless* of whether or not there were other outposts already on the Moon or whether local industry had begun. Only very limited "easy" surface excursions would be possible, so you would want to find a location that "has it all." What would make for a great location?

In MMM # 69 OCT '93, pp. 8-9, "Seven Wonders of the Moon", we divided all the Moon into four parts *from a human point of view:* the *Crooknecks,* where Earth is always high overhead, the *Postcardlands,* where Earth hangs suspended over the horizon, the *Obliviside,* from which Earth is never visible, and finally the *Peekaboos:*

"Straddling the "limb" of the lunar globe which forever keeps the same side turned towards Earth are "the Peek-a-boos". Because the Moon's axis is not perpendicular to its orbit around the Earth and because that orbit is somewhat eccentric and the Moon travels faster when nearer Earth and slower when further away, all the while rotating at a fixed rate, about 7° to either side of 90° East and 90° West are alternately turned towards Earth and away from Earth. The effect is that these areas are alternately part of Nearside or Farside."

These areas constitute a border are from which sometimes you see Earth, sometimes you don't. Hence the nickname - "the Peekaboos".

Now *only* somewhere in this globe-girdling strip, can tourists enjoy *both* of the Moon's celestial wonders. Everywhere else on the Moon, they can see one, but never the other.

- The spectacle of the blue-white marbled Earth in the sky, and at a comfortable elevation over the horizon - especially when the Sun is below the horizon.
- The spectacle of the Milky Way as revealed in unbelievable brilliance and glory in the darkest skies in the entire Solar System: no glare from Earth, no glare from the Sun - when both Earth and Sun are below the horizon.

But we must issue the following pair of disclaimers! While a lunar resort somewhere in the midst of the Peekaboos will offer both spectacles, there will be times when Earth is visible but the Sun is *also* above the horizon and uncomfortably near to Earth in the sky. And there will be times when Earth is below the horizon, but the Sun above, and glare from the surface will impede seeing the Milky Way.

Here's how we put it in MMM # 69 October 1993, pp. 8-9. "Seven WONDERS of the Moon".

The Milky Way. One of the lesser recognized ways in which our Earth environment continues to continue to degrade is urban nocturnal light pollution. Today there are millions of youth who have never seen the Milky Way.**==>**

"Libration"

Libration in latitude: as the Moon's axis is tilted slightly relative to the Earth's, each of its poles will seem to be tipped slightly toward the observer on Earth, in turn, over a four week cycle.

Libration of longitude: the Moon travel's at a slightly varying rate along its elliptical orbit, traveling faster when it is closer to Earth, slower when farther. Meanwhile the Moon's own rotation about is axis continues at an unvarying pace. So alternately, as seen from Earth, the Moon seems to be turned slightly eastward, then slightly westward. In each case we can peek about 7° past the mean 90° longitude over the edge of farside. These 14°-wide strips, from 83° to 97°, both East and West, are called the limbs, or in MMM-speak, the "Peekaboos". For as we can sometimes see around the edge, to observers there the Earth is sometimes above the horizon, sometimes not.

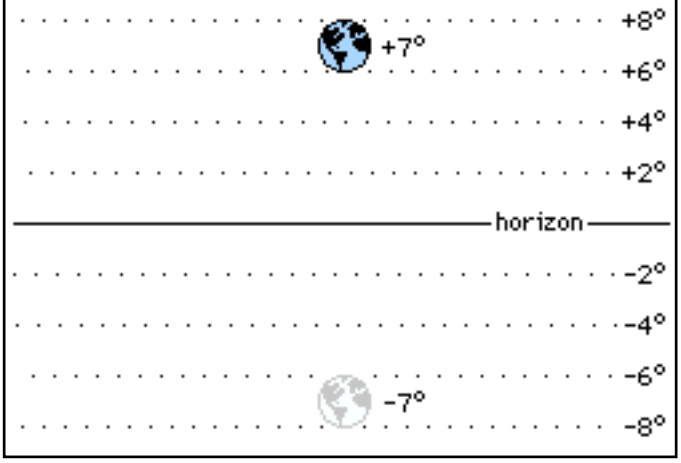
The combined effect of these two librations allows us to see some 59% of the Moon's surface from Earth, though only 50% at a time.

A good way to picture what happens is to imagine a very tall pole at the center of the Moon's Nearside, 0°/0°, whose mean position is pointed at Earth's center, but whose actual direction is sometimes above, sometimes below, sometimes to the East, sometimes to the West of that "anchor".

António Cidadão has created a spectacular 133K animation illustrating libration along with oscillating distance, as seen from Earth.

http://www.minervatech.u-net.com
/moon/not_libr_ac.htm

This animation, covering one full lunation (lunar month, or in MMM-Speak, one full "sunth"), dramatically illustrates libration of both latitude (N-S) and of longitude (E-W). Notice also how the Moon's apparent size changes from perigee (its closest approach to Earth) to apogee (its furthest).



For those of us fortunate to live in or visit at least occasionally countryside areas well outside built-up populated areas, the sight of the Milky Way in dark star-bedazzled skies is unforgettable. But we glimpse it at the bottom of a wet, dusty atmospheric ocean. Even in mid-

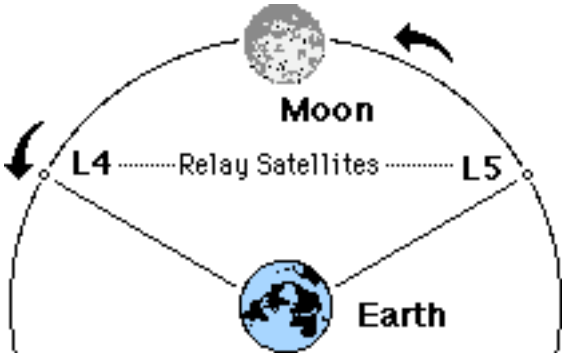
desert where on cold crisp nights the seeing is best, we are somewhat handicapped.

On the lunar surface, atmosphere is absent. But anywhere in the Nearside Crooknecks or Postcardlands, and part of the time in the Peekaboos, there is the distracting brilliance of Earthlight which must be baffled not only from view, but from reflection on one's helmet visor.

It is in Farside during nightspan, both Earth and Sun below the horizon, that the Milky Way shines in full undampened, unchallenged glory. To look up from such a vantage point and scan this river of starclouds as it arches across the heavens from horizon to horizon is a treat no human has yet experienced. For those with soul enough to appreciate it, this awesome sight will be a, even "the reason" to visit, or settle in, Farside. Many will choose the peripheral Peekaboos along the limb, for in these areas one can enjoy both the Milky Way, and Earthrise/Earthset, alternately.

Even though these magnet celestial spectacles are each to be best enjoyed only at certain favorable times, the ability to offer both makes a Peekaboos location a must for an All-in-one Lunar Resort Hotel. But that leaves a lot of turf to consider.

Our other constraint -- *only easy excursions will be supportable,* especially if the Hotel precedes establishment of a full lunar outpost able to provide logistical support of any tourist operations -- helps narrow the "doable" area greatly. We will want to site our Hotel in, or at the fringe of a level, easy-traverse mare plain. This will allow deployment of line-of-sight relay stations from the Hotel, out to at least 83°, E or W, from which Earth is *always* in sight.



Of course, we may already have established a communications relay satellite in one of the Moon's flanking Lagrange positions, L4 and or L5. But even if we do have an L4 or L5 relay, a mare or mare fringe site will allow excursions both east or west to get more favorable views of either great sky spectacle: Earth or the Milky Way.

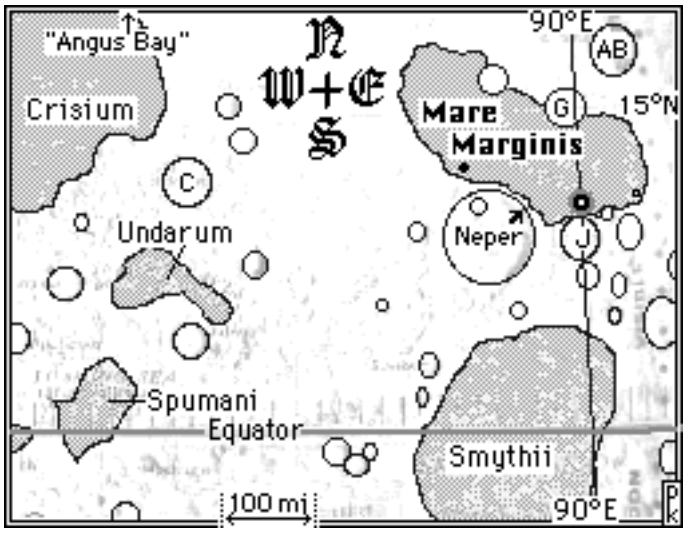
Along the western limb of Nearside, we don't find the ideal conditions. You could erect a Hotel at the extreme eastern fringe of Mare Orientalis, "Eastern Sea", the "Bullseye" in the center of the lead L4-ward face of the Moon as it travels about the Earth, or in its peripheral Lacus Veris, "True Lake". But in the first case, any travel to the east further into nearside would be extremely rough going over the ramparts of Mare Orientalis. In the second case, travel either east or west would be impeded. We will certainly see outposts and/or hotels in this area someday. But this is not the place for the "first."

On the eastern, L5-wards limb, SE of Mare Crisium, the "Sea of Crises" we find Mare Smythii astride the equator. Just north of "Smyth's Sea" and due east from Crisium, we find Mare Marginis, the "Border Sea". And well to the south, Mare Australe, the "South Sea" also straddles the limb.

Of these, **Mare Marginis** seems best to offer what we want:

- level, smooth going to at least 7° in to a point from which Earth is always above the horizon
- smooth going at least a few degrees deeper into Farside for optimum viewing of the Milky Way

MAP OF MARGINIS, NORTHERN SMYTHII, AND EASTERN CRISIUM



Sites in Mare Marginis: "Peekaboo Resort"
Earthlink Relay Station Eastern vantage point
Neper Crater Lookout
LETTERED CRATERS: (C) Condorcet, (G) Goddard, (J) Jansky, (AB) Al Buruni. ["Angus Bay" is an Artemis Society nickname for Mare Anguis, NW of Mare Crisium]

If one were to put this Hotel at the location indicated on the map above, in mid-limb 90° East on the north shoulder of the 60 km [37 mi.] wide crater Jansky, you would have a moonscape spectacle at your doorstep. And it would be a fairly easy 80 km [50 mi.] excursion to the rim of even larger and deeper crater Neper. At 113 km [70 mi.] wide, Neper is one of the Moon's "great craters," appreciably wider than 97 km [60 mi.] wide Copernicus, which, since it is much more easily observed from Earth, is considerably more famous.

Neper, like Copernicus, has a central peak. Our suggested protocol [**Selenology**, AUG '89, pp. 18-21, "Extending the System of Lunar Nomenclature"] for naming such peaks is that if the crater bears the last name of an honored person, the central peak should bear his/her first name. In this case, Mt. John. John Neper (also known as John Napier), 1550-1617, was the Scottish mathematician who invented logarithms.

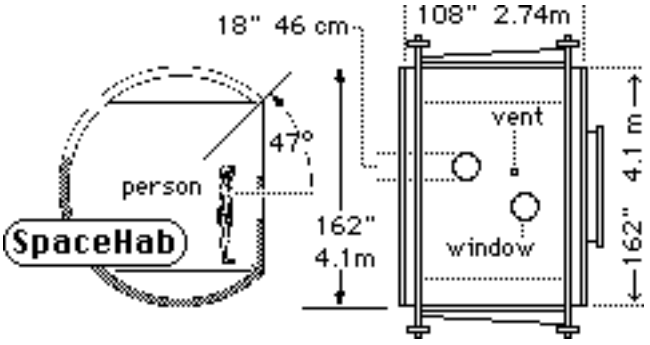
An easier traverse to the north would take us into the partially breached and mare-flooded crater Goddard, 80 km [50 mi.] wide. So a site in the Border Sea seems to offer the best of everything.

Even more reassuring is that a look at this whole section of the lunar globe suggests that as the Lunar Frontier

more fully develops, Mare Marginis will not find itself left out in some backwater. A "highway" from the Mare Crisium - Mare Anguis area could pass through Mare Marginis, then through the highlands between Neper and Jansky into Mare Smythii, before heading ESE in the direction of Tsiolkovsky, and Mare Ingenii, deep in farside.

What might an early Moon Hotel look like?

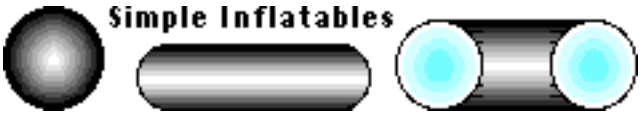
Now that's a pretty wide open question! At this time, it would seem that the least expensive bare minimum would be a complex of **SpaceHab** modules outfitted to provide sleeping accommodations, a ward room for meals, a galley kitchen, communications, an infirmary, an EVA preparation room, etc. Plus a pressurized rover.



You would need at least that much to house and support a handful of hardy tourists, lead individual guided EVA "walks" in spacesuits, and take them on a few guided excursions to see the nearby "sights". The current reference mission for the Artemis Project™ Commercial Moonbase is SpaceHab module-based. SpaceHab offers considerably more interior space than did the Apollo era Lunar Modules. Ganged in twos, threes, or larger complexes, we begin talking about real room. And they exist. They are pieces of actual, many-times tested hardware. Add to that their "affordability."

As the International Space Station (ISS) becomes real, **station-type habitat modules** will come online, to offer further off-the-shelf choices. This selection will grow.

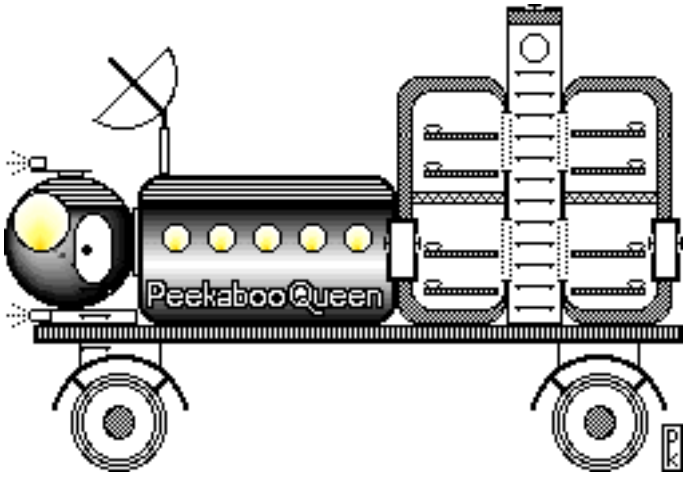
Inflatables should be available offering "big dumb volume" for a spacious central commons and for a lunar "gymnasium." The ability to experiment with no-spacesuit lunar gravity in simple exercise, gymnastics, experimental sports, and even dance will make this a priority feature. Add on the capacity to make telecasts to Earth, and that will only strengthen the market. A plain inflatable could be fashioned as a sphere, cylinder (upright or on a side), or as a torus (the most stable footprint).



As we listed in our ISDC 91 Paper "Lunar Hostels: An Alternate Concept for Both First Beachheads and Secondary Outposts, Part II, The Hostel's Share of the Workload" (reprinted in MMM #49, Oct. 1991, pp. 3-8, such Big Dumb Volume is tailor-made for equipment-light, volume-hungry function spaces such as:

- bedroom quarters
- lounge-chapel
- dinning area
- assembly area • etc.
- exercise facilities
- visitor-made art displays
- lunar rock collections

Outlying interim "rest stop shelters" at places of scenic interest, for example, could be easily deployable **TransHab** type hybrid rigid-inflatable structures. For much greater versatility, and less duplication, one such could be part of the pressurized rover, offering sleep-aboard options.



With such a self-contained, if spartan, motel on wheels, the Hotel could offer a far wider selection of land excursions, sooner. Properly designed for on location assembly of a few basic modules, such a "Wild, Wild Moon" type vehicle could be as essential as the Hotel itself. A smaller "rescue" coach-only vehicle would be a prudent backup.

As for the Hotel itself, more elaborate architectural possibilities will open up with on location building materials: **glass domes** for comfortable observation of the moonscape and heavens; or for a central Garden Atrium. Flowers might grow tall on the Moon. The lure of a walk through a floral forest could be irresistible to affluent newlyweds.

As permanent staff developed **lunar arts and crafts** (art glass, ceramics, regolith paintings, etc.) the decor of the hotel and its various inner spaces, could begin to take on a truly lunar ambiance. Guests could try their hand at new creations in these brand new media, choosing to take their works home as souvenirs, or leave them behind as inspirations and challenges to those who will follow.

Each of these phase by phase additions to the "Lunar Excursion Experience" will add to the market demand and encourage an ever growing flow of people to the Moon. That will make the development of lunar building materials and other industries ever more attractive.

In time, entrepreneur homesteaders will establish an enterprise zone nearby the hotel (if not in sight of it). They will come to offer new services and goods, both to the Hotel, and to the tourists that come to stay there. This will be a first humble step toward a cluster of tourist facilities such as we have at Estes Park, CO outside Rocky Mountain National Park; or at Gatlinburg, TN outside the Smoky Mountains National Park, or at the town of Wisconsin Dells near the river cliffs of that name.

And what a place for a summit conference of implacable foes -- a place where they will quickly see things in a whole new light, looking back at the precious Earth they share.

As population of the resort town grows, team sports and leagues will become possible, not for caricatures of well-known Earth sports, but for all new sports that are fun to play, and watch, and make sense in lunar "sixthweight." This corner of the Moon will not just be in the news. It will be on the Home & Garden Channel and ESPN Sports. Suddenly, this out of the way place will be part of the Greater World.

To be sure, common wisdom suggests such a Hotel resort would follow, not precede, the establishment of a major science, "industry-breeder" outpost. But we are not at all sure that this common wisdom is on target. As illogical as it seems, tourism, not resources, may be the driver that first earns us a foothold on the Moon. Here is the scenario.

An Alternate Return to the Moon Scenario:

1. Tourism to low Earth orbit becomes affordable as new reusable rockets bring the cost of such flights down to the low hundreds of thousands of dollars, enough to sustain a "flow".
2. Loop-the-Moon tours are an easy next step, requiring only refueling the shuttle craft, a week's extra provisions, and spartan sleeping facilities. Once the cost for this is under a million dollars, the first flights will happen.
3. Resort Hotels in low Earth Orbit are built, to accommodate longer stays, more comfortable Earth viewing, and more zero-G sports and even dance. These hotels will slowly grow into sizable complexes, even offering artificial "gravity.
4. The "Orbitels" become travel hubs.
5. Demand grows for lunar Surface Excursions
6. A small "growable" hotel complex is erected in Mare Marginis
7. Demand for more Hotel facilities leads to "on location" (those inept in English are wont to use the Latin equivalent "*in situ*") processing of regolith into building materials to make expected continuing phases of hotel expansion financially "doable" and continue to provide sufficient "return on investment" to backers.
8. Availability of realized on location building materials attracts a consortium interested in developing Moon-based space energy schemes: lunar solar relay arrays, solar power satellites built of lunar materials, helium-3 mining
9. Other outposts -- industrial enterprises -- are built, first in the proximity of the Hotel and its incubator building material industries, then at other locations on the Moon.
10. An infrastructure for travel between outposts develops, both for mutual logistical support and for trade. Roads, even railroads, are built in an ever growing network.
11. Hundreds, then thousands, then tens and eventually hundreds of thousands of pioneers come to the Moon and wind up staying, raising families in the booming settlements. The Moon becomes a Human World.
12. A Hotel built in the lunar Peekaboos to cater to the insatiable demands of the ultra affluent thus proves to be the unexpected Seed of major industrial and economic development of the Moon. Why? Because Tourist Dollars do not need justification by MBA bean counters. Tourism is built on affluence, not on economic needs or justification. **<MMM>**

New Reasons for Synergy Between Lunar vs. Martian Development Programs

By Peter Kokh

Time to 'fess up. Long known as a "Moon Man", I started off 25 years ago as a "Mars enthusiast". I wanted to write an alternative history novel, of how things would be by now -- had we not retreated from the Moon! Of course, I thought, we have to begin with a Lunar Outpost. Quickly I was taken by the challenge of this "first step". How would Lunan Pioneers make progress towards self-sufficiency when the Moon sorely lacked so many vital elements? hydrogen, carbon, nitrogen, copper, lead, zinc, silver, gold, platinum ... ? The search for answers, for workarounds, for substitutes, for make-do's won me over to the cause of Lunan Pioneers. Never did write that novel. But the research helps fill the pages of MMM. The Moon became the love of my life.

That said, I never lost my interest in Mars. As things go, a few months ago, I suddenly found myself voted in (in absentia) as head of the Mars Society Civilization & Culture Task Force, and moderator of one very busy discussion list.

Our discussions of power systems on Mars lead to an unexpected consensus that there are too many problems in the way of an ALL-nuclear system, and also in the way of ground-based solar. A scalable, modular, growable Mars synch orbit Solar Power Satellite relay system built using materials from Phobos or Deimos and the relevant industries might be needed, in addition to nuclear, if we are to field a power mix that can truly sustain any real meaningful development of Mars.

And here it is!

> The technologies to mine and produce elements and building materials, and to use them to build Solar Power Sats, whether from the **Moon** or from **Phobos** and **Deimos** would seem at this point to overlap.

There *is* the mechanically relevant difference in gravity. But from a chemical engineering perspective - unless PhD soil samples should reveal something very different from the Moon (we're no longer so sure that they are carbonaceous chondrite asteroids) - there are a lot of similarities. The technologies needed to mine the undifferentiated soils of all three worlds should be largely analogous.

Priority should be given to surface sampling of both Phobos and Deimos as essential to provide an information base from which to do higher quality brainstorming minimally subject to the garbage-in, garbage-out syndrome. Too bad, in retrospect, that the Russian-Soviet Phobos mission failed!

Other Reasons for Moon-Mars Synergy

- Cheap Access to LEO is necessary to open either world as a frontier
- Cheap Transportation beyond LEO is necessary to open either world
- Starter Outpost Habitat Structures, Rovers, etc. will be essentially the same
- For both Moon and Mars, we need to learn how to do Biosystem Maintained Life Support
- For both worlds, we need modular, reliable, no fuss, compact nuclear power systems
- Neither frontier will open wide unless we learn to involve private enterprise of many types
- In short, partisans of both worlds face the same obstacles on the Road to Space

We personally (and we are not alone) belong to both the new Moon Society and the Mars Society, as well as the National Space Society. We deplore the counterproductive "Rites of Turf Protection" engaged in by some.

