

"Expanding the Human Economy through Off-Planet Resources"

# Moon Miners' Manifesto - pleiades

MMM Classics  
The First Fifteen Years

Year 12: MMM #s111-120  
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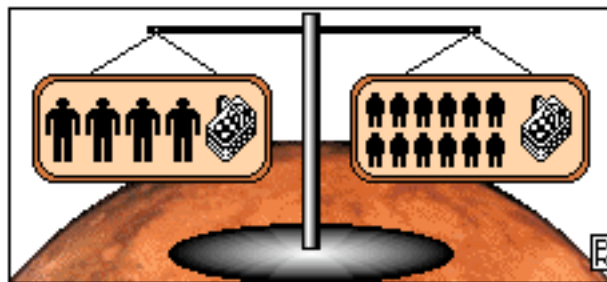
We never tire of trying to sketch the early days of the Lunar Frontier. We began with another article on **skyscrapers on the Moon**; having to live under a blanket of shielding does not mean having to confine ourselves to molehills!

Then, mindful of how many of us love our outdoor sports and other activities, we try to show that even without an atmosphere, the **incurable outdoorsman** will find plenty of opportunities to enjoy being out on the surface under the stars. Later in the year we take up the idea of **skiing on the Moon** and of **cruising the mare seas** and sightseeing **scenic cableways**.

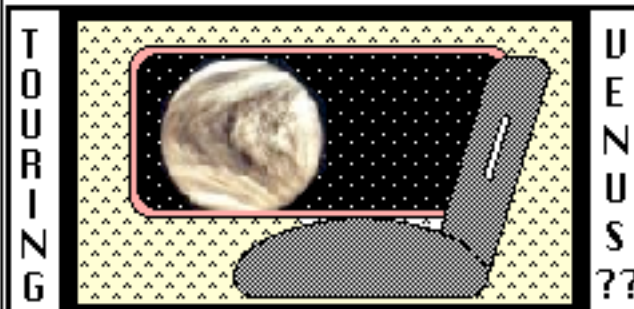
It takes more than one outpost to **make "a world" out of the Moon**, and we attempt to sketch out how we will do that. One sign of coming of age will certainly be the establishment of a **University of Luna**. But why should we wait, when we can set up a U, of Luna at an Earthside campus to begin to tackle and guide all the research and development that needs to be done to allow us to transition smoothly and steadily from a first station to a settlement civilization. We will need to extend the **Internet** to the Moon and beyond.

**Modular biospherics** and the ability to **make fissionable U-233 out of Thorium** are needed technologies. Driving all this will be the **readiness to reinvent everything!**

## University of Luna



"More to Mars" Mission Profile



## Skiing the Moon



"Living off the Ice" on Europa

As usual, we roamed elsewhere through the solar system in this year. We need to abandon the Apollo-like call for a "Mars-andback" effort in favor of a Mars effort rooted in a "**Marsto-Stay**" philosophy. Meanwhile, we continue to pull our punches in "Mars Direct." There is a way to double or triple the crew size for the same amount of consumables: "**More to Mars.**"

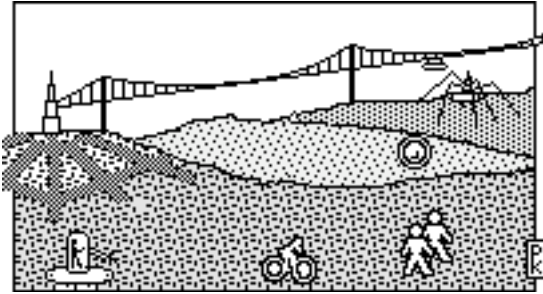
We can't do Mars at the end of an umbilical cord, as we can the Moon. Instead we will need to develop our installations out of pre-landed "**Yolk Sac**" of supplies. **Pantry Stocking** will take a creative approach.

"**Oochies**" - vehicles that run on oxygen (O2 or OO) and methane (CH4) are needed on Mars, and may have application on the Moon as well.

We revisit Venus, and look at industries that will let us "**live off the clouds**" and see skyport-based airlines plying between aerostat Xities. We revisit the idea of "**geomorphing Venus**" on a rational basis of adding hydrogen, not water.