It is *not* a case of one fixed pie and trying to carve out the biggest slice. It *is* a case of working together to make the pie *much, much bigger!* Above all, we need to take responsibility for making things happen and quit deferring to the "government."

Here lie technology R&D initiatives that both Mars and Moon people can unite behind towards the realization of unsuspectedly linked dreams for two quite different planetary frontiers. <PK>

A Fresh Try at "Regolith Impressionism"

by Peter Kokh

DAWN

It was a personal high point for me, back on September 29th, 1994, when I produced the first piece of an art form that had never before been tried. "***Moon Garden #1***" was painted on the reverse side of an 8"x10" (20x25 cm) glass pane, foreground first. But that was not the revolutionary part.

For pigments, I used metal oxide powders -- nothing special about that! But instead of an organic solvent as a medium, I tried mixing these powders, in less than teaspoonful batches at a time, into sodium silicate. Sodium silicate is a liquid so long as it is not long exposed to open air. What's special about it is that this compound is the only known inorganic adhesive. It was a hunch, and it worked. After all, there are no known inorganic solvents, save water.

What's so unique about all this? The success of this experiment meant that Lunan Pioneers could in time express themselves artistically with paints, all of whose ingredients could be produced from raw moondust. Even though the actual source of all my ingredients was quite terrestrial, they could all be found or produced on the Moon. Lunans need not be dependent on expensive art media materials imported from Earth! One small step for a man, one humble but bigger step toward Lunar Self-Sufficiency!

This project was possible only with the help of a friendly chemist at a professional pharmacy not far from my home in Milwaukee -- Laabs. He was very patient and helpful when I brought to him requests for bottles of this oxide, bottles of that. It all began when I mentioned to him my idea, and he told me that he could get sodium silicate for $10 a gallon.

The stuff is hard to work with. The "paints" are viscous, making "planned" detail very difficult, even with tiny artist brushes. Inevitable skips on the glass did allow me to fill in with a contrasting color or lighter or darker shades on the flip side, and that did provide "detail" -- if not quite according to plan.

So I began to call the new art form "***Regolith Impressionism.***" "***Moon Garden #1***" got a write up in the Jan/Feb 1995 issue of Ad Astra, bimonthly magazine of the National Space Society. Over the next year and a half, several new paintings were produced.

I tried in vain to spark the interest of other artists with more creative and artistic talent than my basement workshop schooled hands. I even set up a shadow club: "L.A.A.M.P. - Lunar-Appropriate Art Media Pioneers" and received two $10 memberships. Several more persons became interested, but to my knowledge, no one else has either had the patience to try, or been able to find locally convenient sources of the ingredients I had used.

LIMBO

Then came the letdown. One by one, after several months, an at first hardly noticeable deterioration set in. The paint began delaminating from the glass. The first painting is the only one I held on to, giving or selling all the others. You can still see tell the outlines of what was there, but more than a quarter of it is bare glass. Others reported the same fate for the paintings they had.

I didn't know what the problem was. A film on the glass? Preventive steps were in vain? Was sodium silicate only a "temporary" adhesive? I wasn't able to find sources on its performance. I stopped trying.

FRESH START

In early 1999, at the email request of NSS headquarters, I helped Jason Orloff, a chemical engineering student at the University of Wisconsin in Madison, start the Wisconsin Chapter of the young Mars Society (not that HQ knew that that would be the outcome!). We quickly picked up a dozen or so regular members. This spring (2000) at a meeting in Milwaukee, during a Show & Tell session, I explained what I had tried to do with these paints. Ron Zdroik, a commercial artist who is part of the group, suggested I try again -- after micro-etching the glass with wet metal oxide paper. It occurred to me that if this proved to be the remedy, that I might try a wet rag dipped in lunar simulant, of which our local NSS chapter (LRS) had a small supply. Now if that worked, it'd be a treatment that could be used on the Moon.

I determined to try afresh. Here was another opportunity -- a chance to do a fresh painting to pack in as a bonus. "***Red Sands, Blue-Green Dreams***" was done on an etched 5"x7" glass pane, with the central marsscape continuing into the "terraformed" blue green matting. Time will tell if this one endures. At least it may inspire. <PK>

Meandering Through The Universe

A Column on the Cooperative Movement
on the Space Frontier © 2000 by Richard Richardson

On Liquid Airlocks

In MMM #132, FEB 2000, Peter Kokh revisits the concept of liquid airlocks. This got me to thinking ... there are semi-liquid materials that, with the appropriate research and development, might increase the benefits of liquid airlocks and reduce their drawbacks. For instance, polymer, liquid crystal, and liquid suspended magnetic metal particle fluids all might be able to be made solid either when a mild electric current, electric field, or magnetic field is applied to it or when such a field is removed from it. All might be able to be designed such that -- if shielded from intense radiation -- they would loose mass to the vacuum (or the non-vacuum on the inside) at extremely slow rates. It is conceivable that an airlock made from one or more of these semi-liquids might be able to be made to be so much more cohesive than adhesive that any smooth surfaced object passing through it would emerge almost perfectly free of the airlock medium.

Stepping Stone Benefits of CATS

No humans have yet lived as permanent residents in communities off Earth. And we are still a long way from having even the bare minimum of essential infrastructure to enable a human community -- even a single human -- to live in space for a lifetime. In this vein the notion has been expressed that if we were to achieve only "CATS" -- Cheap Access To Space -- we would still have nothing. I partially disagree.

If there was truly inexpensive access to LEO (even if only speaking *relative* to current costs) I am confident that enough interested parties would find it sufficiently economical to strive to do enough business in space that it would then be economical to begin doing things on orbit which are best done by physically present humans -- things such as construction, service, and repair of orbiting hardware. Consequently, more and more people would spend longer and longer in space. To get an economic edge companies would look for less expensive ways to keep people alive and productive in space and other companies would spend time and money trying to develop systems and equipment to make it less expensive to keep people in space alive and productive, etc. The result, I believe, would be an acceleration of the development of the essential infrastructure needed to make a space community viable. That would be a nontrivial positive development.

On the other hand, what would we have? We would have no control over the process. Except for the rarest of us, we would have little say on what topics research should be conducted, no say in what developments will be brought to market or on what timetable, no say in pricing ... no say in the myriad decisions which will hasten or delay the day when the first space colonies open their doors. Even one critical component of infrastructure being not ready, or not available, or not affordable prevents and precludes the existence of *all* true space communities. But why worry, the space related decisions made over the last 40+ years have advanced our goals better than the most optimistic space enthusiasts could have ever hoped ... right?

Back to Philosophy

Which brings me back to my mantra, if we rely on government and normal, investor-owned big industry to open space, we will be horrendously disappointed. People whose attitude toward space is apathy or worse aren't [let me stress that] *aren't* going to have the same goals for space that we have. And as we have seen over the last 40+ years, our goals will be perceived as being a drain and a detriment to theirs. However, *if* what we have is truly and reasonably defined as "Cheap Access To Space" in the same ballpark as current costs for flying 15,000 km or so around the surface of the Earth, *and if* we don't rely on others to bring our goals to fruition, *then* CATS will be a great treasure and opportunity for us.

If we (yes, *we space enthusiasts* <u>*ourselves*</u> and not some nationalistic, political, or philosophical "we") take the reins and make our own way to space it will show the world that going to space, doing things in space, and coming home from space are real events that can be, and are, happening in the lives of ordinary people. Then many who currently are sideliners will begin to believe in the reality of a future in space for themselves and will come off the benches and into active participation in *our* efforts. That change in belief will make them "us." "Our" efforts will be "their" efforts, and therefore, we their money will support *our* efforts. And their expertise, business connections, even their enthusiasm will support ... will <u>*be*</u> *our* efforts. Most people are philosophically "from Missouri." In other words, Most people get excited about -- and start putting their resources into something only *after* they see that it really applies to them. And those resources will hasten the research, the development, and the implementation of critical technologies we don't yet have.

We do want to get to space with all the things we need to live and thrive there as soon as possible ... well, I should say, *I* want us to. I hate to speak for anyone else since I've so often been surprised in the past. But that is something I personally dearly want. And when I say, "with all the things we need..." I do mean *all* of them. Still the most efficient, quickest way to achieve a goal isn't always the most obvious.

Megastructures versus Modular Growth

For example, in the case of free floating, artificial gravity space habitats, many people seem to be advocating the finish-the-whole-thing-just-like-you-want-it-before-anyone-moves-in approach, or something very similar to that. The problem is that to do this job in that way requires significant space industry with nothing better to do than build huge space habitats. Yet some people believe in the toss-a-can-into-space-and-make-people-live-like-free-falling-sardines approach.

All space habitats up to and including the (hopefully) soon to be operational international space station have pretty much taken this approach. Until there is a very well developed industrial infrastructure in space the go-for-it-all-at-once projects have such high up front costs and such long payback times that they are unlikely to ever be started. But the can-in-the-sky projects are dead ends.

Opting for Artificial Gravity

I believe that a modified modular approach would get space habitats full of residents in the sky faster and easier than

the alternatives. This would start out with a simple three part structure composed of two equal mass habitats and a tether holding them together at the desired separation distance. It would eventually end up as a disk, cylinder, spheroid, or other shape [double helix?] (as desired).

Tethers are usually thought of as single flexible connectors -- lines or cables -- or as systems of connectors intended to hold two massive objects (i.e. habitats) together as they revolve around a common center of mass. Flexible tethers are favored because they can be wound onto a spool for transport to the construction site and then unwound for use. The tether deployment can be done by attaching the spool to one of the massive objects to be spun up and the loose end of the tether to the other, start the whole thing spinning, and use the centrifugal force to pull the tether out as it is fed in a controlled manner.

Rigid tethers are generally thought of as being built up piece by piece in a manner reminiscent of constructing a skyscraper -- one relatively small piece at a time -- and as such are more likely (and accurately) called "beams." I will use the term "tether" because what I will be discussing here starts out flexible, just like a normal flexible tether except that it is a tube rather than a solid cable or line, and is made rigid after being deployed by filling it with a pressurized gas, liquid, or solidifying foam, gel, or slurry. Additionally, when the word "tether" is used as a verb, it accurately describes the function of this component.

Connecting the two habitats of the space settlement with a rigid tether makes navigation much easier ... though still complex and difficult. It would also make changes in rotation rate simple to implement and would reduce or eliminate twisting, bouncing, and bending.

Docking with a rotating structure

A space habitat won't be much good if spacecraft can't dock with it. Since the habitats are at the ends of the tether, rotating around the whole system's center of mass, they would be extremely inconvenient and dangerous targets to try to dock with. The only point in the system that is tenable as a docking site is the center of mass, which is also the center of rotation. But docking and undocking (and possibly other events) would almost certainly push a flexible tether out of straightness -- like plucking a guitar string, leading to all kinds of serious [vibration] problems. A rigid tether almost completely eliminates the likelihood of this problem occurring. But, though many, the advantages can't make up for the cost, danger, and difficulty inherent in the tedious construction of a traditional style rigid tether/beam that would be long enough to warrant its construction in the first place. So flexible tethers are receiving the lion's share of attention by mission planners. And because of their great limitations they are generally only considered for use in remote settings where the need for active navigation and docking with other vehicles is so limited that it is economical to wind in the tether and halt spinning of the system each time.

If the medium used to inflate a tube tether is a material that hardens into a rugged solid, you end up with a fairly easily and safely constructed, fully rigid beam. If you start with a tube inside a tube and periodically fasten the inner tube to the outer tube with something that holds them from exceeding a desired separation (keeping the inner tube from collapsing as the outer tube inflates), and then fill the space *between* the two tubes -- leaving the interior of the inner tube empty, the end product is a rigid "pipe." After the inflating medium has hardened, the pipe is ready for the installation of docking ports, dynamic balancing systems, plumbing, elevators, closed circuit communications lines, power conduits, etc. This tether "pipe" can also be pressurized with atmosphere for further convenience and safety for people moving from the habitats to the docking ports and visa versa, as well as for those who would be working in it frequently -- the cargo handlers, customs inspectors, maintenance workers, etc. The space within a pipe tether (as is the case with any rotating system tether) would have a gradient of artificial gravities from nearly that of the habitat's to zero at the precise center of rotation. As has been pointed out before, the different gravity levels would have appeal for tourism and for training those who are destined for life and work on various celestial bodies.

To make things easy (this has been suggested before), the docks themselves, or the docking interfaces, could be made to rotate at the same rate as the habitat/tether system but in the opposite direction so as to give the docking ships an almost perfectly still docking target. It would not be very difficult to design an interface to allow for the safe movement of people and goods between the seemingly non-rotating docking port and the rotating tether.

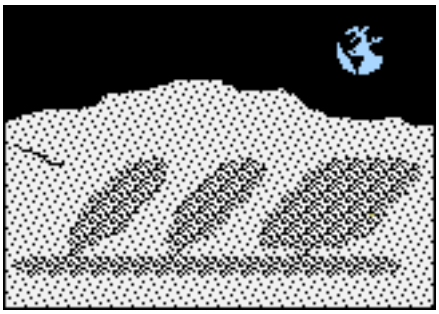
Emergency escape vehicles could be permanently docked on the outward (floor-ward) surface of the habitat modules for quick, easy access. Angular momentum would throw them clear when they were ready to depart in an emergency evacuation. Alternatively, the habitat modules themselves could be made to detach in an emergency. There are some advantages, but significant disadvantages to such a plan.

Growing Pains

But the system as described so far would only be the first stage. The community could continue to add habitat volume to the system around the perimeter of the circle traced by the system's rotation. It would only be necessary to maintain the balance between 180° (directly opposite) points. There might be need for small tethers (either flexible or rigid, I suppose) every so many degrees for structural reinforcement. When a complete circle of habitats had been formed (or sooner, if the community's economy made it possible) a shell could be made around the entire system which could then be outfitted in the manner of O'Neill's vision, or as in the Sci-Fi Babylon 5, or whatever the community's unique desire might be.

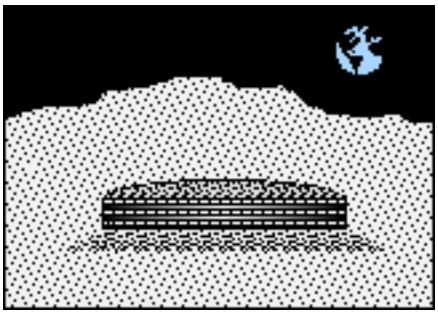
Because of the far lower start up costs and quicker financial break even of this system and the cost of the tether being relatively insensitive to its length, it would be possible to utilize a much greater radius than a built-all-at-once Bernal Sphere (for instance). Instead, the design could be optimized for extremely low coriolis effect, preferred gravity, and other characteristics. If necessary and desired, it would probably not be too difficult to start with a shorter tether and then add length later. However, there would probably be a trade off between difficulty/expense and the degree of disruption to the residents, making this an undesirable option. **<RRR>**

Escape from Mole Hill City



Modular construction with interlinked regolith-shielded units (L) seems the best way to grow a lunar settlement in open-ended fashion. But how do we graduate from "Mole Hill City" and reclaim the surface?

For a fresh architectural approach (R), see below.



In Focus The Secret of Effective Power for Space Organization Leaders

Commentary by Peter Kokh

Benjamin Zander has led the Boston Philharmonic orchestra for twenty years, during which time it has earned a strong following in a city blessed with the famed Boston Pops and Boston Symphony. Zander attributes his success to his efforts to turn the orchestra members loose, to motivate them individually to reach the heights of their abilities.

But Zander has been moonlighting. On the side he conducts motivational seminars around the country -- not for other orchestra leaders or musicians -- but for business leaders, community leaders, even NASA leaders. He wants to share the secret to yielding "real and effective power".

It *is* a secret! For almost everyone intuitively believes that to exercise power you must seize it, and hold it by preventing others from exercising it. In NSS which consumes a horrendous portion of its leadership energies in endless "Board Wars," the quest for power effectively pushes the quest to open space onto the back burner. When they do collectively achieve something, it is a wondrous thing, because it is exceptional, when it should be the normal outcome of their efforts.

To judge from some of the online discussions, the 3-year old, 3,000+ member Mars Society shows some signs of self-selected leadership candidates coming to the fore with the same mindset. Let's hope that this potential for disaster doesn't materialize. The new Moon Society has chosen a much smaller 5-member Board in hopes of not succumbing to the "King of the Mountain" game. But while NSS' very large Board size does contribute to the problem, the problem is less in structure than in attitude.

The secret is that to exercise real and effective power, one does not have to put together a voting coalition, using machiavellian means when all else fails. The secret *is* a secret, because it is so counterintuitive. Preaches Zander, "you wield effective power not by seizing it, but by giving it away." Away to whom? To your employees, to your organization's members, to those not in leadership, as the case may be. Say what?

Those guys down the ranks, the foot-soldiers, clock punchers, members, those not bright enough or driven enough to lead, for what do they need power? Simple. They need it to be able to do the best that's in them, each and every one; power to use their individual talents and abilities and to further develop hidden, even unsuspected potential -- all to the end of working and striving more effectively for the common goal.

In so-called "grassroots" organizations, the bulk of the membership is relegated to the "grass roots" role of providing money and being part of an impressive (to the media? to congress people?) ant hill that can be counted on to generate a deluge of letters or phone calls on command. A good member is an obedient insect that exercises its proper caste role. It would be more honest to call ourselves the National Space Hive. Harsh words are sometimes needed to get across simple revolutionary ideas.

Revolutionary? It shouldn't be the case. This country was founded on the principle of the power latent in the talents of its individual citizens, and has become great by maintaining a climate in which individuals can rise to the full height of their potential, for the "unorchestrated" benefit of all.

Yes, Board members should be concerned with initiatives the Society can take as a whole, on a national or even international level. But individually or collectively, Directors will yield vastly more "effective power" if they concern themselves equally with turning loose the neglected and unsuspected talents of the membership. "But those are just well-intentioned commoners!" How would our leaders, how could they know/feel otherwise? Not since the L5 / National Space Institute merger in 1987 has there been any "census" of member talents, aptitudes, qualifications, occupations, hobbies, etc. There has never been an attempt to create a database of the immense depth and diversity of ability latent in the membership. "What could we do with it? We have no time to direct or marshal these talents?"

Ahah! *You don't direct them!* You find ways to "turn them loose." You provide an open-ended ever-branching menu tree of options and opportunities and then let happen what may. For chapters, yes, but for individuals also. That is the only real way to GROW the **Gross Societal Product**. And only if you work towards that goal, is your leadership effective. Only to that extent is your power real.

"But we can't get volunteers for this, or for that, and we've really tried!" Wrong answer to the wrong question. Turning individuals loose does not mean getting them to do what *You* need done. Nor does it mean contacting a few, probably already overworked individuals and pressing them to take on yet one more commitment. *You cannot exercise real power from the top, unless you let go of the results,* by empowering the individual "roots." It is sad that most Directors and other leaders reading this won't have the foggiest idea of what we're talking about. More next time, plus concrete proposals. -- **PK**

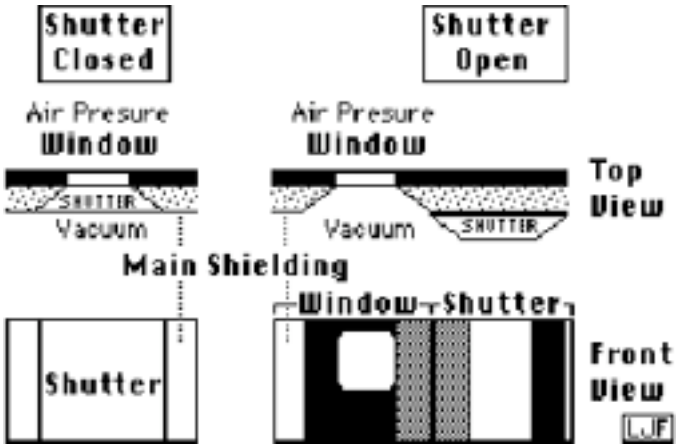
Storm Shutters & Radiation Shielding

By Larry Jay Friesen <lfriesen@genie.idt.net>

I have been wondering for quite a long time how to reconcile the requirements of a lunar settle-ment will have for massive amounts of material to be placed around human-occupied structures, for radia-tion shielding, with the human desire to look outside and see the world upon which a man or woman is living. A great deal can be done with periscopic devices and television cameras to work around this, and allow those inside to have views of the outside, even while they are well buried or surrounded with regolith. But some people, of whom I will admit being one, would like to have a more direct view if we can get one, an actual porthole or window. We'll do without if we must, but if we can figure out a way to get one, we want one.

But how to have a window, and still have the needed radiation shielding? At one time, I considered a tube or hood to extend from a window outward through the shielding, but could think of no way to close it in case of a solar proton event. It was the article "Shielding: the B Options" in Issue #122 of Moon Miners' Manifesto that provided the key idea needed for a better answer. That idea was that shielding need not be piled up loosely, but could be confined in frames or shells. Shielding in frames allows a very old-fashioned concept for shielding windows: storm shutters. This will be an idea very familiar to those of us who grew up in parts of the country subject to hail, tornadoes, strong winds, and similar severe weather. Such shutters would be open most of the time, but would be shut when solar proton events occur or are anticipated.

Given that a storm shutter must, when closed, hold a meter or two or three of regolith to give the same level of radiation protection as the rest of shielding [mound], it may end up looking more like the door to a bank vault than the storm shutters we are used to seeing on Earth for keeping out hail or high winds. Due to its thickness, the mechanics of opening and closing will certainly require a radia-tion shutter to be beveled, at least on the side oppo-site the hinge. Beveling will also allow a wider effec-tive field of view for crew members or settlement inhabitants looking out the window; less of a "tunnel vision" feeling. With the need for a bevel, a one-leaf design may prove more convenient than the two-leaf designs most often seen on terrestrial storm shutters.



The general appearance of one possible design is shown in the figure above, which illustrates front views (from the outside of the inhabited module facing in) and top views of a shutter in closed and open positions. More than one structure for this design is possible: it could be a frame with shelving to hold sandbags, or a metal shell into which loose regolith is poured. It could even be a solid slab of metal, when lunar industry gets to the point of producing such items. **<LJF>**

[Larry Jay Friesen is a physicist by education, and has worked for a number of years with various aero-space contractors at Johnson Space Center. He has worked in the area of orbital dynamics and currently is with the Hypervelocity Impact Laboratory. Larry is an Artemis Society member, serving on the Mission Design Technical Committee.]

[EDITOR'S COMMENT: Many thanks to Larry Friesen for this fine article. But I would like to make sure that every-one understands these basics:

Shielding Facts

Shielding is certainly needed for protection against intense, relatively brief Solar Flare storms.