Europa, too, comes in for another look. There too, we can "**live off the ice**" using the elements in the sea-brine that have made their way to the surface. **Callisto** will be the gateway to Europa and the rest of the Jovian system.

Finally, we revisit the question of whether the Sun was born alone or has siblings. ###



## Out on the Lunar Surface

This month, we take an outdoors, or out-vac perspective on the lunar settlement. Our first feature article takes a second look at the possibility of "skyscrapers" out on the open - not under some fairy dome (for first article see MMM # 55). In our second feature article we explore the various ways the true outdoorsman (who will have given up so much on forsaking the "Green Hills of Earth") might be able to satisfy the urge to be actively one with nature.

## LUNAR SKYSCRAPERS *Shattering Low Expectations*

by Peter Kokh

[see MMM # 55 MAY '92, pp. 5-6,  
"SKYSCRAPERS on the Moon? Beyond Mole Hill City"]

### An envelope-bursting topic revisited

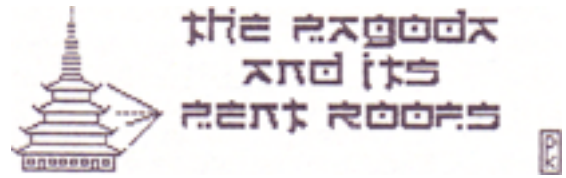
The conventional wisdom is that surface-embedded or surface-burrowing lunar settlements will be monotonous complexes of "mole hills" unrelieved except by docking ports, communications antennae and other systems hardware that must be on the surface or surface-exposed. Yes, we have all seen science fiction artist renderings of skyscraper studded lunar and Martian cities on great glass domes. But that is an eventuality for realization somewhat further down the road, if ever. And as to settlements within lunar lavatubes, some with ceiling heights a thousand feet high or more, - why, what we'll have there, are ceiling-scrapers (or even ceiling-touchers). In both these cases within pressurized megastructures, the first manmade, the second provided by nature), the skyscrapers are likely to be conventional copies of what is current construction structure and form on Earth.

But what excited me when I wrote the first article five and a half years ago, was the realization that the starter premise just wasn't necessarily true. We could build fully shielded "skyscrapers" to centralize the downtowns of lunar settlements built the way settlements on Old Earth always have been, the old fashioned way, one structure at a time.

### The "Pent Roof" makes it possible

Egyptian pyramids, Mesopotamian ziggurats, ant the Tower of Babel notwithstanding, the practical skyscraper was an urban innovation that awaited two inventions: the steel girder, and more importantly, the first people mover - the elevator. (Yes we know the Russians have built high rises without elevators, so, what's your point?)

For anyone imagineering a lunar surface settlement cozily tucked under its regolith security blanket for protection from the local cosmic weather and for thermal averaging, the idea of a skyscraper-studded "downtown" just did not occur. How would you shield something like that?



Enter by happenstance, a picture of a Chinese pagoda in some book I was perusing, and a eureka brainstorming avalanche was on its way cascading down the brainslopes of my mind.

A little redesign slight of hand with those pent roofs (pent as in penthouse), and they could serve as overhanging retainers that could hold a couple of meters of lunar regolith shielding - not prohibitively heavy in the light lunar "sixth-weight".



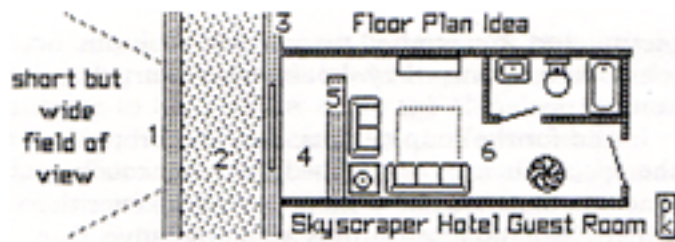
For people on the Moon for long duration or indefinite stays, it is important to be very, very conservative in minimizing accumulative radiation exposure. "Windows" providing the satisfaction of regular views out onto the local moonscape should incorporate broken pathways, using mirrors, so that the observer is protected in every direction by adequate shielding, so that the habitat or moon manor has not "hot spots". The same is true of any type of structure in which people regularly work or spend significant accumulative time.