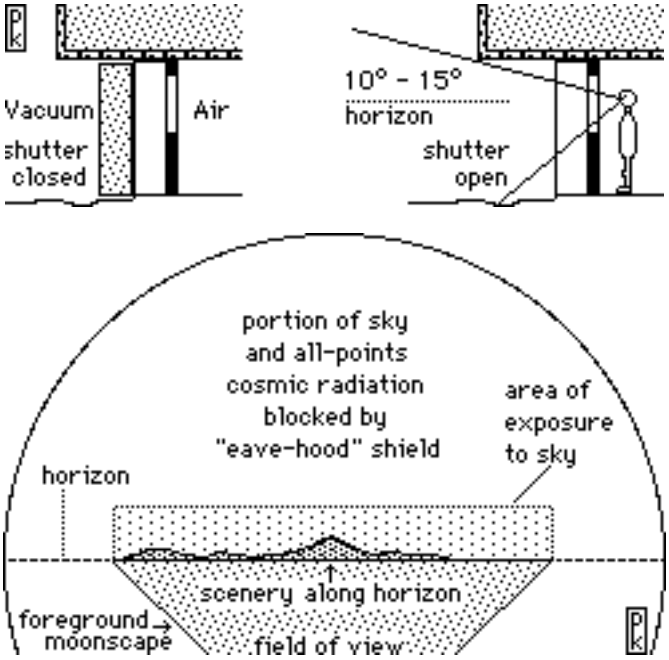
Shielding is *also* needed for the much less intense, but incessant cosmic ray radiation which comes from all areas of the sky, Short exposure to these cosmic rays is not a problem. Our astronauts were on the lunar surface with no protection at all for up to several days at a time. The problem is that the slow damage from this exposure is accumulative. About 2 meters of shielding if we are going to be staying on the Moon for periods on the order of several months. We need double that, if we intend to stay for the duration of our lives and raise children. Yes, you can ask brave carefree souls to sign a waiver and take what comes. Very quickly, you are going to run out of stupid volunteers, for whom glory is more important than maintaining their health.

Storm Shutters: a friendly amendment or two:

(1) I would suggest, that since a storm-shuttered window such as the one Friesen has designed is to be left "open" except during Solar Flare storms, it be restricted to rooms that are not commonly occupied. Not for the den or family room or bedroom' maybe for a solarium one visits on occasion. Flare or not, the window allows cosmic rays inside.

(2) If you provide a generous conventionally-shielded "eave-hood" over the window, that will cut the area of exposed sky down considerably. In the design below, the view of the moonscape and any hills, crater rims, or mountains along the horizon is unimpeded, and still framed with about 10° to 15° of the sky above the horizon visible to the observer inside. One must remember that during the two-week long dayspan, the intense glare of sunlight off the lunar surface is enough to make it impossible for the glare-adjusted eye to also see the stars in the sky. The sky looks pitch black without relief, except for Earth, if it is in the field of view. And at night, if its the stars you want to see, a window aimed at the horizon is not the right tool. So a generous, shielded "eave-hood" does nothing to spoil the view and can cut down drasti-cally on the exposure one might otherwise get.

But this said, we still strongly urge the first precaution be followed also.



Windows and satisfaction

I can readily understand how unsatisfactory "peering through a periscope" might seem to most. That is not what a periscopic window is. It is a veri-table "picture window" -- for lunar application, we will want a round or oval window and mirrors and a tubular shaft -- after all, we will be stepping down the air pressure from full to vacuum.

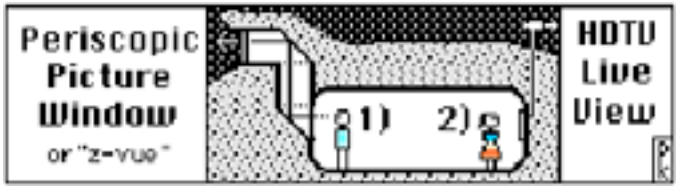
Nor do you have any immediate sense that the scene you are looking at is "up there." You have to remind yourself of that. I talk so confidently about such windows, because I had the good fortune to see a terrestrial house built on such a principle. "Terra Luxe" (literally "Earth Light") in the late Spring of 1985 was an innovative earth-sheltered home that was open for inspection one Sunday in the rolling glacial Kettle Moraine area of SE Wisconsin, a half hour drive from my home in Milwaukee. I paid the $4 Builder-Architect George Keller (literally Farmer [Grk] Cellar [Ger]!) wanted for tours. Unlike run of the mill "underground" and "earth-sheltered" homes of which I had seen several, The south side of Terra Luxe was not exposed to catch the warmth of the sun. The whole house was covered with 8' of soil minimum, entrance being through the garage which opened on the north. Walking into the home, one could hardly have prepared oneself for the experience. In every outer wall was a generous picture window, perhaps 5' by 8' or more and you were looking straight out onto the lush rolling green countryside ahead of you. Of course, what you were seeing was the view from the top outlets of the periscope windows perhaps 15' feet further up than your eye level inside the home.

The house was also flooded with sunlight, there being yard-wide mirror-faceted shafts at intervals through the ceiling, up through all that soil, to swiveling sun-catchers that followed the sun across the sky. And was a sunny day.

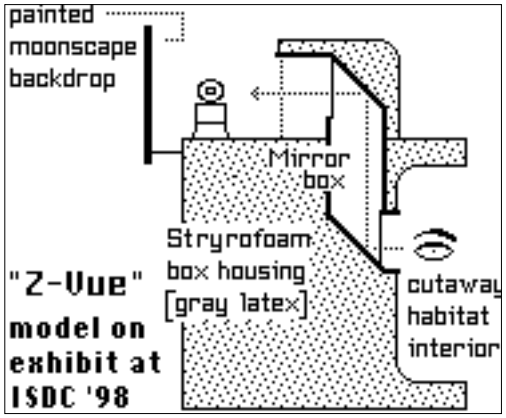
Not only are such windows amply satisfying, their zigzag light path (hence my pet name for them. "z-vues") breaks the would be path of incoming cosmic rays. That feat accomplished, it would be safe to look through such windows endlessly.

You might want to provide shutters, if the sun rose or set in the direction the window framed, or in case of an incoming meteorite shower, especially if the troublesome stuff was expected to come in fairly parallel to the ground. But you could leave them open during Solar Flares storms.

If I were the architect, I would make sure the windows did not frame the sector of the horizon where the sun rose or set. As the Moon's axis has very little tilt, there would be nothing like the wide vector range in which the sun rises and sets on Earth.



What we sorely need to do now, is build a true scale model built to hold air pressure against vacuum



-- then test, rebuild, test rebuild, ..., until we've got some-thing that really will work.

It would be a tough engineering exercise.

<PK>

Taking Back the Surface:
Above Surface Architectures for Moon and Mars Habitats

by Peter Kokh

Background Readings from MMM Back Issues

- MMM #1 DEC '86, p 2, "M is for Mole"
- MMM #55 MAY 1992 p 5. "Skyscrapers on the Moon?; p 7, "Moon Roofs"
- MMM #75, MAY '94 pp 4-7, "A Successful Lunar Appropriate Modular Architecture"
- MMM #109 OCT '97, pp. 3-11 "Luna City Streets" specifically, pp. 7-8 "Custom Frontages"
- MMM #111 DEC '97, pp. 4-5, "Lunar Skyscrapers: shattering 'low' expectations"
- MMM #122 FEB '99, pp. 5-7, "Shielding: the 'B' Options"
- MMM #125 MAY '99 pp. 3-4, "A Levittown on the Moon"

Foreward:

The spirit of the "Manifesto" in MMM was born the instant I walked inside an innovative earth-sheltered home some 30 miles NW of Milwaukee in the rolling glacier-carved Kettle Moraine countryside of SE Wisconsin in the Spring of '85. Eight feet of soil and grass covered the concrete ceiling, and only the garage door was exposed. Yet I was standing in pools of bright sunshine and looking straight ahead out onto the green meadows through picture windows in the walls. The sun came in through mirrored shafts. The views also were channeled down a shaft via a pair of very large mirrors on a 45 degree slant. That you could use devices like this to bring the joys of surface life down underground with you was a revelation. On the Moon and Mars, exposure to the waves of cosmic ocean weather pounding on the barren global coast meant refuge under a blanket of moondust or Martian regolith. Yet we could be comfy.

But the regolith serves as a blanket with this difference. While we live below a blanket of air on Earth we still live above the visual surface. On Moon and Mars, the surface of the regolith blanket IS the visual surface. It is one thing to find ways to enjoy access to the sun and views. But perhaps many Lunan Pioneers will still regret, even resent, the "loss" of the surface from which radiation, solar flares, and other cosmic inclemencies would seem to exile us. The rebel cry will be to "take back the surface."

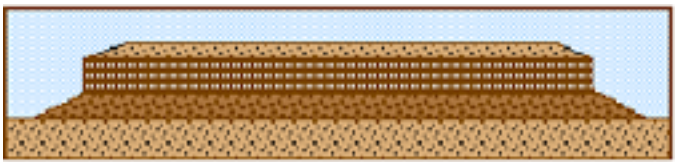
In these pages we have tried to sketch a rich and varied menu of supportable "out-vac" activities including sports. And we've suggested ways in which our settlements could still have "skyscraper"-jeweled centers. And we've illustrated how lavatube settlements could boast elevator shafts to surface observation areas and surface-side restaurants.

Yet Larry Jay Friesen's article in the pages just preceding shows that, as comfortable as we might make life *under* the surface, some will still yearn to recapture more of the life *on* the surface. Can we?

Inspiration in Utah:

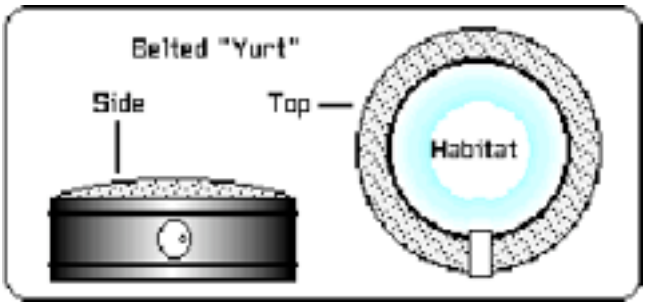
It was early afternoon on a hot summer day in Utah. I had been immensely enjoying my window seat view of the Colorado Rockies and the Utah rockscapes along Interstate 70, this past July 20th. This treat of exploration was a fringe benefit of going by "covered wagon" -- Greyhound -- to the Las Vegas opening of the Moon Society Organizing Conference. Colorado's Glenwood Canyon, and its feat of Interstate engi-neering was fresh in my mind as the scenery started to get fantastic again west of Green River, Utah.

Following on my road map, I imagined myself on Mars as we cut through the San Rafael Reef (where there had been no road at all prior to I-70). Then we entered a broad valley with sweeping views -- Castle Valley between I-70 exits 100-114 (approximately). I didn't have to wonder long at the origin of the name. To right and left there appeared one butte or mesa after another, each of them with rusty ochre rock cliffs bearing a very pronounce horizontal stratification along with texturing vertical lines cut by falling water and erosion. The tops were covered with desert soil. And a fairly uniform talus slope of erosion debris gently bermed these "castles" so they seemed to be extruded from the valley floor itself. I could imagine the geology that created these features and will make it a point to research that in detail.

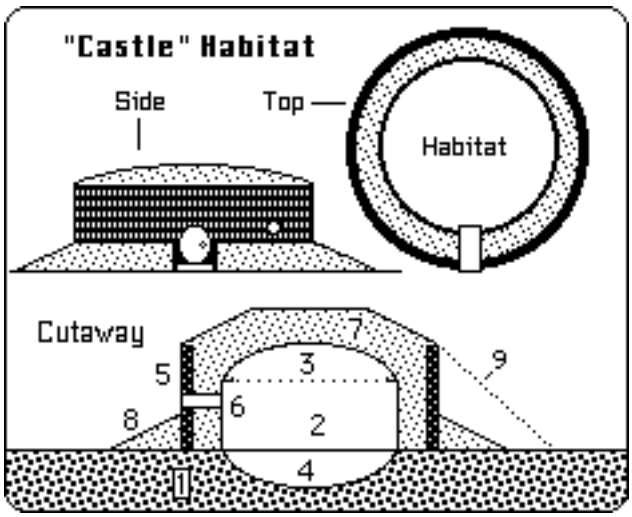


As the majority of my fellow travelers slept or read or looked the other way in inexplicable boredom, I was cycling between visual ecstasy and brainstorming imagineering of fullly shielded surface homes on Mars and the Moon. The vertical walls with their strong horizontal character were retaining walls taming the regolith that safe-hid homesteads inside. We could transcend the mole hill, and reclaim the surface -- with strong architectural character!

In MMM # 122 FEB '99, pp. 5-7, "Shielding: the 'B' Options", I had talked about one similar way to contain and sculpt regolith shielding mound.



While the structure of what I was now seeing so vividly in my mind's eye was much the same, the idea of the retaining wall being made of rock or cast basalt or concrete forged out of the local regolith, paying homage to that origin in its coloration, and being so strongly textured as to give equal testimony to the host planet and to the intelligence that now adopted it as "home" -- that vision was fresh flash.



KEY: (1) surface, minimally excavated to nest the rounded bottom of habitat hull; (2) Habitat Hull, in this case a squat vertical cylinder with round end caps; (3) vaulted, cove-lit ceiling; (4) "basement" area for utilities and systems and extra storage; (5) the "castle" rampart retaining wall; (6) shaft for "window"; (7) regolith shielding and (8) berm; (9) slope of shielding without a retaining wall

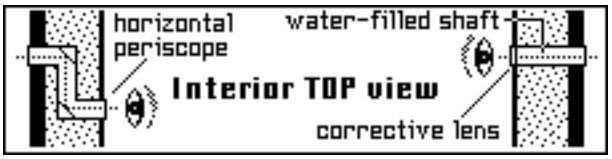
The retaining wall is shown above with a berm of regolith around its periphery. This berm is not dictated by either structural or shielding considerations, but rather by aesthetic ones. Without a berm, the habitat appears to be a foreign object alien to the Moon (or Mars) and just "dropped or set out upon" the surface. With the berm, the habitat appears to be a natural extrusion from the surface, just as the castle rock outcrops in Utah seem to be (and are) a natural part of their valley. And that is the whole point. Our goal is an architecture that "takes back the surface" without "assaulting" it: "selenophylic" architecture for the Moon; "areophylic" for Mars.

In some areas the lunar surface ahas been "gardened" into regolith by eons of micrometeorite bombardment to a depth of up to five meters (16 ft.) In other areas the loose moondust gives way to broken bedrock only a few feet down. In terrain like that, this surface "castle" shielding construction method might actually work more "with the grain."

Openings to the outside

This type of surface construction lends itself more easily to individual home air-locks and vehicle docks to the surface, though one could still choose to rely on public access points, e.g. along pressurized city streets. What about windows? In "castle wall" construction, the habitat is actually at or above eye-level with the surface. The "periscopic" picture windows suggested for "buried" habitats might seem out of place (even given the higher vantage point.)

Friesen talks about an alternative movable shutter system that might work well for our "above surface" castle homesteads. Yet one might still opt for dumb (no moving parts) sight path shielding via a "sideways periscope." An illustration of a horizontal zigzag light shaft is shown at left, below:



Right, above: Advanced possibilities include a water-filled shaft, with active thermal and density management to maintain structural integrity.

"Castle" Retaining Wall Materials:

Showcase vertical retaining wall can be built of various "lunar" or Martian materials:

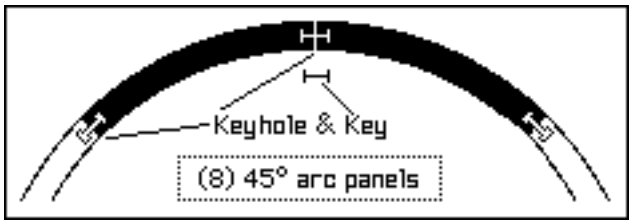
- Metals: cast iron (rust free in vacuum), magnesium (non-oxidizing in vacuum), etc.
- Concrete: fiberglass reinforced steam-cast cement
- Sulfur Cement (no water or steam required)
- Sintered Blocks (easy to make but requiring more assembly even with a mortarless lego-type shape)
- Cast Basalt

Metal and Composite panels (e.g. fiberglass reinforced cement and sulfur cement) can be made thinner without sacrificing strength. In light gravity, the outward pressure on the regolith retaining wall would not be especially great.

At first, the components would be made to order by a manufacturer. The first customer might be a wealthy individual (and his/her architect) or, more likely, a major homestead builder-developer who wants something special and distinctive. If and when the settlement begins a major population expansion, manufacturers might arise for whom a variety of such retaining wall panels are a major product line.

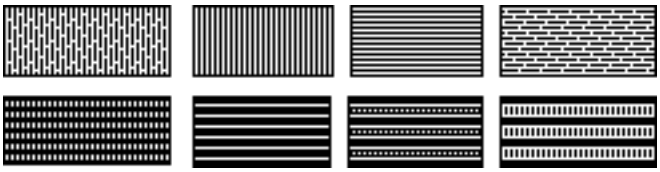
Assembly method

The ideal "castle panel" is something easy to produce and which requires a minimum of assembly. Arc panels short enough to stack easily and light enough to handle, yet long enough to keep assembly to a minimum, could be "keyed" for easy connection. Below is just one type of "key" design.



Appearance: texture, pattern, color, etc.

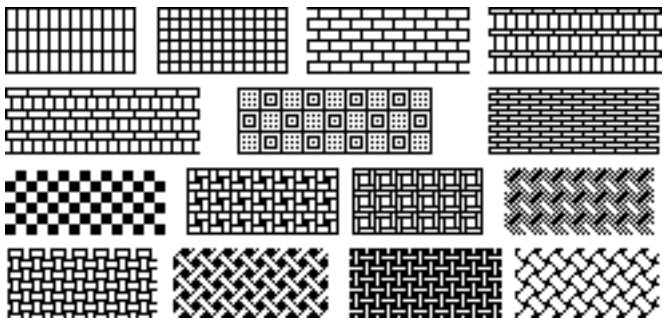
A one-step and thus very attractive option would be to cast the panels in textured molds, a common enough practice on Earth for cement façade panels. Such panels could be cast with smooth or rough, vertical or horizontal ribs, each option with a distinctive overall "look" in texture and shading..



Cement panels and sintered block would take color hues and shades that complement the regolith from which they are made. But they would stand out from the regolith shielding mounds both through their manufactured texture and from their vertical orientation and the play of sun shadows.

Cast Basalt and Cast Iron panels would be rather black; Magnesium silver metalic; Sulfur Concrete a pale yellowish grey. Ochre panels could be made from cast iron panels steam-rusted on the face side in the factory before assembly. It might pay to experiment with various rough texture surfaces to try to find some that would "hold" a dusting of white calcium oxide (lime). A whitewash of lime in sodium silicate would be a more expensive option and may not prove durable under constant thermal stress from dayspan/night-span/dayspan temperature changes.

Concrete retaining slabs could also be cast "smooth" forl covering with decoratively glazed ceramic or cast basalt tiles if either the developer or intended homeowner so desired. Possible patterns are endless. Here is but a small teaser sample:



If a non-regolith color palette is used, the color combination options are likewise vast, even if limited to Moon-sourced metal-oxide glaze pigments. These will include black, rust, green, white, blue, pale yellow, and various blendings of the above. Bright red, yellow, and orange would be unlikely.

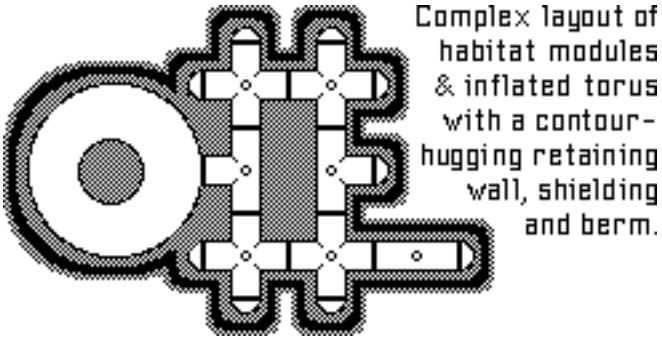
Preferably, each panel would be "tiled" in the pressurized factory, allowing quick installation with minimum EVA. To put up plain tile-backer panels, pending a later greater selection (e.g. as more color pigments and glazes become available) would allow quicker initial assembly but then look a bit ugly for an indeterminate amount of time. The calculated risk is that custom finish cladding is a "postponable" expense and may never be completed. Perhaps the smooth tile-backer finish could be minimally textured to be presentable 'as is.'

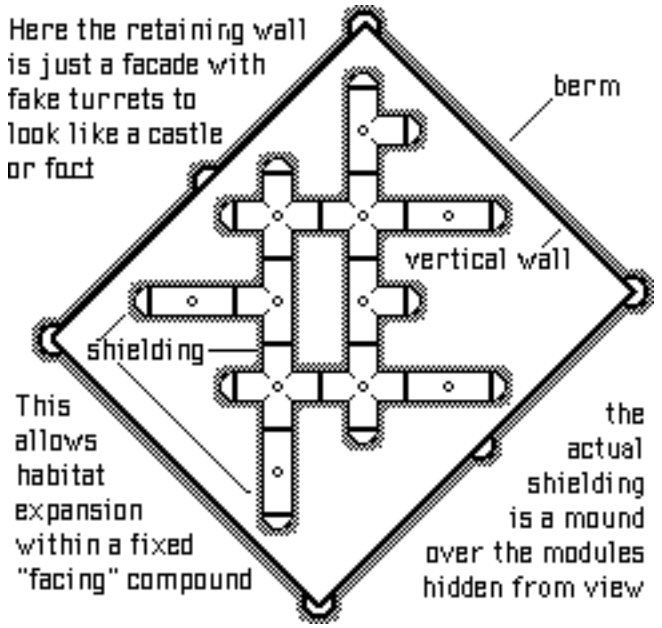
We want to personalize our homes, not just the sanctuaries inside, but the public faces as well. We previously discoused how their entrances upon the city's pressurized streets will create opportunities for personalized expression.

In "Moon Roofs," we described ways people could customize and style the surface of the regolith mounds that protected their habitats. "Castle wall" constuction offers us welcome new ways to personalize our homestead "exteriors".

Variations on "Castle Home" Shapes

This surface-exposed "castle-panel" architecture is not limited to the simple one or two story vertical cylinder type habitat. Go for the layout you want! Then erect a retaining wall that outlines the exterior wall footprint, *or* one that disguises it.





Doing a whole Settlement or Neighborhood:

Just one residence designed in this manner might look out of place. A whole town of habitats built with similarly textured retaining walls would be rather striking, much as are the Spanish tile roofs of the University of Colorado at Boulder, or the red brick colonial buildings of the Univ. of Kentucky in Lexington, or the adobe buildings of the University of New Mexico in Albuquerque. Keeping to a uniform architectural "language" can yield visually impres-sive results but yet suffocate the individuality of those who must live in them. In our case, if all the retaining wall elements are similarly textured and colored, this would quite defeat the whole purpose of including a personalizable public facade to one's dwelling - a seeming Catch 22. Somehow I think that the similarity of "above surface bermed homes" will prevail and give the settlement a distinctive feel even if patterns, textures and colors, as well as footprint shapes vary widely from home to home as they should in a healthy and vigorous settlement. Standards of "conformity" should be very generous in their inter-pretation. Neighborhoods might well vary in the styles that are characteristic of them. The Home is the very essence of personal expression. It is very important to allow this personality to be expressed on the public exterior as well as in the interior.

Managing shielding "with style" in this fashion might first appear in "upscale" settlement neighborhoods. *Or perhaps* it will first appear in the isolated inter-settlement and off-road reaches of the endless global boondocks. Indeed, isolated outposts may put a premium on "standing out" against the moonscape, yet "being one" with it. "Castle wall construction" in all its possible varieties should appeal to the hardier breed of "rural" pioneers.

Whether set out on a broad plain or on high ground commanding views in many directions, hotels and inns, general trading posts, and other types of country outposts built in this fashion would catch the eye from afar, welcome tired travelers, and signal the pride within. Wherever it takes hold first, we can expect a lot of experimentation within this paradigm.

There's more to a town than homes:

Variety versus conformity is not the only issue. "Castle" homesteads must still be connected by pressurized, shielded thoroughfares. These also could be minimally set into the surface with bermed walls taming the shielding mounds. That might be taking the architectural idea too far, detracting from the homesteads themselves. On the other hand, public architecture could be used to "set the theme" and example for privately built individual homes. That is something Lunan architects and the people who hire them must work out for themselves. And a non-trivial issue is that such features for public assets come with an additional price tag -- additional taxes.

Conclusions

In the previous articles cited ("Moon Roofs", "Skyscrapers on the Moon", "Lunar Skyscrappers: shattering low expectations", "Luna City Streets") we had already laid the grounds for considerable diversity and individuality. Both articles dealt with ways Lunar and Martian settlements could

escape dismissal ("Once you've seen one molehill city you've seen them all!"). In this article we've tried to develop additional architectural options. Combine that with further options such as lavatube settlements and cities within megastructures, and it becomes quite clear that while all Lunar and Martian settlements will be recognizably Lunar or Martian respectively, it will not be true that once you've seen one, you will "have seen" the Moon or Mars.

Earth cities are recognizably "Terran" - they are outdoors in a planet wide biosphere. Yet variety and diversity abound. We think that as the lunar and Martian frontiers develop, initial monotony and uniformity will in time give way to a quite surprising creativity and innovation of expression. Variety is the spice of life, and we will not lose our need for it by transplanting ourselves to other less motherly worlds. The Moon and Mars similarly challenge us with their lack of breathable atmospheres and expo-sure to the waves of the cosmic ocean. But there will be more than one solution or set of solutions to those challenges. The easiest is but the first.

Architectural diversity encourages tourism. Visitors from Earth will have several settlements on their itineraries. But it will also be healthy for the settlers. They will have attractive and interesting places to visit, or escape to if only for a badly needed change of scenery, on their new home world.

External shapes and forms are but one vector of cultural diversity. They will be complemented with a diversity of arts and crafts, clothing fashions, performing arts, sports, and more. It's about making both the Moon and Mars whole new Worlds, captial W, each with a "world-full" of variety and diversity to forever delight. The limited diversity of the stark and lifeless landscapes will work to encourage special attention to all these other avenues of making places special and unique.

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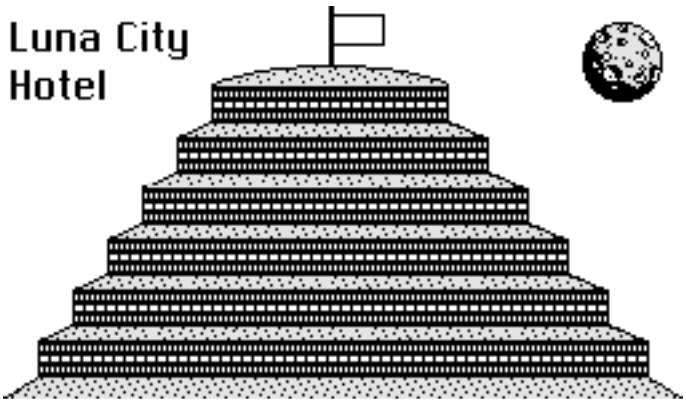


From Artemis Society International To Moon Society Plus Artemis

Big & Small Changes in the Air!

By Peter Kokh

For Artemis Society International members, there are both big and small changes in the air. On July 22nd and 23rd, 2000 at Caesars Palace in Las Vegas, Nevada, thirty people gathered to midwive the birth of the Moon Society.

In some ways, the new organization replaces Artemis Society International. But ASI will continue to exist, grow, and thrive, transformed to play a new, more focused role.

Here's what it all means for you. Membership Services, including your subscription to ***Moon Miners' Manifesto***, will be shifted to the new organization. If you are a current ASI member, you will automatically become a founding member of the new Moon Society, at the same $35 renewal rate. If you are not a current member, you can become a "founding member" if you join the Moon Society by December 31st, 2000. [See page 13, col 1 for more.]

The Moon Society will have a more broad-based approach to the effort to bring about lunar settlements, taking an interest in "all things lunar". The Moon Society is a 501c3 non-profit, as Artemis Society has been, *up 'til now*.

Meanwhile, the Artemis Society will focus more narrowly on the Artemis Project™ proper, the realization of a commercial Moonbase. Legally, ASI will make the change to a 501c6 type organization to allow it to serve as a Foundation and better build the business support structure needed to follow through on the Artemis Project™ to put the first commercial base on the Moon.

Those who want to continue working on tweaking the Artemis Project™ reference mission and/or working on its business plan and business support structure, can retain associate membership in ASI at no extra charge. There may be a higher rate dues for new ASI members, a matter to be decided.

Artemis Chapters will also transition to the Moon Society to become the nucleus of what we want to be a "chapter-based" organization, as membership grows and produces viable local clusters of members. Chapters can choose from a very diverse and open-ended menu of projects - basically anything that involves the talents and interests, energies and free time of their members in a way that supports the common goal. This will vary widely from chapter to chapter, arising spontaneously from individuals, not topdown style from Society leadership.

The "Moon Society"? What kind of Critter will it be?

by Peter Kokh

One way to size up at least the "intended" character of an organization at a glance is to look at its Vision and Mission Statements.

Coming up with proposed language for both of these statements was entrusted to a committee at the founding conference. They will not have to start from scratch as the "Purposes of the Organization" section of the new Moon Society Bylaws as amended and adopted at the conference points the way.

The **Vision Statement** describes how the world would be changed if the organization is successful: what is the desired product? The first "purpose" listed in the Bylaws falls into this vision category:

(a) The Creation of a space-faring civilization which will establish communities on the Moon

The **Mission Statement** is an open-ended list of tools and strategies the Society proposes to use to bring about the realization of this Vision. If a Society has an inadequate set of "tools" in its "toolbox", that is a clear indication that it will be ineffective.

There is an old saying, that if your only tool is a hammer (e.g. political activism), all problems look like nails (e.g. something we can get the govern-ment to do). The Moon Society Mission Statement will include a wide array of enabling tools. And the Society will remain open to identification and utilization of additional tools with which to work towards the realization of its Vision.

(b) The promotion of interest in the exploration, research, development, and habitation of the Moon, through the media of conferences, the press, library and museum exhibits, and other literary and educational means [including the Internet]

(c) The support, by funding or otherwise, of scholarships, libraries, museums and other means of encouraging the study of the Moon and [lunar exploration / development-] related technologies

(d) The stimulation of the advancement and development of applications of space and related technologies; encouragement of entrepreneurial development thereof

(e) The bringing together of persons from govern-ment, industry, educational institutions, the press, and other walks of life for the exchange of information about the Moon

(f) The serving as a clearinghouse of information on projects and programs of other societies working towards the utilization of the Moon, and the promotion of networking between them

(g) Informing the public at large on matters related to the Moon

(h) The provision of suitable recognition and honor to individuals and organizations which have contributed to the advancement of the exploration, research, development, and habitation of the Moon, as well as scientific and technological developments related thereto.

Agreement between Artemis Society International and the Moon Society Regarding the Transfer of Membership to the Moon Society

July 23, 2000

1. Artemis Society International (hereinafter referred to as ASI) and the Moon Society agree to a transfer of all current ASI members and the associated responsibilities, liabilities, and assets to the Moon Society.
2. The effective date of the transfer of membership is July 22, 2000.
3. ASI will pay the Moon Society the sum of $1.25 per member-month of liability for regular members. A member-month of liability is defined as the amount of time remaining between the effective date of this agreement and the date that an individual's membership expires.
4. ASI will pay the Moon Society the equivalent of 240 months of member-month liability, as defined in paragraph 3, per member for each life member transferred.
5. ASI will transfer all membership data to the Moon Society by providing a duplicate copy of its Team Director membership data base.
6. For a period of not less than five years after the effective date of this agreement, ASI will offer associate membership in Artemis Society International to all regular members of the Moon Society at no cost to the members or to the Moon Society. Associate membership entitles members to access the members-only areas of the ASI web site, to participate in ASI communication forums, and any other services which ASI may in the future provide to associate member
7. The Moon Society assumes all responsibility for membership services, including maintaining membership information, recruiting, providing membership incentives and benefits, publishing a newsletter, contact and communication with members, and all other activities associated with membership that the Moon Society may adopt in the future.
8. ASI will transfer any new members it receives in its old "regular" member category to the Moon Society, along with the full amount of dues collected for those members. The Moon Society will reimburse ASI any reasonable expenses that ASI incurs for services to these members or for new members during the transition of membership to the Moon Society.

• Agreed, by the Board of Directors of Artemis Society International

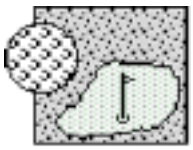
Robert S. Gammenthaller, Secretary

• Agreed, by the Board of Directors of the Moon Society

Rhoda Bryant, Secretary

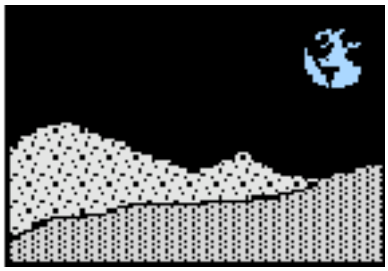
MMM #138 - SEP 2000

Of Golf Courses, Mail to Home, & the "Black Sky Blues"



Suppose you wanted to entice Tiger Woods to push the Return to the Moon to Stay movement and you needed to show him how he might continue his favorite pastime on the Moon. => Regolith Beach, below.

Suppose you wanted to send something home to Earth and email just doesn't quite cut it => Postage ET-Style, below.



Suppose you start slowly sinking into depression, and the Doc says you've got the "Black Sky Blues" => article by this title below.

In Focus Ramping Up R&D on Lunar Resources via the U. of Luna - Earthside

Commentary by Peter Kokh

If you can make it here, you can make it anywhere!

Those who look at the Moon and see its many challenges as unmeetable might also find *themselves coming up short* in other more friendly places like Mars which does have many more resources than the Moon. Compared to the United States, Japan is very resource poor. But it has used the resource it has, the brains of its people, to do quite well all the same, thank you. The Moon does have the resources we need to get started, and advance to the point where it can trade for the other things it needs.

Getting started *with what the Moon does have* is the question. Those who plan permanent return to Moon but who are cavalier about the challenges, do the lunar frontier a considerable disservice. We must stop glossing over the challenges.

Some of us have brainstormed a few of these critical issues. But as educated laymen, we can only suggest paths that might be tried. We *need to recruit* those who might be able to walk down those paths. *We need to involve a rare breed of expertise* -- people who are both knowledgeable in their fields, yet who are not captive to the assumptions prevalent among their colleagues and peers, but who are ready to find new ways, chart new territory. We must look for those mining engineers and chemical engineers who are one in a thousand, if not rarer.

It is time to take responsibility for making this happen. How? By putting into place the mecha-nisms and infrastructure that will foster and nurture this kind of radical revolutionary technological activity. Even if we are not able or qualified to do the investigations ourselves, we do have it within our power to create the environment and favorable conditions that will strongly encourage progress

Should we wait for nanotechnology?

In the past 15 years or so, since the heyday of first post-Apollo research using the returned soil and rock samples, almost nothing has been done of a non-theoretical nature. Is it premature? Should we wait until the nanotechnology messiah has reached its 30th year and is ready to go public with the gospel. I confess to being a doubting Thomas.

Even if nanotech can economically produce (isolate) pure elements from the homogenized lunar stockpile, that will not solve the question of doable alloys, glass and ceramic formulations, etc. for which we will have to get by without traditionally preferred alloy and other immixing ingredients. Nor will the nanotech savior solve any of the other hurdles that face us on the Moon. In time, nanotech may become a very useful tool, but not a panacaea. *It is time to take the plunge!*

The University of Luna -- now!

In MMM #112, FEB '98, as a prelude to a workshop on the subject at the upcoming ISDC '98, we printed a three page article on "Project 'U-LuCy', Founding the University of Luna in Cyberspace." The idea is not a bricks and mortar institution, nor of a teaching institution, but of a forum for keeping tabs on research done, research underway, and research still waiting to be tackled. While eventually U-Luna would have departments covering every field appli-cable to settlement, geology and mineral resources, and how to mine and process them and use them to serve domestic needs as well as provide exports - these of utmost import. We need mining engineers, chemists and chemical engineers, metallurgists. We need architects who can design modular "languages" that work with the qualities of the materials we can produce. We need rocket scientists who can develop engines to use lunar producible fuels. And more.

U-Luna could promote badly needed research, listing appropriate theses projects for students at other institutions. U-Luna could host periodic think tank conferences on critical issues. *Job? Get the ball rolling. Keep it rolling!* Today we are at a rusty standstill. Let no one doubt that.

WHO can/should/must do what?

The young Moon Society does not yet have a leadership core large enough to give this matter the attention it deserves. How then, do we begin? Rather than postpone this initiative indefinitely, we must go out and recruit the leadership that we need to begin. This is a matter that the pro-Moon community has dismissed, to its collective discredit, too long. To the outside world, we look like a bunch of idealistic kids wet behind the ears. We do not give challenges and obstacles, obvious to others, due respect.

This is a Project, that once underway, can proceed either under the aegis of the Moon Society, or independently, co-sponsored by the Moon Society and the National Space Society. As many of the technolo-gies and processes that need to be developed to open the Moon will be invaluable to the new Martians in making use of the assets of Phobos and Deimos, the Mars Society would do well to cosponsor this Project.

However we begin, begin we must! To kickoff, we propose a U-Luna-discuss list hosted by the Moon Society, in which those interested in this project can further brainstorm how to get it off the ground.

We have no chancellor. We have no Board. We have no faculty. Yet we *must start!* - **PK**

Regolith Beach

A Lunar Golf Course

by Peter "Tiger" Kokh

Well, let's not talk about who calls me "Tiger" and just admit that I'm not a golfer. Yes, I've golfed, tagging along with my parents to humor them, and to do repentance for my sins - apparently.

Nonetheless, I do understand the gut-passion of golf addicts ("Some of my best friends ..."). We all have our different drums. But while I am not exactly a devotee of the game, that does not prevent the landscape architect in me from admiring the great variety of course layouts and host terrains. After all, if you don't have cable or satellite (as was my situation until recently), and are otherwise unoccupied on rainy Saturday or Sunday afternoons, there are times when you can't easily escape watching a round or two, especially when the real Tiger is playing.

This is an essay about Lunar (or Martian) Golf Course construction, with incidental remarks about appropriate adjustments of the Game itself to the reality of conditions on the new host planets.

First, forget the grass! Natural or artificial, "grass" would be quaint import absurdly out of place on any world without a native biosphere, as well as considerable and unnecessary expenditures in the name of tradition - not "the game" itself. What is essential for fairway, "green", and rough alike, is texture as it affects the ball's ability to roll, period.

The out world golf course architect needs to experiment with different sieves of tamped regolith (very coarse, medium coarse, fine, very fine) as to its affects on the bounce, roll, and direction of the ball.

1. Acquire or lease a variable sieving vibrator
2. Acquire or lease a medium size "steam" roller to compact the course and make it footprint-proof and improve the ball's "roll."
3. Build a one hole test course
4. Get an especially supple light weight space suit
5. Try your game. If the ball doesn't behave reasonably, rebuild the troublesome areas of the course ("fair"way, "smooth", "rough", or crater "traps")
6. Try it again (back to step 3)

This process may take a while. Who said it would be easy? One could perhaps get a good idea of the coarseness vs. fineness of rolled regolith mix to use by experiments on Earth with various mixes of crushed gravel, stone, and sand. That would cut down greatly on the amount of time- and money-sucking fiddling one would have to do on final location.

Color? Yes we can do green. Just mine a few million tons of Chromium Oxide and sprinkle liberally. On the other hand, one could take a "when in Rome do as the Romans do" approach and settle for a golf course palette that is much less expensive and costly to produce and maintain.

On the Moon: darker shades are available by using mare basalt regolith; medium ones by using highland regolith; very light ones, by producing calcium oxide powder (lime) from highland regolith for use as a whitening overcoat mix. All one needs is contrasting shades. Brighter ungrayed colors should be reserved for smaller objects and areas. Okay, you might splurge with chromium oxide on the "smooths" and thus preserve the sacred bovinity of the "green". Limited "rough" areas could be danger-marked with rust-hued iron oxide powder.

But you especially need to provide easy to follow and find coloration for the ball, the hole pins, and tees. We might want to abandon the traditional white color of the ball and experiment with various fluorescent shades. Then, again, it may be easier to keep track of white balls against the graytone palette of the course and against the black sky, than one would think. We'll simply have to try the options.

On Mars: You'd probably want to use Mars' natural palette to best advantage and lowest cost, in color and shade differentiation of the various kinds of playing surface. If lime could be produced easily enough, that might be a good choice for the "greens" analog. But a limited amount of green chromium oxide would produce a pleasing effect, especially if terra cotta rusts are used for the inevitable "roughs" that guard the approaches to the "greens."

On Earth, courses in flat host terrain are themselves relatively flat. It takes a lot of "dozing" work to modify the given terrain appreciably. But we all appreciate the challenging effects of rolling terrain on golf competition, as well as to the scenic enjoyments that come as a fringe benefit. That's why we have golf courses in mountain valleys and along coast hugging bluffs. Finding just the right terrain for a beautiful and challenging course will be part of the golf course architect's job. Scenic enjoyment is important for the players, and for the audience, especially those of us who don't quite get the sense of hitting a ball and chasing after it to hit it again.

The lower gravities of the Moon (16%) and Mars (38%) along with the absence of appreciable wind resistance (vacuum, tenuous atmosphere) will mean adjustments to the equipment itself. The size and mass of the ball and the distribution of its momentum must be codetermined with the design and mass of the clubs if we want to keep hitting distances in check My guess is that lighter clubs and/or larger balls will be needed. Computer simulations may point the way to best design mix.

Shoes must give traction without tearing up the fairways. Rover tires may need very broad and relatively smooth treads. Golfers may need to carry along rakes and tampers to repair damage. But not to worry. Given the passion, we'll find a way. **<MMM>**

The Black Sky "Blues"

Coping with "Black Sky Country"

by Peter Kokh

Foreword

On Earth we enjoy a brightly illuminated sky. If it

isn't clear and blue, the clouds are bright. The darkest storm cloud is far brighter than pitch dark.

On Mars, the sky seems to be "salmon" hued, though there is one researcher who insists that this is only the case during and after dust storms. The point is that on Mars, as on Earth,, the daytime sky is a source of diffused ambient light that makes viewing the landscapes easier. Earth and Mars are "bright sky worlds," a gift of their atmospheres.

On the airless Moon, however, the sky is pitch black during dayspan. In the glare of the unfiltered Sun the naked eye cannot see even the brightest star. During the near-side nightspan, Earthlight will cast a glare from up to eighty times as bright as that of full moonlight on Earth. Even a partially lit Earth will also blot out most of the stars. Only on the lunar farside, forever turned away from Earth, do the stars come out during nightspan - and with a brilliance we cannot imagine. But at no time anywhere on the Moon is the sky itself "bright."

We've all grown up with the night. We don't mind it. Nighttime darkness is only temporary. With dawn comes welcome visual relief. On the Moon, that relief never comes. Our pioneers will be transplan-ting themselves to "Black Sky Country." And that can have long term psychological consequences.

With the black sky even at "high noon", the contrast volume between surface and sky is intense. Shadows are bottomless visual pits. This will cause some eyestrain. Of course, this will be more of a problem for those who spend a lot of time out on the surface - in the "out-vac". But it will affect those who spend most of their time in pressurized spaces as well: in what they see through various types of "windows" (visiscreen, periscopic picture windows, etc.); it may affect "skylights" as well.

Coping with Black Skies

To the extent that the "Black Sky Blues" do become a subtle morale problem, and this may differ from individual to individual, ways of providing deserve serious attention. Here are a few, we can think of for starters (and we invite readers to send in additional suggestions):

- **Electronic Windows**
  Whether we call them telescreens, visiscreens, or something else, electronic images of the surface scene outside offer , for good as well as mischief, the opportunity to be manipulated. The viewer may be able to select a sky color and brightness to his or her liking. The viewer, much like an Internet browser, would then "interpret" the black areas at the top of the picture accordingly. Pick a light gray to go with the moontones, or a smoky blue. Or, if you're a visiting Martian pioneer, a dusty salmon. Those homesick for Earth can pick a brilliant blue. The idea is not to deceive oneself but to prevent eyestrain - if it has become a personal problem.
- **Spacesuit Helmet Visors**
  Would it be possible to give the visor some differentially reflective coating that would "brighten" the sky, even if just a bit, without interfering with clarity of visibility of the moonscape? We throw out the challenge. If this proves feasible, could we do something similar with regular windows and peri-scopic picture windows (Z-views)?
- **Skylights & Clerestory Windows**
  On Earth, water vapor in the atmosphere scatters the suns rays so that light seems to come uniformly from all directions. Our atmosphere is a natural "diffuser" with a bluish cast. For those windows meant to bring in light but not necessarily the views, could we produce some sort of frosted and translucent, but not transparent, glass pane that will not only let in sunlight but appear itself to be bright, giving the illusion of a bright sky beyond? Again we but throw out the challenge. One might experiment by holding up various kinds of existing glass and diffusers to a streetlight against the dark nighttime sky.