In comparison, the "pent roof" balcony overhangs would provide safely set back vertically narrow eye level slit windows, and through them, horizontally constrained views of the moonscape. Looking out through one of these, the observer would see just enough "sky" to frame the view, a sky with very few square degrees of exposure to the naked cosmic heavens and its hot delights.

If you wanted to build a pentroofed office building, you would have to tweak the internal layout so that the interior space sporting these view ports was reserved for use principally by visitors, and, compromisingly, for regular office personnel and daily maintenance staff people "on break". The principal break room and lounge areas, however, would be in interior parts of the building that did not sport such direct-view windows). In other words, lunar office towers would have such slit windows only here or there. The architect could always resort to rows of fake trompe l'oeil windows to create the right external effect. After all, the architect has two goals in mind: an optimum, occupant / user-friendly interior arrangement, with a full suite of desirable function areas; and, a pleasing, readily identified, and positive image-creating external appearance on display for the potential using public passing by.

Such pent roof windows might be used with more abandon in buildings more heavily used by visitors, such as the

Luna City Hotel. Even so, for the protection of guest room cleaning staff especially, the architect would want to tweak the internal room layout to minimize the total accumulative fraction of daily time spent in the hot spot pools of naked sky exposure. And hotel management will be constrained by law to rotate staff duties to minimize the chances of anyone getting too much accumulative exposure.



KEY: (1) Outer retaining wall of pent roof; (2) shielding; (3) "Hull" wall of Hotel, with narrow, high, window slit; (4) Interior, shielded, viewing "balcony"; (5) an interior "shielding partition"; (6) Guest Room proper

### A Second Look

In that article we looked at three possibilities: (a) single or multiple vertical cylinders with pagoda like pentroof balconies holding shielding mass, yet which allowed vertically narrow views of the surroundings; (b) Stagger-stacked horizontal cylinders, again with pentroof shielded and windows; (c) a circular pyramid of horizontal cylinder sections of decreasing diameters.

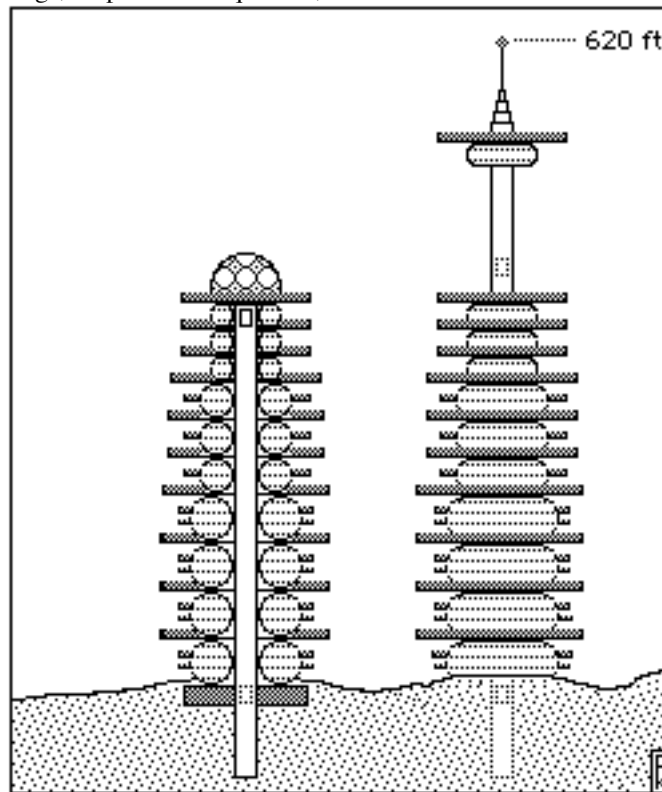
In retrospect, this last design option seems the most strained. Pressurization stresses would make it the most likely to fail. This article offers a radical rethinking of the round pyramid format.

Instead of stacked cylinder sections of decreasing diameter, we now propose stacked torus units of decreasing outer diameter, but of set inner diameter (of the donut hole). And they would be stacked over and around a vertical cylinder which would carry the elevator shaft and service chases for electricity, communications, thermal control, and plumbing. If this seems reminiscent of a popular children's building block toy, it is with reason. Here lies the humble source of our inspiration.

In the design shown below, for illustration purposes only, the upper torus tier would be sized to include floor to ceiling clearance for one floor, The next tier, two floors, the bottom tier three floors. The exposed roof overhang of each torus would be covered with shielding, pentroof style, as illustrated in the previous article, partial pent balconies at each intermediate floor level. Not a very visually pleasing design, however structurally sound.

One possible building top embellishment is a geodesic dome or hydroshield dome (a Marshall Savage idea) serving as an observation area, the later much better shielded. Another obvious topper option is a service core shaft extension to a revolving rooftop restaurant, à la the Space Needle in Seattle (just the first of many copycat structures now highlighting downtown skylines around the world). With possible structures like these, the analogy of the downtown centered Earth city is wonderfully translated into the construction idiom of incrementally growing regolith blanket shielded lunar, or Martian, surface settlements. Marketable uses are for bank office build-

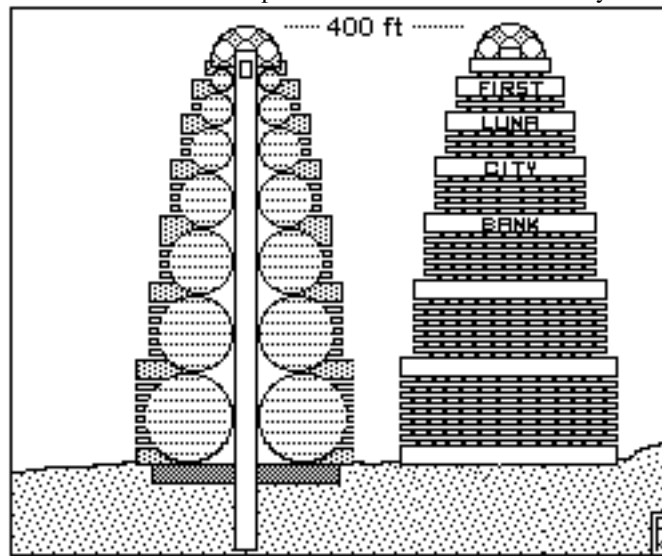
ings, corporate headquarters, and hotels.



KEY: (left ) see-thru observation dome skyscraper (right) outside view of twin tower with revolving restaurant. Both have 23 occupiable floors.

### From Pent Roof To Caisson

The illustration effort above yielded rather ugly results. The important thing about the torus - central shaft stack is its dynamic stability pressurization-wise. Why not, for this application, shuck the pent roofs for cylindrical caisson sections holding shielding up against the building. These bulkheads would not be pressurized and can be vertically flat.



This results in a much more conventional look. These are some ideas thrown out for improvement. We'd like to see now good artist renderings of a downtown-centered lunar urban panorama. <MMM>

# ***Opportunities on the Moon for the Incurable Outdoorsman***

by Peter Kokh

What's a Field & Stream sort of guy to do on a world where you need a clumsy spacesuit just to survive?

## **A Truth-in-Writing Declaration**

The author is not a hunter or a fisherman, nor a sailor or pilot. Nonetheless, he loves the outdoors with a passion, finding exhilaration and renewal in long walks through woods and fields, up mountain-slopes and through rocky canyons, either by himself or with his dogs. Through the years he has had many a treasured moment sitting alone by a well hidden waterfall, or perched on some mountain peak looking down on valleys, yes, down even on clouds and eagles. Yet this has been sporadic activity for him, and he knows full well that there are those for whom the outdoors is not just a shot in the arm, but lifeblood.

## **Just the facts, Mam**

The Moon has no atmosphere. You cannot stand outdoors in your shirtsleeves, not even bundled up but with face exposed, enjoying the uninterrupted sunshine, or the star spangled skies beyond belief. You must wear a spacesuit, or be in side a protective vehicle, or within a pressurized structure. Your communion with nature cannot be immediate, as on Earth. It must be mediated, very unsatisfactorily, by contrivances and contraptions allowing you to survive outside of your element.

While there is no air or breeze to be chilly or sultry, surface temperatures can swing wildly between sun and shade, between dayspan and nightspan. Exercise and exertion mean a buildup of heat from which it is difficult to find relief. Sweating only makes things worse, steamy in the sun, clammy in the shade.