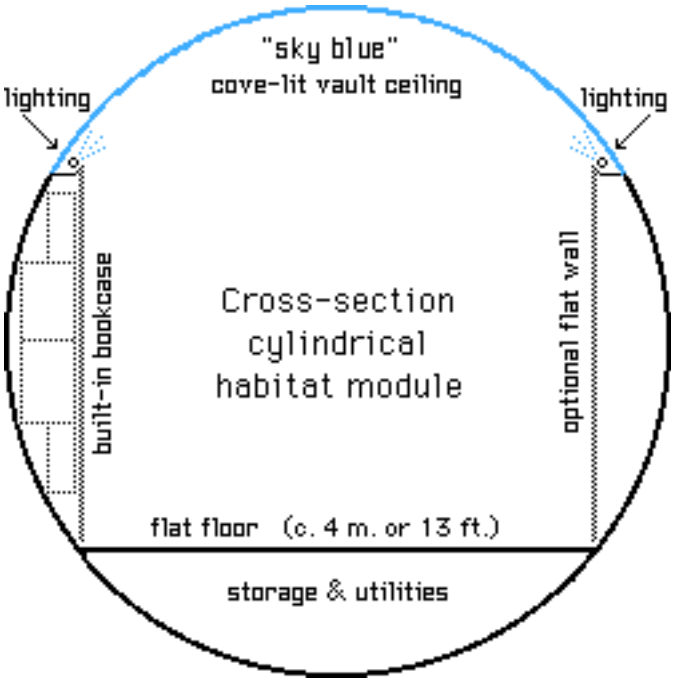
Windows, skylights, and clerestories of this type will be desirable not just for private homes but for sunlit pres-surized streets and other "middoor" spaces, sports facilities, highway waysides, etc. Passive light scattering panes to the extent that they present a satisfying illusion of a bright sky could become standard, or at least common.

Without real experimentation, we would not pretend to guess what will work best. But we should be trying a lot of things, including foamed glass, aerogel, special coatings or laminate layers, etc.

Meanwhile, this standby:

Some may not want to wait for such *tromp d'oeil* developments, or disdain them as dishonest. And it may turn out that none of these suggestions will be possible to realize in a truly satisfying way.

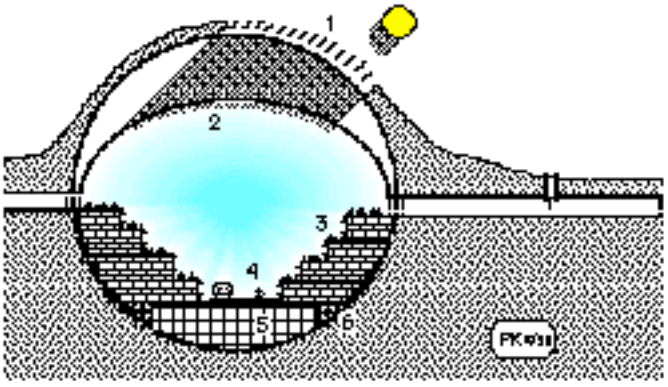
There is another, simpler way. Pressurized habitat structures and modules will commonly have curved surfaces. We'll need to install flat floors, of course, but the curved ceilings of spheres, cylinders, and toruses present an opportunity. Finish them with a light-absorbing matte texture and illuminate them with cove lighting. Give the finish - *or the light source* - a subtle blue cast, and Voilà, the appearance of blue sky. That these vaults offer greater ceiling height will only enhance the effect.



We can in effect, recreate the familiar blue sky indoors on the Moon. On Earth, where all we have to do is step outside, this hardly seems like a worth-while extra expenditure. On the Moon, suggestively bluish cove-lit vault ceilings may become the norm.

Cove lighting, especially if it is really "sky-bright", will reduce the need for other lighting: floor and table lamps, wall sconces, and especially ceiling lights and chandeliers. Strong indirect ambient light reflected everywhere off the vault ceiling from cove light strips hidden from view will create a positive psychological "atmosphere".

It's understandable if some residents might prefer the flat, white ceilings they are familiar with on Earth and to get their daily dosage of blue skies in common "middoor" spaces such as pressurized roadway tubes. Below is a suggestive illustration from MMM # 53 March '92.



THE RESIDENTIAL STREET ('HOOD) AS THE MODULE
Cross-Section of cylindrical module 40m x ?00 m: [1] shield louvers let in sunlight; [2] suspended sky-blue diffusing "sky" - air pressure same on both sides; [3] terraced residential housing with rooftop gardens; [4] thoroughfare running the length of the (neighbor)'hood; [5] light industry, shopping, offices and schools; [6] conduits for utilities.

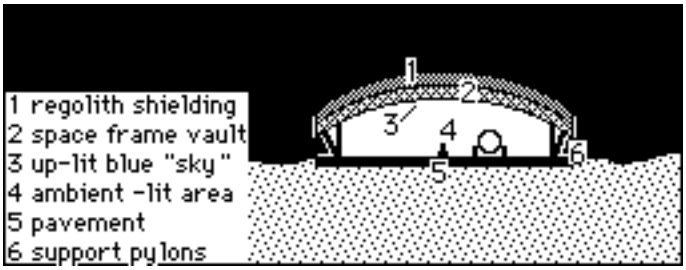
At first, roadway tubes will be of a much more modest scale, of course. But other "middoor" spaces (pressurized common spaces neither inside private quarters nor "out-vac" on the surface) such as school recreation spaces, public squares, sports arenas, and "park and picnic areas within agricul-tural modules all are prime opportunities for faux blue sky ceilings.

During the two week-long nightspan daylight (on an artificial 24 hour schedule) could be simu-lated by using electric cove lighting aimed at such vault ceilings. During the equally long dayspan, sunlight could be indirectly channeled by mirrors to reflect on the vault-ceilings full-time, or shuttered to simulate night conditions on a 24 hour schedule.

Blue Sky Simulations Out-vac

What about simulating blue skies outside the settle-ments, out on the surface? This might be very desirable for frequent inter-settlement travelers, truckers, and others whether they spend a lot of time in such conditions or not. Certainly, one could design emergency solar flare shed vaults and other covered roadsides, even if unpressurized, lit from below, thus providing "bright skies" of a sort, whether they be blue, white, or light gray.

One can foresee a day when many thousands of people live on the Moon in several settlements. There might then be one or more heavily traveled surface corridors. These could be covered with shielding vaults lit from below, open to the vacuum. Such lunar "superhighways" would make for safer, more comfortable driving conditions, day or night.



Someday, settlements may be built within great megastructures with soaring ceilings. These too could be designed to offer bright blue skies. But meanwhile, the use of cove-lit vault ceilings in habitat and other interconnected settlement modules will go a long way to shake those "Black Sky Blues" or at least help inoculate the settler pioneers against the accumulative visual deficits of the "magnificent desolation" of the lunar terrain.

But hopefully, someone will pick up on the other challenges we've put forth, of individually tunable "browser-like" video screens, special light scattering glazing options, and smart helmet visors.

The "Black Sky Blues" is something we need to take seriously. It poses an acculturation challenge unique to the Moon and other airless worlds which future Martian settlers will *not* have to face. **<MMM>**

Postage ET Style

"Mailing" a letter from the Moon?

by Peter Kokh

The overwhelming counter-question to that proposal is that given very high cost and long time delay constraints, "why wouldn't everyone just use email?" For sensitive communications, secure servers and scrambled codes should allay most problems. And by now, most, not all, of us are quite used to email and rely on it almost exclusively. It is the bill collectors and junk mailers who need "snail mail."

To leave the discussion there would be a mistake. If electronic communication takes care of 97% of the commu-nication traffic, (a figure out of the top of the writer's head, for sake of argument) that still leaves the other 3% of demand unsatisfied.

On Earth, what things are resistant to electronic communications solutions? For starters, (and if you think of more, email us at <kokhmmm@aol.com> or stamp-mail us at the MMM submission address on page one) we can think of these things:

- personal love letters and other letters where the personal touch is appropriate
- parcels: gifts and other items that cannot be shipped out of warehouses on the other planet

- souvenir "Having a great time. Wish you were here. Love to the kids!" type postcards
- magazine subscriptions

Well, we did say "On Earth." For missives from Earth to the Moon, and from the Moon to Earth, unless transportation costs sink to trivial levels beyond the wildest expectations of 'Cheap Access to Space' proponents, such costs will put quite a damper on the volume of such "resistant" types of mail and parcel post. Necessity is the mother of invention as everyone knows and a prohibitive cost situation certainly qualifies as an instance of Necessity. The scramble will be on to find alternatives. Unless they are cost-be-dammed affluent, Lunan settlers are likely to resign themselves to, if not be quite content with, the following "make do"s:

- personal love letters and other letters where the personal touch is appropriate can be sent by secure email servers. It is quite likely that we can choose to handwrite on scanning pads with that personal touch showing up in the email on the other end (okay, you software engineers, get working on this. There is a market, now, here!)
- magazine subscriptions: Lunans will rely on Online magazine versions which are becoming quite satisfying, if not "more so," because they allow interactivity, and easy reference to supporting and relating material on the web. And as computer storage capacity soars, storage of pictures and whole graphics libraries is no problem at all.

That's the easy part. The other two categories present tougher challenges:

- parcels: gifts and other items that cannot be shipped out of warehouses on the other planet.

Here we are talking about made-on-Luna gifts to send to Earth and made-on-Earth gifts to be sent to the Moon. There is no easy substitution. But it is clear that transportation costs will discourage parcel traffic. At the same time, we should point out that it will much less expensive (say a twentieth or 5%) to send a made-on-Luna item to Earth than a made-on-Earth item to the Moon. Even given the much lower fuel costs of Moon to Earth traffic, there are likely to be tariff and other incentives to ship "exports" and "gifts" to Earth.

Yet, for those who just can't pay the costs, there are likely to be on planet catalog warehouses to make inexpensive options easy to use. Your son and daughter-in-law are living in a new lunar settlement and you want to "send" them a gift on the occasion of a birthday, a promotion, or for a baby shower. Just get online and go to the Lunagiftstore.com and select a made-on-luna item for them to be shipped locally. When its your turn to be on the receiving end, they will browse through terrestrial online catalogs and select a made-on-Earth item to be shipped locally to you. After all, a great deal of gifts sent these days, have not been physically picked out and shipped. The bulk of traffic in flowers by wire (FTD) has been "by proxy" for some time.

Okay, it is *really* a special occasion and cost is no object -- almost! What are your options? We all already have learned the hard way that our options are greater the further ahead we act than they are "at the last minute." With enough forethought and lead time, we can choose less expensive slower shipping methods. But there may be certain tariff and other programs in place to encourage traffic one way or the other in certain categories of goods. For instance, the Lunar Settlements themselves may wish to subsidize imports of valued items in short supply locally:

- giftware made of copper, zinc (and brass), lead (and pewter), gold, silver, platinum, etc.
- arts and crafts tools
- musical instruments or parts thereof that cannot be manufactured locally (wood, copper, brass, ivory, etc.)
- food specialties that are not yet available from Lunan farms, and which end up adding to the mass of the lunar biosphere(s) -- i.e. precious hydrogen, carbon, nitrogen
- Gifts made out of wood, for the same reason, even if they may not be recycled into the lunar biosphere(s) for some time.
- There may be other such categories of gifts that are encouraged because of what they are made of

Another plan-ahead way of getting gifts to the Moon inexpensively may be via settler bring-along-allowances. Say for example, each settler is allowed a 50 kilogram (110 pound) allowance for "family heirlooms" on the grounds that this will help build the cultural heritage on the Moon of items "from old Earth." Some settlers may have nothing they really want to take with them. If they can sell this right, by agreeing to take along instead gifts meant for others, then that will be a cheaper way of sending items to the Moon. The market would determine the "cost" of this service -- to work, the "gift instead of heirloom" service would have to be significantly cheaper than outright parcel post. And if the authorities are going to allow such substitution "smuggling", hopefully they will guarantee that the "gift" does get to the intended recipient on the Moon. That leaves us with the following:

- souvenir "Having a great time. Wish you were here. Love to the kids!" type postcards

To get a souvenir piece of mail actually made out and addressed on the Moon, and stamped and postmarked there, is a significant value. The value is not in the message (immeasurably cheaper to send electronically) but in the physical form and its origin. The "postcard" or whatever IS the message. No electronic alternative can possibly do.

Many of you are way to young to remember the early days of "air mail" - when there was a clear distinction with "surface mail." Especially when sending a letter overseas where air mail rates where excessive (we are talking 1930s, 40s, 50s, early 60s) one could buy tissue-thin stationary and envelopes, even pre-stamped envelopes. The idea was to keep the total ounces as low as possible. Now for souvenir mail, we may be talking "picture postcards." The point is that for real Earth-Moon mail, the cost will be per gram, not ounce (1 ounce = 28 grams). To the extent that it is just the idea of getting something actually from the Moon, we can expect small, thin "cards" that are "cards" only by allusion or analogy.

What about the stamp collector trade. Why not just affix the stamp to a same size substrate (or just slightly larger to "matte" it) with the address information microengraved, along with any message, on the flip side.

Well, it is fun to wonder about these things, but when the times come, the technologies available will include those we don't yet foresee. Unsuspected solutions may work well. For now, it is enough to realize that the needs won't go away and that people will be creative and resourceful. **<MMM>**

Fred Farley's Fermentin'

By Richard R. Richardson, Frontier Bard

We dropped Fred Farley into the fermentor today
Old Fred was a talker with a whole lot to say
I guess all he had eventually got said
'Cause Fred Farley's fermentin'
Old Fred Farley's dead

He came to old Luna after mining on Mars
To hear Farley tell it he'd been to the stars
He used to repeat seventeen times a day
How he'd been a rigger riggin'
Out Jupiter way

He told how he hobo'd from asteroid to moon
And would mutter forever 'bout mix ups with goons
In way long past days as a gambler in towns
That float high above Venus
Old Fred's been around

The old boy was jawin' the day he got fried
His suit sprung a leak and we tried and we tried
But nothing would stick to such grimy old stuff
Ma Nature out space way
Can surely be tough

Old Fred kept on talkin' as he lay on his side
Till he turned a bright blue and his tongue it got tied
He'd never been quiet a day in his life
And he just kept on talkin'
Till finally he died

Well in space we don't waste nothing at all
Not nothin' of sweetness and not even gall
So Fred Farley'll always be with us for sure
Though he'll be a far sight more quiet
And far more demure

'Cause old Fred Farley's in the fermentor today
He was surely a man with a whole lot to say
But I guess all he had eventually got said
'Cause Fred Farley's fermentin'
Old Fred Farley's dead

This piece also appears in issue (#3) of Artemis Magazine.

Telling Time On Mars

"Elegant" Mars Clock unveiled in Toronto at 3rd Annual Mars Society Convention

by Peter Kokh, Mars Society Time-Sig

On Mars, the sol (noon to noon) period is 24 hours, 39 minutes, and 35.2 seconds long - amazingly "Earthlike." As you might expect, there have been quite a few suggestions for a "Mars Clock" to divide that period into clock time units. These suggestions fall into into these types, all with drawbacks, in [ ]:

- 24:60:60 (as on Earth) with slightly longer hours, minutes, and seconds (analog or digital clock) [Altering the length of the second, minute, and hour would mean having to rewrite ALL science textbooks for Martian students, and endless confusion, the more so as the new units are similar but not exactly the same.]
- Keep the standard second, minute, and hour,with a shorter 25th hour (digital clock) [creating havoc with unsynchronizable time zones]
- Keep the standard second and minute but have a longer 61.65 minute hour (digital) [a compromise]
- a metric clock 25:100:100 or 10:100:100 (analog or digital clocks) [producing units very different from what we are used to, thus unnecessarily increasing the difficulty of adjustment]

Along comes a newcomer who had not previ-ously participated in the online brainstorming of the Mars Time-sig, **Tanya Harrison** <apple@nwlink.com>. Tanya looked at that 39+ minute "overage" in the Martian day, 40 minutes, if you will. Realizing that *our* day plan of 24 hours of 60 minutes is equivalent to 36 shorter hours 40 minutes long each, suddenly that "overage" looks like an integer, a whole period, not just an inconvenient fraction.

Why not, argues Tanya, divide the Martian day into 37 hours each 40 minutes long. You can keep the familiar Earth second and minute, use a shorter yet rational (divisible into halves and quarters) "hour" (with a different name to avoid confusion). And you could have analog (hand) clocks as well as digital ones. That 37 is not conve-niently divisible by 2 and 3 is a lesser problem.

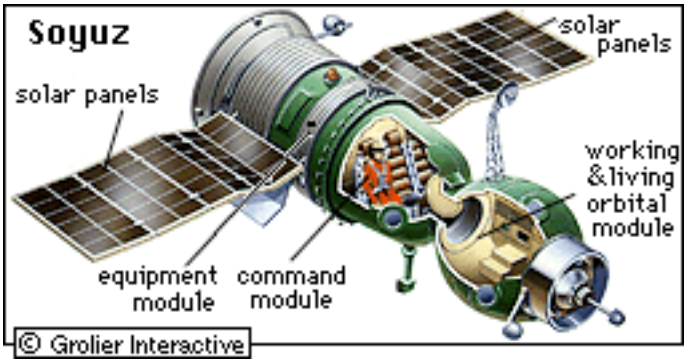
Yes, the 39.5867 minute overage isn't exactly 40 minutes. A day exactly 37 x 40 minutes is 24.8 seconds too long. To manage the daily slip, we need to schedule a dropped "hour" every 96.774 Mars days, about 7 times per Mars year (668.6 Mars days).

This neatly avoids the problems that flow from either keeping standard seconds and minutes with a 24 hour clock, or using longer units. This is an "elegant" solution. Not bad, Tanya!

Time-sig member Gary Fischer suggests a friendly ammendment: 20 hours, 74 min. long each.

> 20 x (**2**x37) instead of (20x**2**) x 37
> shuffling one 2-factor to the # of minutes
> from the # of hours.

Meanwhile, the "sig" is all over the map on questions of months, weeks, and fixing the epoch. **<TH/PK>**



"A place to go, and a way to get there"

Soyuz, along with the **Progress** freighter, its unmanned version, provide full access support for Mir, making the recommissioned station a complete "Destination Package." The 7-tonne TM version carries 3 people, and thus can take a paying visitor along with 2 crew members. Soyuz, is currently the only man-rated vehicle available to support early tourist ventures, given the long-standing anti-tourist climate at NASA.

In Focus Mir, Soyuz, Survivor -- Tourism Scenario Turned on its Head!

Thanks to a born-again Mir Station that has gotten the religion of the for-profit prophet, we've suddenly skipped a few steps in what was supposed to be the game plan to open space to tourism: affordable man-rated launch vehicles; sub orbital sorties; sorties into orbit; tourist facilities in orbit.

While we Americans, who supposedly wrote the book on free enterprise, have been successfully subverted into acceptance of a highly Socialized Space Program as "just as American as apple pie", the once ultra-Socialistic Russians have suddenly become "more catholic than the pope" in seeking ways to earn money in space. In a turnabout that gives NASA nightmare shudders but thrills the rest of us, recent Mir-anchored events have turned the common wisdom space tourism scenario on its head.

Why wait for future developments when the Russians have both a place to go, Mir, *and a way to get there,* Soyuz, *both ready for hire?*

Instead of "build it and they will come" it's "hey, we have it, you all come now!" And the traffic is about to begin. At first when the MirCorp deal was announced and an all points invitation went out to anyone who wanted to be the first private citizen in space, there was widespread skepticism that anyone would pay the price. But now deals have been made and money has changed hands. Dennis Tito has put up $20,000,000 to realize his own lifelong dream and will ride to Mir next year. Then Mark Burnett, Executive Director of the very successful Survivor show, inked a deal with MirCorp whereby the 3rd Survivor competition (#2 is underway in Australia) will be for a ten day trip to Mir. And now NBC has come forward to underwrite the $35 M cost of the venture. The first two toes are about to get wet!

MirCorp is highly motivated to find ways to encourage this trickle to continue, and turn it into a steady stream. If the "Destination: Mir" iteration of Survivor is a big hit, you can look for more creative ways to open Mir to private citizens: more competitions, perhaps some lotteries; and, as the price of a ticket begins to fall, more paying individuals.

Once the glory of being first (or second) to go to Mir wears off, MirCorp could take steps to make the station an even more "attractive" destination. A commercially built "hotel module" with a room for 3-6 or so, would open the gates for those unwilling to "rough it" in the present spartan conditions. If this opens the faucet a bit more, it will become attractive to upgrade the Soyuz capsule, or replace it with something larger, more comfortable .

Will NASA continue to wear white gloves and look with disdain on both common citizens and such lowly prostitutions as plastering their vehicles and modules with commercial logos? Or will the agency belatedly get the entrepreneurial religion of the people it serves and belatedly join the bandwagon? It really doesn't matter, because if a commercial enterprise is willing to finance and build and launch a "hotel" module to be attached to the ISS, it *will* happen. Congress will tell NASA to open up and get used to being "a" player. At that point, the first real commercial rivalry in space will be born.

Mir and ISS have similar "high inclination" orbits, inclined by more than 50° to Earth's equator. In both cases, this orbit configuration is chosen to accommodate the launching latitude of the Baikonur Cosmodrome in Kazakhstan. But the happy prime benefit is that this orbit allows coverage of 90% of the inhabited land masses of Earth. It is thus a good orbit choice for remote Earth sensing programs. And it is also ideal for tourists who will want to look out the window once they are up there, and be able to find their homelands and hometowns.

As cheaper transports come online to serve the growing number of people wanting to make the trip to orbit, the possibility of refueling a vehicle and putting on extra provisions to send it on a loop-the-Moon cruise will quickly become the "next" tourist rage. And that may lead to additional orbital facilities in a more equatorial orbit, better suited for frequent and regular outbound service.

The upshot? The age of Space Tourism is about to dawn well ahead of expectation. *Events are leading developments,* not vice versa which is always the common wisdom. But it is possible to argue that this is put a prefiguring sputter, that the real dawn of space tourism awaits the arrival on the scene of affordable space transportation, as of now still a very problematic goal. After all, many of us thought that Apollo was the dawn of Human Presence on the Moon. Just as those epochal landings ended in a miscarriage of national resolve, might not these first two tourist deals be yet another false start?

Time will tell. This time private enterprise is involved, and once it smells profits, there is sure to be a continued effort, with other players seeking to get a piece of the action. This type of rivalry turned out to be a myth thirty years ago. But we are dealing with business now, not with national policy makers. There is reason to believe that this time, the start is for real. Now if only I could afford a ticket! - **PK**.