Outdoor sports like flying and soaring and kiting and hang-gliding are not possible. Though human-powered flight may become a commonplace in large enough pressurized mega-structures. Fishing and hunting will be possible someday, but only in small captive reserves, smacking of "canned hunting." Swimming needs only an indoor or middoor pool, and canoeing along urban canals and boulevard streams is a likely target for city fathers seeking to make life as homelike as possible. But open sea sailing and boating will be a memory, or at best a virtual reality pastime.

For the spelunker, there will be lavatubes aplenty. But these great lunar underworlds, unlike Earth's limestone caves carved by water through sedimentary rock that once was ocean bed, lack stalactite and stalagmite, no curtain, column or drapery formations; they boast no underground streams or pools.

And for the coup de gras, even the protection of the spacesuit is overwhelmed by time, too long out-vac at a time, too many short excursions over the long haul. Radiation exposure is accumulative. One will have to hoard his surface outing time, saving it for occasions that are the most necessary, and/or the most rewarding. No all day, every day stuff. Never again for those who would forsake Cradle Earth. Not until another sweet thick atmosphere blessed home world is found, or made.

What's a guy to do? no green hills or valleys, no woods, no grassy plains or meadows, no boundless seas horizon to horizon!

## **Quit your bellyaching!**

The Joe Six Pack, who only imagines himself indulging in all these activities from the safety of his sofa cushion, will moan and groan. But the true inveterate son of the outdoors will find a way, make a way if necessary, to satisfy his search to live one with nature, one with the wind, one with the sun, one with the stars. At least on the Moon, it is possible. Those who boast that they are nature's children, but only indulge themselves from the safety of a tether-leash, in urban parks and man-made meadows, will delight, poor souls, in those human "zoo-parks in the sky", the great O'Neillian space settlements. Some of us must march to another drum. We need to be one on one with nature, and not just nature counterfeited by man - in a bottle.

Here on that harsher frontier, where there are natural landscapes and land forms undreamt of, where one is surrounded by nature untamed and uncaricatured by man, the true outdoorsman will find a way, indeed many a way. And the result will be all the more gratifying for the challenges that will have been overcome along the way.

## **The Spacesuit is dead! - Long live the Spacesuit!**

The spacesuit has its origin in a series of ad hoc improvements to the high altitude aviator's pressure suit. It has been made capable of handling not just thin air, but vacuum, not just cool or warm air but the merciless heat of the unmediated sun, and the insatiable heat sink of the naked cosmic skies. In the process it has grown ever heavier to wear, ever more cumbersome to move around in, or do useful tool-yielding physical work. Using it to transfer between pressurized habitats or vehicle cabins and the vacuum out side requires expensive airlocks, poor at retaining precious volatiles, and failing altogether to keep outvac the insidious, mischievous, ubiquitous moon dust.

The spacesuit needs to be rethought. The time is long overdue. But you don't see the need if you have only short term goals. It is perhaps imagined by many that the spacesuit is what makes it possible for humans to be in space, or on the Moon, or Mars. In actuality, it is the spacesuit, in the forms realized to date, that is the biggest onsite obstacle to human acculturation to these alien shores.

First, routine chores outside pressurized habitats, outposts, and vehicles, can be performed much more comfortably in the older more flexible less weighty high pressure aviation suits. All we need to do is to put in place sky/sun shielding ramada canopies over routine work areas and aprons.

Second, the space suit can be radically redesigned to be entered as if it were a formfitting vehicle, from a turtleback life support unit. One backs into a conformal convex dock-lock, the turtle back engages, the inner hatch opens, the turtle back opens into the interior space thus opened up, and the suit wearer reaches up and out behind his head to grasp a bar inside the habitat or vehicle and pulls himself out of the docked suit, into the habitat or vehicle. There would be much less precious volatile loss (specifically Nitrogen) during each outbound cycling, much less insidious moon dust tracking in on each

inbound use. [see MMM # 89 OCT '90, "Dust Control"]

Today's suits are veritable "Dagwood sandwiches" of layer after layer of different materials, chosen to hold in the pressure, keep out the vacuum, and buffer against thermal extremes. The result is an unwieldy amount of bulk that makes motion difficult, and the graceful agility prized by the outdoorsman, nothing more than a forgotten memory. Are there alternatives to this overbearing layering? Maybe not, but the "Young Turk", the won't-take-anyone's-word-for-it type of guy who in the end invents everything, will be the one to test the uprightness of this all too early capitulation. One almost suspects that the greater the perceived technological difficulty the more likely "ordinary folk" will continue to leave space, and the Moon, to the godly experts. It is important to the priestly class who now permits only token human scout activity, to maintain all myths.