Tramp Art

by Peter Kokh

Artistic Resourcefulness

No amount of access to materials and tools can make up for a lack of talent. Nor, on the other hand, can lack of access to *preferred* materials and tools prevent resourceful expression of creative instincts. The artist in a person will surface, be his or her talent schooled and cultivated or not.

Natural artistic creativity and crafting abilities are widespread in all human populations. And there are abundant examples to demonstrate that the incidence of such talents do not correlate with either economic or social accidents of birth. In fact, it is the expression of artistic feeling by those without access to refined media and special tools that allows us to get a fuller grasp of just what art is, of just what artistic talent is.

Another factor that comes into play is the strong desire of artists to distinguish what *they* do from the work of others. Younger artists are ever on the lookout for new materials on which to work, for unsuspected or underdeveloped "talent traits" of old and familiar materials, for other ways of developing their own unique, special "style." Thus, amazingly, even in affluent cultures, many artists display the resourcefulness and creativity of "Tramp" artists. To see for yourself, just go to any art festival.

"Tramp Art" is a name given to a particular art form practiced by "hobos" plying the American railroad lines. Using common pocket knives, they carve intricate patterns into any wooden boxes, crates or broken wood pallets found along the tracks wherever they roam. Prime examples of this art from have come to be highly valued by collectors. "Tramp Art" is not a term used disparagingly.

But our purpose is not to examine this art form in itself. The emphasis is clear: tramp ART. "Tramp" is a word that stuck, but it could just as well have been "Hobo", "Homeless," or "Have-not."

Many art forms have been practiced through the ages using "found objects" for raw materials out of which to give form to one's artistic visions. Folk art, pop art are similar. So are the "cutesy" crafts that use plastic pill cups, popsicle sticks, empty coffee cans, and other commonly available and inexpensive use-them-once-and-throw-away detritus of our consumer civilization.

Even empty steel drums have been put to use by West Indies musician craftsmen who carefully reshape their ends to produce some of the world's most beautiful folk music! We've all heard the maxim: "necessity is the mother of invention." It applies to artists, craftsmen, and musicians as well.

Meanwhile, back on the Moon and Mars. ...

On the rough, rugged, and raw early frontiers of the Moon and Mars, pioneers will in time learn to make refined media out of local resources: regolith, mining tailings and processing byproducts. They will produce pure metal oxide powder pigments for use in paints, glazes and art glass; special claystuffs for ceramics: special alloys for metal sculpture and jewelry. But these preferred materials will become available as byproducts of industrial mining, processing, and manufacturing operations. Some of these byproducts will appear early on, others much later.

In the dawn period of lunar outposts and settlement, artists and craftsmen will have much less to choose from: raw regolith (carefully gathered for shade and hue); glass spherules; aggregate breccia pebbles and rocks. But they will also have some "value-added" materials to challenge their instincts:

- packaging left from items brought from Earth
  - ◇ containers - drums, boxes, crates, tins, etc.
  - ◇ separators, dividers, fillers
  - ◇ wire, strapping, foil
  - ◇ filler stuffings
  - ◇ rope, twine, string, rags
- "trash" from consumables
  - ◇ tin cans, bottles, jars, caps, lids
  - ◇ boxes, cardboard, paper, plastic film
  - ◇ worn clothing - "rags"

Now a lot depends upon how intensively and thoroughly the lunar operation is planned. If we do it right, all packaging materials, consumer or not, will be deliberately chosen, formulated, or designed to provide cannibalizable *manufacturing* stuffs not easily found or produced in the early settlement from the local materials. Some examples:

- copper (and brass and bronze)
- stainless steel
- lead, zinc, gold, silver, platinum and other industrially strategic metals
- reformable simple plastics: stuffing peanuts etc.
- biodegradable, nutrient-rich paper & cardboard

We've previously talked about this critical opportunity on several occasions, notably in MMM # 65 MAY '93, pp. 8-9 "Stowaway Imports". It all depends on who is in charge of the operation. If it is government, we will not see much of this kind of caring foresight. If it is business and industry, of necessity trying to leverage every opportunity to ensure profitability, preplanning of this sort may be intense. The pace and scope of future industrial diversification and growth will be at stake.

In this case, because the emphasis will be on meeting strategic manufacturing needs,the amount of scrap or leftovers available to artists and craftsmen will be less. But the law of diminishing returns as applied to such foresight efforts guarantees that there will still be some.

Looking ahead, we cannot predict the kinds of surplus items that will be available on the frontier for the use of artists and craftsmen and musicians. But perhaps planners should keep their needs in mind to include some packaging stuffs (e.g. food and other "consumer" packaging) that can be carved, reshaped, sculpted, decorated, etc. Input from artists of demonstrated resourcefulness on Earth will be helpful in this regard. Even durable goods with limited lifetimes can be designed to be made of materials the artist or craftsman can use. And not to forget worn clothing for the fabric arts!

Those with artistic soul will not suppress their need to create *until* more sophisticated stuffs and tools become available. Any discarded items that patient artists can find a way to shape, paint, mold or otherwise modify or assemble to

express their feelings will do just fine. Arts and crafts based on pioneer resourcefulness will lead to well developed space frontier folk art forms highly valued by collectors. In the meantime, it will be much appreciated by the early pioneers of whatever "status."

By whatever adjective -- tramp, cargo, folk, pop -- frontier arts and crafts will always thrive. It is, after all, part of being human to put the stamp of one's soul on the material counterparts of existence.

Past MMM Articles on Arts and Crafts

MMM # "Moon Mall"
MMM # 22, FEB '89, p. 6, "Hair"
MMM # 23, MAR '89, pp. 5-6 "Tailings"
MMM # 26, JUN '89, p 4, "Toy Chest"
MMM # 26, June '89, pp. 5-6, "ThermoPlastic"
MMM # 34, APR '90, pp. 3-5 "Recycling"
MMM # 55, MAY '93, p. 7. "MoonRoofs"
MMM #55, MAY '93, p. 8, "Shantytown"
MMM #77, JUL '94, pp 4-9: "Cinderella Style," "Furniture for the Lunan Homestead," "Upholstery Fabrics," "On the Wall," "Art du Jour"

Sculpture Stuffs

Sculpture includes more than objects which are carved or poured into crafted molds. Heterogeneous materials can be welded or bonded together or mechanically assembled into beautiful objects. Old bumpers and other junkyard auto parts plus imagination produce interesting and attractive pieces. In Mozambique, young sculptors have been welding the large supply of abandoned rifles into amazing pieces that are fetching top dollar. Scrap lying around and available at low or no cost is enough to energize the artistic creativity of frontier artists.

Depictive Arts

If it is prohibitive to import familiar art paints and painting substrates from Earth, frontier painters can carefully pour color sorted regolith fines and glass spherules into glass pane sandwiches not unlike the sand paintings done in the southwest. Collages of these materials small breccia will work. Once sodium silicate, the only known inorganic adhesive, can be produced, more options will open. As we start producing more secondary elements for formulating metal alloys, their oxide powders will be a great source of pigments for paints, ceramic glazes and glass stains. Even shorn human hair, in small strands and in powdered form, have been used to produce "paintings". An extremely rare art form, hair art might see a revival on the space frontier.

Fabric Arts

Packaging twine and rope and stuffing rags, along with worn clothing, and other fabric scraps will be enough to get frontier fabric arts started. We might encourage visitors and tourists from Earth to wear garments of desirable fabrics and patterns on the way out, to exchange for frontier-made apparel for the trip back. This practice would "sneak in" an affordable supply of fabrics that could not be easily produced in the early settlement. Worn clothing can be fashioned into colorful rag rugs, rag dolls, quilts, and patchwork apparel accessories.

Art Stuffs for Kids

Import packaging made of wax, reformable plastics, or fabric shreds will be one source of toy stuffs. So will many garden byproducts, considering the short life expectancy of most toys.

Imported Arts & Crafts Tools

Newly arriving pioneers might have an "heirloom allowance" so that they have relics of "home" to make life more rewarding. Thus artists could bring in special tools they need to practice their art - tools being much more important than materials.

Consumer Containers for Secondary Use

Consumer containers, whether frontier-made or made on Earth for use on the frontier, can be predesigned so that their material or shape makes them useful for an artistic "afterlife."

Craftable Imports:: modifiable utilitarian items

Some imported items will be assemblies of a "works" chassis, whose design rigorously follows function, and cabinets or casings that are a matter of style and preference. The optimum strategy for maximizing the industrial growth and diversification of the frontier calls for making the sophisticated parts on Earth and the less sophisticated, simpler parts where choice of materials is wide open entrusted to frontier industry.

Television cabinets are a poster boy example. They can be made locally of metal, glass, fiberglass-glass composites, ceramic or combinations thereof. In doing so frontier industrial designers can determine the finish styling. But we challenge them to come up with cabinets and casings that can both stand as made, but also support after-market customization.

Items with casings, cabinets, and handles that are imported from Earth in the early days before local frontier industries are able to contribute, can be designed with casings etc. that can be carved, stained, embossed, glazed or otherwise customized by frontier artists and craftsmen, for themselves, on commission, or for blind sales.

Art & Craft Stuffs from Early Industries

Every kind of industry produces waste of some kind. Substances that are melted produce slag made of immiscible elements that float to the top. Molten substances poured into molds produce splash out and spill over. Parts that are "machined" produce shavings, filings, saw and drill dust. All fragile products experience some breakage: ceramic pottery shards, and broken glass slivers and pieces.

- metal scrap: filings, shavings, cutoffs, dust
- slag & casting scrap
- ceramic shards
- glass
- concrete spillage
- sieve-sorted mining tailings

It will be general policy to recycle all such wastes back into the batch where possible. But in so far as we are dealing with materials from elements that are reasonably abundant, artists and craftsmen might be allowed to take what they can use of these stuffs from the bins of stuffs awaiting recycling. Of course, it will be up to the ingenuity and

resource-fullness of the artisan to put such materials to use.

Bottle glass is commonly sorted for color and then crushed and tumbled before being remelted. These piles may be attractive sources to some artists. Glass mosaics or collages can be partially or wholly melted to produce pieces of great heterogeneity and diversity. One modern craftsman makes custom table tops in this fashion. Crushed glass, whether available in sorted colors or not, could be used as is out-vac to decorate sintered pathway pavers and to embellish regolith shielding mounds. Indoors they could be used as is in Japanese style rock gardens, or to fill the hollows of two layer candle jars. The possibilities are limited only by the imagination.

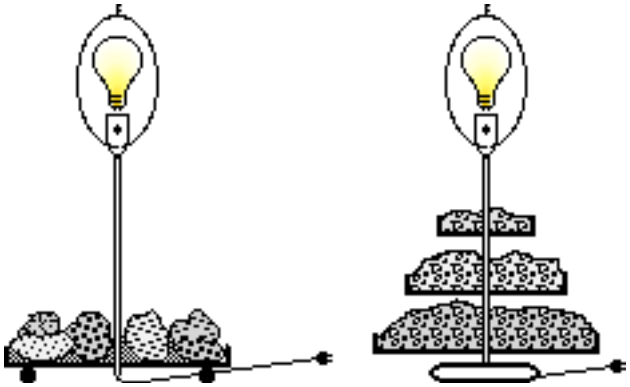
Recyclable post-consumer materials in any of these categories can be a source for the artisan. Scrap metal or ceramic fragments can be made into art.

Rock Decor

On the Moon, most rocks are breccias, angular fragments from older rocks, melded into clumps by glassified splashes from meteorite bombardments. They lack an even, homogeneous color or texture; each is a fascinating three-dimensional collage of minerals, an artifact made by Nature. Outdoors, such moon rocks can be used as borders for path-ways and approaches, or to decorate regolith shielding mounds covering habitat complexes.

Indoors, one could make interior Japanese style rock gardens with breccias, or cut them in half with a wet saw and polish them for display. (using a blacklight to bring out likely phosphorescent hues.) There should be a number of ways to mechanically attach sawn rocks to vertical "accent walls" without using wet mortar.

We could use rocks as well to give interest along with needed "weight" to bases of table and floor lamps. In the Moon's light one sixth gravity, we want to make tall items like lamps and drinking glasses bottom-heavy to prevent them from otherwise being easily tipped over. Lamp "kits" could come with trays of rectangular, hexagonal, or spherical shape, used singly or in tiers as optional accessories. The user would fill the tray(s) with interesting rock collections or sintered pebble-strewn moondust, or with other "collectibles".

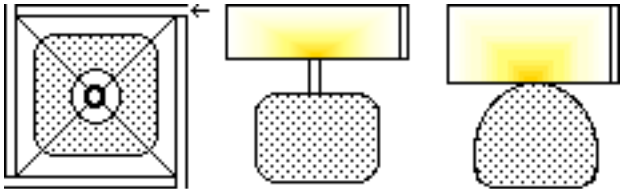


[NOTE: moondust contains a significant fraction of pure, unoxidized iron fines. To preserve the natural gray tones of the dust (and anything made of it) in pressurized, humid indoor conditions, remove as much of these iron fines as possible with a magnet. Or, to achieve a uniform rust tone shading right away, simply steam the dust as is.]

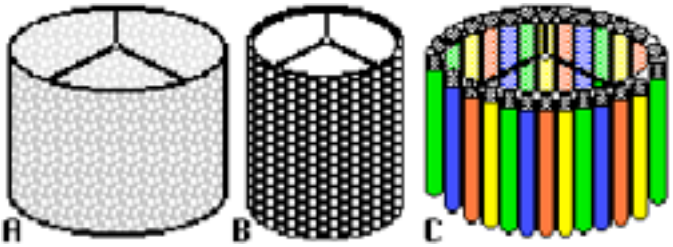
On Mars, their will be more kinds of rocks including sedimentaries, sandstones, granites, etc. While the gravity on Mars is more than double that of the Moon, it is still only three eighths that of Earth. So weighted bases will not be a bad idea there too.

Lamp Shades and Light Diffusers

On the Moon, where we'll want to leave our precious hoard of hydrogen, carbon, and nitrogen in the biosphere and food production cycles, we will be trying to avoid organic and synthetic fabrics and other materials. Fiberglass-based fabric lampshades are one option. Glass shades are another, there is already a lot of precedent; painted glass shades; Tiffany stained glass creations; cut, smoked, and etched glass shades. Earlier frontier artist and craftsman has many as yet unexplored alternatives. Below: a standard metal "frame" to be "filled" with any form of glass, metal, or ceramic panel set:



Overhead/side views of a lamp shade design of rectangular metal channel frame "shade starters" designed for slide-in panels of various materials, designs, textures, and colors: art glass; etched glass, pierced sheet metal, fiberglass fabric.



A) a "cracked" or frosted or regolith-blasted etched glass shade B) a punch-pierced tin can diffuser C) a "poor man's stained glass" shade: a metal frame with top rim accepting capped glass vials filled with vegetable-dye colored water: use all one color of the same or various shades, or try several colors, even a full rainbow of them. If the glass vials have molded texture or etched patterns for more interest.

Arts and Craft Stuffs from Frontier Farms

The constraints facing those who would use byproducts of lunar farms for the purpose of art or craft will be quite different to the situation facing their counterparts on Mars. For this reason, we will leave this engrossing topic for another article. Look for it in our annual Mars Theme Issue next March, in MMM # 143.

The Big Picture

When it comes to survival on highly challenging frontiers, whether it be for building and furnishing homes, farming, manufacturing things for domestic consumption as well as exports, resource-fullness and free spirited creativity creativity are essential. It is natural for pioneers to attempt to rely on what worked before - in their homelands. But all too often pioneers have found that the old doesn't work. Needed materials or tools may not be available. Or the old products do not meet new conditions. It is then that inventiveness is neces-

sary. And here we humans have never been found wanting.

On the Moon and Mars, pioneers will face environments "orders of magnitude" more different from those that any pioneers faced before them. They should be prepared.

The topic of pioneer selection has come up often. Whether sponsoring agencies move to aggressively select volunteers according to some list of desirable traits, or whether we rely on the process of self-selection by interested persons *fully brought up to speed* on the challenges that they will face (we would prefer educated free self-selection!), it seems clear that a premium should be placed not just on skills, but as well on creative resourcefulness and inventiveness - not just for artists and craftsmen, but for the would be frontier population in general. There is simply no other way they will survive.

Given this monition, it would be foolishly self-defeating for settlement sponsors and planners *not to invest* in a very complete, diverse **library** of frontier, folk, and ethnic productivity around the world and throughout the ages. Now the vast bulk of past forms of art, crafts, farming methods, building techniques, transport aids, *whatever* ... will not be obviously translatable to the space frontier. But the spirit of resourcefulness, the inspiration of their creativity will! And that wealth of instances will fortify the pioneers with the evidence that "we have rose to the occasion before, we can do so now!"

Arts, Crafts, and Trade

Some "practical" persons with undeveloped artistic sensibilities will find all this to be of "low priority" if not needless frillage. Yet the economic impact of developing arts and crafts is enormous.

When it comes to homemaking, a very significant sector of any economy, *we all* want to express our own personality and tastes. And it is largely to artists and craftsmen, individually employed or in the service of manufacturers, that we turn.

Art and Craft creativity also produce distinctive goods to fuel trade between communities and countries - again for the same reasons. From the old days of the Hudson Bay Company, to the Sears Catalog to today's online internet shopping, it is these frills that underlie much of our trade prosperity.

Perhaps the largest growth sector of most affluent communities is travel. Why do we travel? Yes, to be able to enjoy first hand, nature in its various manifestations: wonderfully different coastlines, mountains, forests. But also to see cities and towns, homes, farms and castles that are special because they include or embody different examples of art and craft creativity. And we travel to shop -- where the wares and wears are distinctively fresh.

On such trivia rest a major fraction of the world's economic activity. Now what can be more practical than that? Yes there are more pressing and more immediate concerns" -- finding and processing the ores we need, building enough pressurized space, planting and harvesting enough food, getting a mini off planet biosphere to work in the first place! No one would deny that. But in the long term, if we don't take care of the "frills", we will neither have settle-ment worth living in nor a future that is ever more attractive and fulfilling.

In the early years, it will be various forms of "tramp art" that carry the load. **<MMM>**

Looking out the Window

Direct-view water-filled windows

[footnotes are to Editor's comments which follow]

The MMM #137, August 2000 issue has some good material concerning windows for the Lunar environment. Here's my two bits: Water is another substance which can be used as a transparent medium for providing views of the outside while blocking cosmic radiation in cases where one prefers, for any reason, to have a direct unreflected view.[**1**]

One suggestion I've heard before is to hold a considerable width of water between two thick panes of glass. There are potential problems with organic residues building up, as well as mineral deposits eventually degrading the transparency of any window which holds or passes water. But these problems are probably not insurmountable. Mineral build up can be prevented and even reversed by applying an electrical charge of the appropriate amount to the body of water. Organic material in the water will be reduced to very low levels for the drinking water supply by numerous means. It is further advantageous, for the purposes of reducing the number of living organisms in the water, to expose it to strong ultraviolet light ... and cosmic rays are as hazardous to microorganisms as to humans. So water filled windows could function as part of the water purification system as well.[**2**]

Some might be concerned that a great enough width of water to block harmful radiation would cloud or distort the view too much to be acceptable. I've heard of natural systems with water clear enough to be almost completely invisible (when no waves are present) up to a depth of about ten or 15 meters. That is in natural bodies of water. Drinking water on the Moon would preferably be much freer of organic material (which is usually the greatest contributor to opacity in water) and have minerals no more abundant than the normal range for healthful potable water. So water which is almost or completely ready to be consumed on the Moon should be extremely transparent. A meter or two thick body of water should be essentially invisible. Also consider the water in neutrino detectors for an indication of how transparent water can be.[**3**]

But water can block radiation, including UV rays, so a very thick water window having only containment panes on the inside and outside would leave much of the water nearer the inner pane essentially unexposed to the rays which are being used to cleanse the water of microorganisms. If the only purpose of the water is to block dangerous radiation, then this probably would not be a problem. if the water in the window is permanently contained there, convection would almost certainly provide sufficient circulation to prevent clouding. But if the water is supposed to be cleansed for later consumption, then convection could not be counted on to do a sufficient job.[**4**]

There are several ways around this. One way would be to have the inner pane transparent enough to allow it to be up to a couple meters thick.[**5**] As with water. glass can be made that clear. The water would pass between the thick inner pane and a thin outer pane. One of the other possibilities would h=be to have many panes and pass the water between the outermost two panes and then back and forth between the other

panes until the flow finally passes between the innermost two. This makes sure that all of the water is well exposed to the cleansing radiation as well as using mostly water mass to block the radiation from having harmful effects on the residents inside the building.

Electronics to the Rescue?

That's one thought about how windows could be put to dual use. But personally, I prefer very high definition video screens as windows because they are so much more versatile. if one wishes to see out onto the Moon's surface they can. It would be possible in fact, not only to see a view of the surrounding area, but it would be easy to see any scene-scape on the Moon so long as there was a camera capturing the view. Indeed, any view anywhere in the realm of human reach could be displayed live as the signal comes in. It would be just as easy to look "out" the "window" to see images which had been recorded in motion or still photography. Artwork, too, could easily be displayed.

Think of the possibilities. View the construction efforts on Mars one moment, look at an outer planetary probe's view of Saturn the next, have Spaceship Earth visible "out" your window no matter where it is in the sky relative to your actual location, or even look "out" upon a view from Earth's surface. Imagine it, with an integrated environmental system you could look "out" on the view of a tropical beach, feel the warm tropical breeze on your skin, hear the sea birds and the rustling of the trees. Of course, if the settlement decides that people shouldn't have this kind of access to virtual settings (for whatever reason), it might still be a reasonable consideration to equip one or more public relaxation areas with something similar to whatever degree is deemed appropriate and affordable. I can image a water park arranged as a sandy beach with gently rolling waves, and with whole wall displays HVAC system creating the ambiance. And just because I happen to be stuck on a tropical beach theme as I write this doesn't mean that other themes aren't equally possible. let your imagination run wild.[**6**]

There are a couple other advantages to using video displays as windows. The first that occurs to me is the ability to use them also as communications displays when desired. And another advantage that occurs to me has to do with the physical nature of the Moon and of windows which depend on ambient light passing through them. The problem is dust building up on the outer surfaces. Given the nature of lunar dust as experienced by those who have been to the Moon, it is likely that it would quickly accumulate and degrade the view. Exterior surfaces of periscopes could be located high above the surface. But though accumulating dust more slowly, it would be much harder to access for cleaning. A video camera's transparent lens cover could quite easily be cleaned and/or replaced in a very short time, at very little expense, and with very little danger of injury.[**7**] **<RRR>**

EDITOR'S COMMENTS:

[**1**] If you have ever looked into a large aquarium, you will have noticed how greatly your view was triply distorted: as to apparent size, distance, and direction – thanks to the bending of the light path by water. It is reasonable to ask which is better: a zigzag, mirror-mediated undistorted view or a direct but distorted view? Now if you could just put something in the water to eliminate the diffraction index. Having looked through actual full-scale zigzag windows and finding the viewing amazing, I would not hesitate to choose that type of fenestration in my own lunar homestead. Binoculars, telescopes, even one's own brain "sees" what it sees through indirect pathways.]

[**2**] If the unit is sealed, why not simply fill it with distilled water - condensed steam. The water will be free of both minerals and organic content. No organic content, no food for microorganisms. Simple.

[**3**] Distilled water would be quite clear, but still drastically distort the view (diffraction physics.)

[**4**] Sealing in distilled water solves the problem but admittedly means water-windows would be outside the water recycling loop. If you do want to recycle water through the windows, you will need to circulate it, not just so that all of it can be UV-radiated, but to manage thermal heating and cooling which will be a big problem . If the window unit receives no direct sunlight, overheating will be minimized. Electric heating during nightspan will be needed. If the water is cooler than the interior air of the habitat homestead, condensation on the inner surface of the inner pane will greatly interfere with the view.

[**5**] Those familiar with the making of the thick mirror for the Hale (Mount Palomar) 200" telescope, know that it takes a very long period of controlled cooling to cool thick glass to avoid fractures and distortions. In fact, this is so prohibitive an undertaking both in monetary terms and in the amount of effort, that no larger lens has ever been attempted. Panes "1-2 meters thick" are currently constructs of the imagination.

[**6**] I can think of no reason not to have such video-mural screens on Den walls. *But by definition, if they show something other than the current real exterior view, they are not "windows."* Why not have both? If one is stuck with a location that sucks, you may not want to see the real scape outside. Heck, why go to the Moon or Mars at all? Why not just send a videocam or two and have such "let's pretend" video windows in our down Earth homes? That would save a lot of money! All of a sudden the old real estate adage of "location, location, location" looses its meaning! I don't mean to be sarcastic. This sounds like a great idea especially for the majority of us who want to go but will never get the chance. Selling such "universe windows" might earn us some money to help pay for the videocams and remote live feeds. But as desirable as such devices are, they are still not "windows." So let's keep brainstorming both!

[**7**] Going out-vac in a spacesuit to clean or changeout either a window pane or a videocam lens is something to be avoided as tedious, onerous, and not without risk. We have to experiment with electrostatic dust cleaners. At dawn and dusk when electrostatic dust suspension above the surface is more of a problem, both windows and lenses might be shuttered. Over time, both will slowly degrade from micrometeorite impacts. But changeouts every couple of years or so will be much more manageable than having to do the chore once, twice, or more each sunth (lunar sol or complete dayspan/nightspan cycle). I think we'll hear the familiar protest "I don't do windows" on the Moon as well. - **PK**

Synergy between Space Advocates and Greens

[footnotes are to Editor's comments which follow]

Another issue recently discussed in Moon Miner's REVIEW #27, July 2000, is the potential value of drawing connections between Earth's ecological needs and the space movement. This is becoming an ever more popular idea, and with good reason. If people are going to survive in space they will have to develop and put to use technologies and patters of behavior which could be applied to the protection and restoration of good ole Earth's biosphere.

The intersection of space and ecology *is* an important leverage point for us as aspiring space settlers, but it isn't a panacea. Selling the benefits of a healthy Biosphere One ecology has proven to be a very difficult, tedious, and hazard fraught battle that more than equals our own struggles to open the space frontier. There are numerous very well funded enemies to everything remotely related to a healthy ecology. Some actually have good reasons for their particular resistance. But most oppose everything "green" solely our of a fear of lost profits.

The space movement merely has to fight against a lack of funds. No significant forces that I am aware of battle against the exploration and settlement of space. Those who put up obstacles to our goals do so only because they wish the money that would be spent on space work to go to some other work which they prefer. They are not fighting us; they are *only* fighting for their interests. A very small number of less significance (to the welfare of our goals) oppose some aspects of space development because this or that bright object in the skies above Earth is sacred to them or because they don't want to be left out of the power and wealth which might result from successful space development. These have not proven to be very meaningful obstacles so far. My concern is that if we try to tie space development together with the ecology movement we will take upon ourselves powerful obstacles and considerable distractions while gaining nothing of real value. I know a lot of Greens and none of them who are not already interested in space are at all willing to admit that space could be a positive factor in achieving their ecological goals.

Nonetheless, there are niches, nooks, and crannies that we might fruitfully exploit in the realm of Earth ecology. There are those organizations, wealthy individuals, and even some businesses which value techniques and equipment which can be used to prevent environmental degradation or contribute to clean up. Our opportunity lies in developing the things we need for our futures in space and then raising capital for our plans by selling these things and/or their spin-offs to those who want them. We would be wise, in my opinion, however, to keep the battle for space access and development separate from the battle for a livable environment on Earth.[**1**] **<RRR>**

EDITOR'S COMMENTS:

[**1**] I count myself as an unofficial Green, concerned with the issues, But not a card-carrying party member. My personal take is this. We pollute Earth and its enormous "forgiving" biosphere *because we can get away with it:* our environmental sins affect the next generation, and we can take the attitude that "that's their problem." Money in the pocket is more immediate, and those who do not care what kind of Earth their grandchildren will inherit are much more impressed by near term monetary fallout of alternative courses of action.

Elsewhere in the solar system there are no biospheres at all, and the mini-biospheres we will need to build, grow, and maintain with loving care will not be large enough to "forgive" or "buffer" chemical or other abuse. In space, for the first time in our history, everyone will be *living immediately downwind and downstream of themselves*. Pollute, and *we* die, *not* our grandchildren. We will learn to do it right because there is no other choice. What good is being rich and dead? So by pioneering the space frontier -- even by brainstorming just how we are going to pull it off -- we will develop technologies and techniques that will help the Earthbound rescue our beloved Earth. - **PK**

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The Lay of the Land and Frontier Townsites

On Earth, the lay of the land, its mountain ranges, valleys and rivers, the location of passes, waterfalls and rapids, natural harbors etc. all help constrain roads and other transportation corridors, with their key intersects becoming sites for cities and towns. It will be much the same on the Moon and Mars. To some extent we can presketch their future frontier maps. For more, read "Transportation & Townsites" => below

MMM's "**Destination Moon**" Game Plan

FORWARD

To all but a few, the Moon is a monotonous, unpromising rubble pile. This is a bum rap and there are things that can be done to change it.

CONTINUED EXPLORATION

- Lunar Prospector's discoveries need "ground truth" verification and qualification - one or more rover probes to the polar permashade areas to confirm, quantify, and qualify the hydrogen-rich "water-ice" deposits.
- An all out effort to develop instruments that can detect subsurface voids (lavatubes) from orbit and map them.
- Produce an initial global "Economic Geography" atlas of the Moon

TECHNOLOGY DEVELOPMENT

- Make lunar resources more attractive by predeveloping "poor ore" water-stingy mining technologies
- Demonstrate an in situ silane (SiH4) production
- Demonstrate the energy and activity management strategies to enable overnighting anywhere on the Moon)

- Develop advanced versatile lunar transportation technologies - "amphibious" landers and terrain hoppers
- Make progress on modular biospherics strategies, with
  - ◇ system design problem abatement
  - ◇ source biological problem abatement
  - ◇ hydroponic and geoponic agriculture

COMMERCIAL VENTURE PUMP PRIMERS

- Bring exceptionally scenic Moonscapes into the living room with well-placed web-cams that follow the changing lighting conditions
- Return soil samples for materials processors to experiment with in workable quantities
- Return soil samples specifically for artists and craftsmen to experiment with to produce a touring exhibit of artifacts and art made from moondust
- Put contestant-teloperable rovers on the Moon.

DATA MINING MOON GLOBE ELABORATION

- Using Lunar Prospector altimetry maps and Lunar Orbiter photographs (high resolution Trailblazer I photos when available), identifying easiest, most negotiable transportation corridors and such pinch-points as rille fords, mountain passes, etc. [see following article]
- Identify and note promising townsite locations based on transportation routing. [see following article]

Transportation & Town Sites

by Peter Kokh

Home Planet Habits

A careful glance at any atlas will reveal a significant number of city and town sites that owe their location to geographic features that anchor transportation routes. Along the coast, there are many cities with natural harbors, some of these at the mouths or estuaries of navigable rivers (New York, Boston, Norfolk). Inland, perhaps a majority of cities and towns are located on lake shores or riverbanks. Among the latter, are many that have been founded at special points along their rivers: waterfalls and rapids (Minneapolis, Cedar Rapids, IA), fording points (Rockford, IL), easy portage points to parallel rivers (Portage, WI), and at major river junctions (Pittsburgh) or deltas (New Orleans). Others sit at an end of a lake around which surface traffic is diverted (Chicago!). Still others guard mountain passes serving as gateways (Denver). And then there are those secondary and tertiary sites that spring up wherever two roads or a road and a river cross. Not to forget railroad junctions! Perhaps not many people give the reasons for town location much thought. But they don't just plop down out of the sky.

On Shoreless, Riverless, Trackless Worlds

Interesting, perhaps. But what relevance does any of this have to the Moon or Mars? Neither world has actual oceans or lakes or rivers. Nor are there any roads or railroads across their barren trackless wastes. Ah! Perhaps not in the same explicit and developed sense as on Earth. But both worlds are full of features that will attract, redirect, or otherwise *constrain* transportation corridors and increase or decrease the suitability for townsite location.

Coasts, Seas, Lakes

The Moon *does* have coasts, even if its seas are of congealed lava floods rather than water. Maybe we won't have to change transportation modes when we go from lunar sea to lunar highland as we do on Earth (boat to car or train), though in time there may be vehicles specialized for both. More significant is the fact that there is a chemical makeup interface at the lunar coasts on the Moon, just as on Earth. Instead of "ground" to water, we go from soil richer in aluminum, calcium, and magnesium to soil richer in iron and titanium. Lunar Mare/Highland coasts are the prime locations for industrial town sites, affording access to both major chemical suites of lunar regolith.

But not all coastal sites are created equal. Some lunar coast areas will afford easier overland access through their rim ramparts into the highland hinterland "interiors" than others. That is, some coastal sites will offer breaks, passes, or easy ramps up into the higher, more mountainous and more crater-pocked highlands. They have the advantage.

Some lunar maria or seas are landlocked or isolated: Crisium, Marginis, Smythii, Humboltianum, Orientalis, Ingenii, Moscoviensis, etc. But on the nearside, most mare lava plains are interconnected: Oceanus Procellarum and Mare Frigoris, Imbrium, Serenitatis, Tranquilitatis, Fecunditatis, Nectaris, Nubium, Humorum etc. In some cases, neighboring seas are conjoined along broad stretches which leaves a lot of room for choosing one's route. In other cases, there are areas where it is much easier to traverse from one to the other. In these cases, the likely transportation corridors narrow considerably. Even a rudimentary Moon map or nearside photo will illustrate several such instances.

One especially narrow natural corridor links Mare Frigoris in the far north to the northern coast of great Mare Imbrium via the Alpine Valley. It is a no-brainer to predict the rise of settlements at both "valley gates."

Surrounding some seas or maria we find a number of "satellite" lava floods, sometimes named as lesser seas (Mare Undarum, Mare Spumans southeast of Mare Crisium, Mare Anguis [Greg Bennett's "Angus Bay"] northeast of Crisium) or lakes (Lacus Veris near Mare Orientalis): but many are nameless, e.g. northwest of Crisium. Perhaps these lakes will attract transportation corridors, becoming easy-going respites from otherwise more difficult highland traverses. We need to pour through the orbital maps and topography and altimetry data to define the best routes, ones needing the least bulldozing and grading, less cuts and fills.

On the maria themselves, as flat as they are in general, there are here and there impediments to easy going which one must either negotiate or detour around. There are some craters, even a few large ones, with their rubble strewn rims. There are also crater ruins or reefs, pre-lava flow craters that are only partially flooded. These are common in M. Smythii.

More important to consider are the lava flow features themselves. Flow fronts can be a hundred or more meters higher than older flows beyond. And then there are the sinuous rilles universally interpreted as collapsed lavatubes of especi-

ally large dimensions. Recall the pictures of Hadley Rille from the Apollo 15 mission. We must either negotiate their slopes or detour around them. In some cases we will be lucky to find natural bridges, actually uncol-lapsed lavatube sections. There are several of these along the Hyginus Rille in Mare Vaporum in central Nearside. The larger, most central of these bridges is likely to attract both highway location and, as an uncollapsed lavatube section, settlement. Put a town and an assured transportation corridor together and you get a prosperous trading center too.

As to the lavatubes we strongly expect to find wherever there are lavafloods, some of them, all else being equal, will make more logical settlement sites than others, simply on the basis of how conveniently they are individually located in relation to transportation corridors selected on topographical grounds. Eventually, all "buildable" lavatubes may be occupied, but the best placed ones will be settled first. If we have both a well-argued transportation corridor map, and an orbital radar map of lavatube sites, we could put together a good short list of prime sites.

Surveyors of the most logical routes for the highways and railroads and pipelines of the settled Moon ahead must pay attention to all these things.

Thus 2 things will shape the lunar globe:

1. **where** the various resources are
2. **how** we get materials, goods, services, and people back and forth between them

To determine a lunar outpost, even the first one, without paying attention to these other considerations risks setting the course of lunar development on a dead end course. Those determined to start at the South Pole rather than the North, risk just such an outcome. More about that next month.

The Northern Ocean & other Martian "Seas"

Mars, like the Moon, has no bodies of liquid surface water. Unlike the Moon, it once did. The seas of Mars are dried up real seas, not seas of frozen water. Here as on the Moon, we are likely to find clear chemical interfaces at the "coasts." Here also we will find easier or more difficult entry into the surrounding higher hinterland. Here as on the Moon, we will find some obstacles in traversing these seas, but they will be obstacles carved by water rather than by lava floods.

All of these considerations will constrain transportation routes and help determine future town sites. But there is this difference. On Mars, there is the real technical possibility, the ethical and moral debate aside, of filling this ocean and these seas with water again. Those who dismiss this possibility will dare to build settlements on the dry ocean floor, much as some Israelis, who dismiss the possibility of Palestinian statehood, dare to build settlements on the West Bank. In either case, no one can demand that those in question not take that risk. But the risk remains. And much as diehard Israelis hope that there settlements will provide a barrier to the recreation of a Palestinian state, future "Reds" on Mars, as they have come to be called, are likely to found settlements and build roads to them on the dry ocean bottom in hopes that this will pose a political fait accompli to prevent refilling of the ocean basin.

The other significant depressions are the Argyre and Hellas basins, the latter by far the deeper and most extensive. If one were to pick and choose areas to flood with precious water, Hellas is the most logical, the vast northern ocean bed the most ambitious. Arguing against the flooding of Hellas is the fact that as the lowest depression on Mars, it enjoys the marginally highest air pressure -- it is still very thin. It is unlikely anyone alive today will see either eventuality. Speaking of Hellas, by pure chance, the greatest seaport in the fictional Mars (Barsoom) of Edgar Rice Burroughs was Helium. Both words come from the Greek but are from different roots. In Greek, Hellas is Greece, Helios is the Sun.

The great Martian lava floods poured out from volcano throats, building up shield volcanoes layer upon layer analogous to, but far, far larger and taller than Mauna Kea/Mauna Loa (the Island of Hawaii): the trio of Ascraeus Mons, Pavonis Mons, and Arsia Mons, plus the mighty Olympus. In contrast, the lunar lava floods oozed out of the fractured bottoms of great impact basins and spread out evenly. In both worlds these lava floods are likely to be riddled with lavatubes, ready made shelter for settlements, industrial operations, warehousing and archiving. In both cases these offer safe and secure settlement sites. On Mars, Pavonis Mons, being by chance astride the equator, assumes an enormous advantage, its west slope the best location in the solar system for a launch track, its summit the best anchor in the solar system for a possible space elevator. Add in an extensive maze of lavatubes and Pavonis Mons is the most assured major urban site in the solar system beyond Earth.

The Crated Highlands of Moon and Mars

The crater-pocked highlands of the Moon and Mars are strikingly similar in appearance and morphology. In both cases there are areas that are saturated with craters large enough to discourage travel. In both cases there are "intercrater plains" that would seem to be easier going. Whether we set about to survey future roads, railroads, or pipelines, we need to pay very close attention to the altimetry and topography data in picking the easiest most sensible routes. The routes selected will in turn decide which potential town sites see the light of day. Even in the case of significant highly localized mineral deposits, sites on or near logical transportation corridors are the likely to be developed.

If one looks at the best photographic atlases of the Moon and Mars, it is almost possible to plot the most negotiable routes now. But we won't want to cast our choices in concrete before seeing the very high resolution data. Terrain that looks very smooth in medium resolution, can be revealed to be strewn with boulders of significant size on further investigation. The whole length of all proposed route options must be looked at carefully, their various pluses and minuses weighed before making a decision.

Happily, on the Moon and Mars we have the chance to identify and preplan these corridors in advance of settlement, and thus in advance of politics. On Earth, it is all too frequent that a less logical routing is picked to bow before political pressure from already established settlements along one of the proposed routes. *Lay out the transportation map first, then*

choose the settlement sites. On the Moon and Mars the jury on successful establishment of human civilization will always be out. We cannot afford to make mistakes for political reasons.

The Poles and their Approaches

Both on the Moon and Mars, the significance of the poles is that they hold known water reserves. Even if, in the case of the Moon, we find excess hydrogen rather than water ice, it amounts to the same thing. Oxygen being everywhere in the rocks, the essential special ingredient of water is hydrogen.

On both worlds, thirsty circumpolar and equatorial settlement prospects may rest on tapping these polar reserves. On Mars, some non-polar areas are blessed with abundant permafrost in the soil. Siting a settlement in or adjacent to such areas will be very attractive IF these reserves are shown to be sufficiently extensive, practical to tap, and sweet rather than saline. Only "ground truth" probing can determine this. In advance of on site testing, we can only sketch the vague boundaries of permafrost areas of high promise, *all else being equal,* and we can do that only if we succeed in brainstorming and flying instruments to detect and map subsurface permafrost from orbit. This is a high priority for which there is as yet almost no demand among the planetary scientists interested in less practical "knowledge".

Meanwhile, early planning is wise to start with brainstorming how to get polar water ice to other areas of the globes of the Moon and Mars. If we truck it, we need roads. If we send it by rail, we need railroads. If we pipe it, we need pipeline routes. In all three cases we need reasonably easy routes. These preselected routes will determine the corridors along which secondary settlements make sense.

Heated water pipelines or aqueducts seem logical for Mars. On the Moon where surface temperatures range to both higher and lower extremes, it would make much more sense to refine the water ice along with any immixed carbon oxide ices (highly likely given their cometary origin) into Methane CH4, and oxygen, piping both gases in carefully separated parallel pipelines to user market terminals. At the various destinations, these gases can be recombined to produce water and useful carbon dioxide in a process that recovers the energy put into refining as a most useful bonus. That makes this operation a logical choice for nightspan scheduling when availability of energy is lowest.

Thus the paths of water movement away from the poles on both Moon and Mars will do much to fill in the maps of both globes with the details of human civilization. On Mars, human-built canals will be as significant to both economy and biosphere as the imaginary ones of Percival Lowell.

Starting Now - a Project for 2001

We already have good enough altimetry and topographical data on both the Moon and Mars to begin now to predict at least some off the more logical transportation corridors on both, as well as narrow down where they will intersect. Who will do this? Not NASA, which uncommitted to settlement, is not about to indulge in such foolishness. This is a job for groups of volunteers, perhaps dedicated chapters of NSS, the Mars Society, and the Moon Society.

Railroad routes will be more demanding than road-ways to plot as they have more demanding grade constraints, even in lunar gravity, perhaps especially so as traction is reduced along with gravity while momentum remains the same. We will want the highest resolution altimetry and typography data to select wisely from route options of competing merit.

Pipelines can use pumping stations, and gas pipelines are less sensitive to grade than liquid ones. but, we will want to plan either with pump stations conveniently serviceable from parallel roads.

In carefully, slowly, filling up our maps and globes with promising routes and nodes, we should not neglect nearby scenic attractions of opportunity. There is a lot worth seeing on the Moon and Mars. What people get to see most commonly, will be those features nearest to travel routes established for trade and commerce on topographic grounds. We may find logical names for some of these scenic overlooks.

As routes, intersections, nodes and hubs are identified, we might give the more prominent of the settlement sites suggested by this network provisional imagination-feeding names. In many cases we can do this quite logically by basing these names on nearby features with internationally established names, using suffixes or modifiers like ford, bridge, pass, gap, valley, gate, head, delta, outlet, lake, heights, point, junction, portage, ridge etc.

We needn't name them all, only those where a logical name is rather obvious. The other sites can be marked with mapping symbols for the nature of their advantage, the symbol sized according to apparent strength of that advantage. For example:

And Voilà! two suddenly more "human" worlds. Science fiction writers would have a shared convergent plateau from which to build further. The rest of us, pouring over such "frontier feature annotated" Moon and Mars maps and globes would sense worlds the outlines of whose human futures could already be glimpsed through the fog of events still in the future.

Of course, none of these names can be more than provisional "working designations" pending the approval or disapproval of the eventual settlers themselves. The point is that simply naming places on the Moon or Mars with carefully reasoned high settlement potential will work to advance the day such settlement becomes a reality. **<MMM>**

Rick Osterick

Foreword

In a recent MMM issue [#135 MAY '00, pp 7-8], Peter Kokh wrote about cast basalt, a material used on Earth, and speculated about its possible use on the Moon and Mars. Within the article, several claims were made about the unusual properties of cast basalt such as extreme harness (9 on the Mohs hard-ness scale) and extreme toughness. Hardness, in the technical jargon of materials science, is the resis-tance to being scratched while toughness is the resis-tance to breakage. As a

geologist familiar with natural basalts, I was extremely skeptical of the unusual properties claimed. After some discussion with Peter, it seemed clear that direct measurements on cast basalt samples were needed. I was able to purchase four tiles from Decorative Cast Basalt Sales, LTD of WQebster, West Virginia for testing.

Cast basalt is advertized as being an "abrasion resistant" material suitable as a coating on metal or metal parts which are subject to abrasive wear. The term "abrasion resistant" is simply another way of saying that the material is very hard (resists scratches). Since abrasion of lunar regolith within machinery is of great concern, an abrasion resistant material which could be manufactured on the Moon would be extremely useful. In addition, cast basalt could be useful as both structural and decorative building materials.

Putting Cast Basalt Samples to the Test

When the tiles were cut open, using a saw with a diamond blade, they displayed an interesting cross-section which is illustrated below.

Hardness measurements were performed on the cast basalt tiles using a series of "hardness points" with each point having a known hardness. The tests were conducted by Carolyn Reynard, president of the local gem and mineral club, and myself. We found that most spots tested on the exterior of the tiles were approximately $8^1/2$ on Mohs Hardness scale, with a few spots as low as $7^1/2$. [On this scale, Diamond tests as 10.] The interior of the tiles are slightly softer, from $7^1/2$ to 8 on Mohs Hardness scale. The samples of cast basalt studied are *indeed very hard* and should be very useful as an abrasion resistant coating.

Several microscopic slides, called thin sections, were also made from the cast basalt tiles. The thin sections were studied using a petrographic microscope which is designed for the study of rocks and minerals. The microscopic analysis can identify which minerals are present by determining their optical properties. The microscopic study of textures and structures within the sample yield insights into the conditions during formation.

The thin sections examined have the following constituents:

- glass
- olivine = $(Mg,Fe)_2SiO_4$
- pyroxene = $(Ca,Mg,De)_2SiO_6$
- an opaque mineral, may be magnetite = Fe_3O_4. (1)

This mineralogy matches the description given on the website* of Decorative Cast Basalt Sales, LTD. The hardness of these minerals range from 5 to 7 on Mohs Hardness scale and therefore can not account for the measured hardness of the tiles. (2)

* http://www.decorativebasalt.com/

Analysis of the Test Results

My best guess at the moment is that the glass present is responsible for the great hardness of the cast basalt tiles. Study of the thin sections shows that glass is more abundant around the edges of the tiles than the interior. This may explain why the exterior of the tiles are somewhat harder than the interior. Spherulite structures enclosed in glass are commonplace around the tile edges. A spherulite is composed of tiny needle-shaped crystals that radiate outward from a common center, producing a roughly spherical cluster. Both the presence of basalt-compo-sition glass and the presence of spherulites indicates a very rapid cooling rate. (3)

Natural basaltic glass is most commonly produced when a basalt lava flow erupts into water and is cooled in a few seconds.

Further study of the thin sections showed that approximately 5 to 10% of each tile consists of mineral grains with the following features:

a. they are significantly larger than the other mineral grains
b. they often have an angular shape characteristic of broken crystals
c. some of these large, angular crystals display resorption textures which indicate they were dissolving into the molten basalt.

These observations can be explained if the natural basalt was crushed, melted partway (90-95%) and then poured into molds to form the cast basalt. Once in the mold the melt was cooled rapidly, producing the basaltic glass and spherulites. The tiles are then annealed or baked for many hours according to the manufacturer.

Suitable Crucibles and Molds

Other issues concerning cast basalt include the type of materials needed to make crucibles and molds and whether Lunar cast basalt would have the same abrasion resistance as earthly cast basalt. Generally speaking, the materials used in molds and crucibles should have two properties:

- a high melting temperature (and)
- a low solubility in the molten sample.

Since basalt melts fully at 1100 to 1200° C, the mold and crucible materials must have a higher melting temperature than 1200° C. (4)

As a graduate student, I made simplified basaltic-composition melts using crucibles of platinum and of platinum-rhodium alloy. These metals have suitable characteristics but are rather expensive and scarce on the Moon. (5)

It is important to understand that the choice of material also depends on the details of manufac-ture. For example, some high temperature molds are designed with internal cavities through which water is circulated. Such water-cooled molds would not have to be made of an exotic material like platinum, but might be made of silicon, iron or titanium (melting temperatures of 1382° C, 1535° C, and 1668° C respectively). (6) Each of these elements is rela-tively abundant in lunar rocks. (7)

The crucible material needed also depends on the style of heating. The platinum crucibles I used as a graduate student were placed inside a furnace, thus both the sample and the

crucible was at very high temperature. During lunar manufacture, a "solar furnace" may be used to focus the sun's energy onto a small region of the sample. This top-heating geometry would result in strong thermal gradients with the highest temperatures near the focal point and much lower temperatures near the crucible. As the sample is heated by the solar furnace, a puddle of molten material would form, but a buffer of cooler, unmelted material would also exist between the melt and the crucible. Over time, the molten puddle would expand as the material in the buffer region melts. Just as the last of the buffer zone melts, the molten sample could be poured into molds. Using this top-heating geometry would ensure that the crucible was only briefly in contact with the hot, molten sample. Iron or titanium crucibles would probably be adequate for this type of heating.

A completely different approach would be the use of aqueous gels to create a glassy ceramic material similar to cast basalt. (8) In this method, a gel is created from a water-based solution. When the gel is heated and dried, a glass of the desired composition is produced. This approach has been used to create quartz and feldspar glasses, but I've never heard of basalt-composition glass made in this way. The benefit of this approach s that very high temperatures are not needed. However significant amounts of water and chemicals *are* needed, and it isn't clear whether the properties of cast basalt can be produced in this manner.

Conclusions

Would lunar cast basalt have the same useful properties as earthly cast basalt? The honest answer is, I don't know. Lunar basalts are different from basalts used to manufacture cast basalt on Earth in two ways. First, lunar basalts have slightly different chemical compositions than earthly basalts. (9, 10) Second, the conditions of formation on the Moon are different than on Earth. Specifically, the oxygen fugacity was different producing less oxidized minerals on the Moon. (11) Even worse, I don't really understand why cast basalt has the unusual proper-ties [extreme hardness] that have been observed.

My best guess is that lunar cast basalt will be useful as an abrasion resistant coating and as a building material. It is clear, however, that much work needs to be done to verify this guess. Fortu-nately, it is possible to produce both lunar basalt compositions and their conditions of formation of the proper equipment is available. many simulated lunar basalt samples have been created and studied. (12 and the many references therein) unfortunately, the physical properties of these samples (hardness, toughness, etc.) were not measured **<RO>**

Footnotes:

(1) Dana's Manual of Mineralogy, 17th ed., 1966, Cornelius S. Hurlbut, Jr. John Wiley & Sons, Inc.; pages 400, 431

(2) *Ibid*. [same book], pages 309, 400, 440

(3) Experimental Studies on The Dynamic Crystallization of Silicate Melts, 12980, Gary Lofgren in "Physics of Magmatic Processes", R.B. Hargraved, ed., Princeton University Press

(4) Petrology, 2nd ed., 1996, H. Blatt and R. J. Tracy, W.H. Freeman and Company, page 81

(5) Physics and Chemistry of the Solar System, 1995, John S. Lewis, Academic Press, page 385

(6) Engineering Materials, 5th ed., 1996, Kenneth G. Budinski, Prentice Hall, page 8

(7) Solar System Evolution, 1992, Stuart Ross Taylor, Cambridge University Press, page 268

(8) Engineering Materials, *op. cit.* [#6 above] page 8

(9) Physics and Chemistry op.cit. [#5 above] pp. 382-5

(10) Outpost On Apollo's Moon, 1993 Eric Burgess, Columbia University Press, page 42

(11) Mining the Sky, 1996, John S. Lewis, Addison-Wesley Publishing Company, Inc., page 45

(12) Experimental Studies *op.cit.* [#3 ›] pp. 487-551

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Meandering Through The Universe

A Column on the Cooperative Movement
on the Space Frontier © 2000 by Richard Richardson

Who is best fit to work on the Space Frontier?

Scientific American, July 2000, p. 8 [Letters]:

"I read with great interest 'Staying Sane in Space' [Scientific American, March 2000]," by Sarah Simpson. Astronauts have traditionally been chosen from the ranks of test pilots, people with highly trained minds and bodies. Unfortunately, such a body rapidly deteriorates during a long period of inactivity, and a mind trained to make split-second life-or-death decisions is not likely to be content spending years with a small group confined in space. A body that was never very fit is not likely to change much in a small spaceship, and the world abounds with people content to spend all of their waking hours in front of a TV or computer screen. The solar system will not be successfully explored by people with "the Right Stuff." It will be conquered by couch potatoes."

- Leo A. Frankoswski

Well, folks, what do you think of Mr. Frankowski's idea? You know, I think he's very very close to the mark. It seems to me that the ideal person for space exploration is someone who fits the "computer nerd" stereotype in many ways with a few good dashes of armchair intellectual and casual athlete. We don't necessarily want our explorers or earliest settlers to be excessively overweight, dangerously thin, nor otherwise unfit, but beyond a certain degree of physical fitness, we are likely to start facing diminishing returns.

Our world's spacefarers, thus far, seem to have included many truly good and well rounded personalities -- and I would argue that they have generally fit reasonable requirements for earliest explorers of the space frontier very well. But figures of Adonis and Diana are neither necessary for those just behind the vanguard nor are they the best pool to draw from to find those most qualified for after-the-vanguard roles.

The test pilot/PhD/ultra-athletic model shouldn't be excluded, but those qualities are not the most important for what we want to do. Indeed, whether a veritable god/goddess or not, the qualities which are most valuable in settlers are the ability to entertain oneself productively in prolonged boring settings, to find innovative solutions to unexpected problems, to work well with others over the long haul, and the ability to rise to crises as needed. One thing is for sure: in the long run, those who will be the heroes (recognized by history or not) of humanity in space will be those who happen to find themselves in dangerous and pivotal circumstances and respond successfully with courage and intelligence.

The only way to positively identify such individuals (and not even all of them, at that!) is to look back into the past. The "best" person can never be identified for any particular setting or circumstance. How anyone will respond to a specific setting or circumstance is only known after the fact. Of course, it is possible to make somewhat reasonable guesses about these things in advance, but one should always remember that they are guesses.

My point -- and at least a corollary to Mr. Frankowski's assertion -- is that we need to think long, hard, and clearly about what qualities and what priority of qualities we want to *select for,* and which qualities we want to *select against,* when we begin choosing people to establish our earliest settlements in space. And even if transportation costs fall so low that anyone who wants to do so can move to a home in space, we will still have to make choices about which person will fill which job. I am suggesting that, in general, the traditional means for making these decisions may not be the best way. Doing anything in space in any way other than the best way that can be discovered and applied, only adds an additional layer or risk to an already extremely risky endeavor. If we seriously desire to succeed, we will have to reevaluate everything carefully, and not rely on conclusions derived from Earth-based, tradition-bound assumptions.

Effect on the Frontier of Slowing Aging

This same issue of Scientific American (July) also has a fascinating piece in the "News & Analysis* section about sugar-protein bonds, their implications in aging, and recent research which might [I emphasize, might] eventually lead to breakthroughs in slowing aging, reversing many diseases, and generally improving the quality of life. Such an eventuality would have an immense impact on the effort to take Gaia out of her cradle (i.e. settling space).

Yes, achieving victories in the battle against aging presents the danger of rapid population increases which could result in serious problems. But if reproduction issues and their repercussions can be figured out and handled well, then there would be the potential to greatly extend the period of productivity of individual citizens (both absolutely and in percentage of the total life span), perhaps reduce the percentage of low productivity and dependent citizens, and maybe even allow individuals more time (and less stress from the perception of life passing too quickly) to develop their potential more fully than is now common. Still, don't hold your breath.

The Right to Risk Injury & Death

While we're on the subject of life and death, let's talk about the right to die and/or risk injury or death on the space frontier. There are at least two especially significant aspects to this whole area:

1. "thrill seeking" activities, and
2. suicide as a release from severe disability or suffering.

At some point, we will need to define the acceptable limits of risky behavior. Should any activity which does not directly threaten the welfare of anyone other than the reasonably sane adult choosing to participate in the risky activity be allowed? Should the welfare of those who might be indirectly harmed by the injury or death of the reasonable sane adult in question be considered when deciding what activities should be banned, restricted or regulated?

For example, if a parent of minor children is maimed or killed, both the children and those upon whom their future care will fall are going to be seriously impacted. This is going to be a very tricky question if the early settlement is struggling to survive. Of course, if the early space settlement's economy is robust enough to easily afford rearing orphans, etc., and if there aren't a lot of people intent on pushing their moral values related to risk-taking down others' throats, then ... no problem(?)*

Suicide on the Space Frontier

The other question I mentioned concerns suicide to address quality of life issues. This one has got me stumped. I personally believe that a reasonably sane adult ought to be free to do most things which do not cause greater harm to other people than the probable positive contribution to those same other people's welfare. That can be extremely difficult to judge, and any rules, regulations, laws, or moral precepts that a society might construct would surely not address all circumstances well. But as long as there are serious injuries, illnesses, and disabilities among humans, this question will continue to be an important one. What should a space community's position be on this issue? **<RRR>**

* [**EDITOR:** I can think of a tougher example.

> The only surgeon in the settlement, once an avid spelunker on Earth, wants to indulge his neglected passion by exploring lavatubes, on his own, in his own free time. His death would plunge the settlement into crisis.

In general, in the early days of the frontier, there will always be too many things needing to be done and too few people to do them. That is quite unlike the situation that prevails most of the time in established terrestrial societies, where jobs are usually scarcer than people wanting them. If someone skilled dies on Earth, the loss is felt, but usually society recovers quickly. We are drilled from birth that no one should be unexpendable, that everyone should take care that whatever enterprise he or she is engaged in will go on, should something untoward happen. On the frontier, this will be much more difficult to guarantee. But rather than mandate that anyone who cannot be easily replaced *must not do anything risky,* it will be better for those of special talents and expertise to spend quality time training contingency replacements. *Risk has value!* - **PK**]

The NSS Road Map to Space Settlement

A Special Message from the NSS Chairman

Charting a Course for the New Millennium

http://www.nss.org/community/roadmap/index.html

by Ronnie Lajoie, NSS Director and
past president of the NSS Chapters Assembly

Those of you who have followed my columns over the last couple of years will have seen some recurrent themes appearing throughout. Issues to do with the globalization of space activities; the ever increasing trend to commercial space activities; recognition of the multifaceted environment in which space development takes place.

The space environment that we face today is different to that of a couple of years ago, and it will be different to what we will face two years from now. Some underlying trends are slower to change, but some shift with the blink of an eye. Some important sources of influence are completely outside the usual domain of the space environment. For example the fall of the Berlin Wall had all sorts of consequences for the space industry, and space development in general. What all of this means is that we as an organization must continually reassess the environment in which we operate, and choose those activities, which will be most effective.

In 1998 NSS embarked upon a process of Strategic Planning. The process of Strategic Planning is very much a top down progression. We began by establishing our *Vision* (the future that we are attempting to create), then our *Mission* (what it is that we plan to do to bring that about), and then moved on to some of the major areas that required our attention. Some of these areas of focus were internal, such as broadening the Society's base of funding. Others were external. The most significant of these being the development of a “Road Map” to chart how today's space scene must evolve, in order to produce the spacefaring civilization that NSS seeks.

In September ‘99 a group of highly committed Directors, Chapter leaders and activists came together at an NSS Policy Summit to collectively, and intensively, debate what they determined to be the key attributes of a spacefaring civilization; what developments needed to occur to achieve it; and what barriers needed to come down to make our vision, reality. The output of that Policy Summit is the Road Map that NSS will now use to guide our activities. It not only establishes the pathway forward, but also identifies milestones that we know must be passed, if we are to be making progress towards our goals. Not only does it help prioritize the key areas requiring change, but also it gives us a timeframe for how long we have to change these things, before they become anchors holding us back from the future.

With the Road Map in hand we can begin focusing our efforts on addressing the most urgent, and most important barriers. At all levels of the Society's efforts, from individual activists, through chapter activities, right on up to the national and international activities of NSS, we can channel our efforts for maximum effect. One of NSS' greatest strengths is often also one of its greatest weaknesses. We have a tremendously diverse array of backgrounds and skills amongst our membership, yet all too often members feel that they need to be part of the space industry to be able to contribute to our cause. That couldn't be further from the truth, and in fact the Road Map helps highlight the fact that we have technical, legal, economic, regulatory, psychological, cultural, and physiolo-gical barriers to overcome. In effect we NEED people from all walks of life to be able to influence the diverse array of barriers before us.

Aside from guiding NSS in where to focus its efforts, the Road Map also serves to help every activist understand how their efforts help to make a difference. Whatever activity the Society or its members undertake, should have some relationship to attacking the barriers we have identified. If it is an NSS seminar to educate investors about reusable launch vehicle technology, it is helping to bring about the cheap access to space that we require. If it is Australian members writing to their Government Ministers to have Australia push for the abolition of the Moon Treaty, it clearly supports our belief in the need for protection of private property rights in space. Every thing that we do should be able to be linked to removing those barriers along the pathway to our vision. If they can't be linked to the Road Map, then chances are that those efforts are not addressing our highest priorities, and therefore should no longer absorb our resources.

While the Road Map is our guide for now, like all road maps, it will need to change with the evolving scene. Just as Strategic Planning needs to be constantly revisited to stay in tune with current needs, our Road Map must be reevaluated periodically to make sure we are pursuing the issues of greatest relevance to NSS' vision, and those most in need of our assistance.

The current Road Map is a bold step forward for NSS. Rather than simply following well-trodden paths, NSS has taken a major step in spending real time to examine, debate, and discuss the real issues standing between us and our vision. Those who were directly involved in the Policy Summit that produced the Road Map felt that it was one of the most meaningful activities that they had been involved with for many years. We owe a debt of gratitude to those 'Summiteers' who spent so much of their own time to achieve this result. We can all now repay that debt by focusing our efforts on bringing down the barriers that they have identified. The road may be long, but at least someone has marked the pathway for us.

NSS wants you to get involved in this roadmap to space. We need every member and space activist to take up the issues and obstacles identified in this plan, and suggest possible pathways to overcoming these barriers. Review the NSS Road Map by going to:

http://www.nss.org/community/roadmap/index.html

[Editor: this is the current address as of 6/4/2006]

The Menu at this location includes the following:

- NSS Roadmap to Space Settlement
- NSS Vision
- Envisioned Milestones
- *No Matter Where We Go These Milestones must be passed*
- To The Moon

- To Mars
- To Other Destinations
- NSS Mission
- Social Barriers to Space Settlement
- Economic Barriers to Space Settlement
- Technological Barriers to Space Settlement
- Political Barriers to Space Settlement
- Our Task
- What Should You Do?
- Acknowledgments

Please explore and study the above and send your comments and ideas to Ronnie LaJoie, NSS Roadmap Coordinator, at:

Ronnie@lajoie.com

[**Editor:** The Road Map to Space Settlement is the most constructive and potentially the most productive policy initiative ever undertaken by the National Space Society. We strongly urge all readers, whether members of NSS, of other organizations, or unaffiliated, to get involved in this pooling of brains.

Only if we make ourselves fully aware of all the obstacles - roadblocks - to the achievement of our space frontier dreams, will we be able to work effectively to overcome them, one at a time, patiently. More importantly, only with such a global Road Map can we hope to wisely pick our battles.

It is not enough to be enthused, not enough to work hard, not enough to put bottomless energy into our efforts. We must *"work smart!"*

The Road Map at present is but a "Work in Progress." It will always be a work in progress. The obstacles will shift and change and our tactics and priorities must change with them.

Previously, the Space Frontier Foundation has identified some of the priorities: cheap access to space, saving the Mir space station for commercial use, etc. But now we are in the process of developing a more encompassing tool that will complement the prior work, address blind spots, direct diverse energies, finding appropriate tasks for each of us. - **PK**]

APPENDIX - from MMM #134

The "Human History" of Eros

by Peter Kokh

On Saturday night, August 13, 1898, Eros was discovered photographically by Gustav Witt, director of the Urania Observatory in Berlin, Germany. Once its orbit was calculated, it received the number 433. Number 1 Ceres had been found 97 years earlier. Eros was the first Earth- approaching asteroid to be discovered. All previously detected minor planets being denizens of what is now called the "Main" Belt.

That it crossed the orbit of Mars to come within 14 million miles or so of Earth's orbit (two and a half times closer than Mars ever gets) immediately made it famous, and stirred the imagination. As did its striking variation in brightness with a period 5 hrs. 16 minutes. On that basis alone, astronomers quickly realized it must be an elongated "sausage-shaped" object. In fact it measures 22 miles long with an 8x8 mile cross-section.

To the brilliant imagination of Dandridge Cole, this suggested a startling possibility - *perhaps Eros was artificial*. Perhaps, he conjectured it was *a giant derelict spaceship of some other civilization*. Its builders had taken an ordinary asteroid and *reassembled it into a hollow rotating structure that would hold atmosphere and have artificial gravity through its spin, with a living surface on the inner exterior wall of the cylinder*. Sound familiar! Yes, the idea of Space Colonies floating freely, perhaps even on interstellar journeys was developed by Cole long before Gerard O'Neill popularized the idea in the late 70's. I myself read all about Cole's vision in a 1950 pulp magazine - I would have been twelve, and I was a space nut already. So for space activists with dreams of such possibilities, NEAR's arrival at Eros, and its ongoing orbital reconnaissance is something of a pilgrimage to our roots. Of course, Cole's musings were wide of the mark. Eros is a solid body, elongated but far from cylindrical.* But so what! He planted the seeds of imagineering on a colossal interplanetary scale. [see page 30 above for photo of Eros.]

Space.com Interviews MMM Editor

ET Lavatubes Get Publicity

MMM Editor Peter Kokh was interviewed via email by Space.com senior science writer Robert Roy Britt on the topic of lavatubes and their potential use on both the Moon and Mars. Britt got Pete's name from R.D. "Gus" Frederick of Oregon L5 who was also interviewed on lavatubes on Mars. Gus is an avid lava tube explorer in the Pacific Northwest where such features abound. The interview resulted in two articles, both published online on March 21, 2000.

Lunar Caves: The Ultimate Cool, Dry Place
www.space.com/science/solarsystem/moon_caves_000321.html

Future 'Martians' Could Live in Caves
www.space.com/science/solarsystem/mars_caves_000321.html

On the Artemis-Discuss list, someone reading the first article said he smelled a novel on one of the mind-stretching thoughts expressed. If anyone wants to take up that challenge, there is a lot more where those ideas came from, and you can contact Peter at KokhMMM@al.com or 414-342-0705 or at the MMM submission address on page one.

MMM has carried many articles on lavatubes through the years, with issue # 100 NOV 96 being dedicated to the subject. That issue and an article in #101 that continues the discussion are online at: http://www.asi.org/mmm

Also online are photos taken inside Pacific Northwest lavatubes by Bryce Walden. These will give you a feel of what lavatubes look like.

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

MMMC #14