Assume a lighter suit, one that is entered through a docked turtle back hatch, rather than donned inside in preparation for a ceremonialized grand exit or entrance through the airlock. Given such substantial improvements, personal after-breakfast or after-supper hikes through the never quite the same moonscapes becomes a possibility.

In his novel *Earthlight*, Arthur C. Clarke has his hero jog some 600 kilometers to the nearest outpost after his vehicle breaks down. Not bearing all that weight. Not without being able to shed all that perspiration and heat from exertion. In high sun conditions (say within 20° of the equator, and within two days of local dayspan noon) solar overheating can be avoided by deploying a gossamer helmet mounted parasol of aluminum foil. In sixthweight and in the absence of air and wind, such a comically ungainly contraption will be less ridiculous than it seems.

In the all time number one science fiction best selling classic *Dune*, the desert dwelling Fremen wore stillsuits to both conserve body moisture - even the urine was recycled into drinking water - and shed excess heat. This fictional invention provides a goal for those who would improve the spacesuit to strive after. It is those who would not try, and don't want to be proven wrong, who say it can't be done.

### The Buppet

The Buppet, like the turtle back suit, is something we've spoken of previously, for instance in the "Dust Control" article cited above. The Buppet (contraction of Body Puppet) is really a telephone booth sized upright personal cab(in) within which the shirt-sleeved operator directly controls manipulator arms and either "legs", tracks, or wheels. This device will allow a more immediate sense of oneness with the terrain than that afforded by vehicles of more conventional configuration. What's more, it is made for one, and will take you where you want to go in acceptable comfort. Ideal if you are a prospector, like to collect rocks, or simply explore difficult but scenic terrain. It will do fine, with inboard stereo, to just loose yourself over the horizon for a while, meditating on all the mysterious meanings and enigmas of life.

### From Personal Vehicles to Motor Coaches

Your spirit of adventure may be well-enough satisfied satisfied by following sundry beaten tracks. Or it may compel you to seek the trackless expanses "where no man has gone

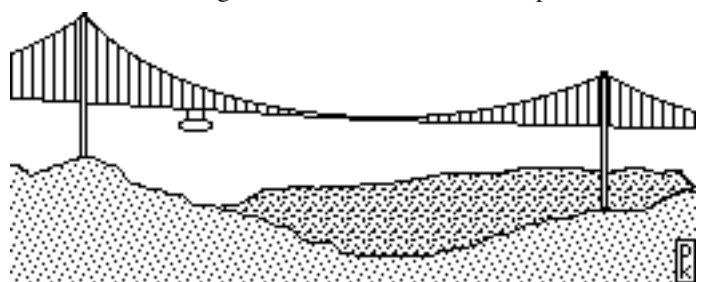
before" or at least not too often. You know yourself. In the first case, just the right personal vehicle for you may be relatively small and simple. In the second case, you may need prudent capacity for provisions, spare parts, tools, and medical supplies, as well as a vehicle with a much more capable suspension and life support system. If you are not one to stray far from home, but like to get out on your Harley all-terrain moonbike once and awhile, there probably will be just such a bike for you. [Herein Milwaukee, where Harleys are made and designed only a few blocks from my home, we had hoped to coax Harley-Davidson into putting together just such a dustmaster for ISDC '98. Alas, we let our lead time slip, and it's not to be.]

For the everyday intersettlement traveler or businessmen, the first modest coaches operated by Graymaster Lines, may be conversions of the crew cabins of "amphibious" lunar landers. Such vehicles which we have dubbed frogs, or toads (depending upon whether the conversion is temporary or permanent) would have the crew compartment, equipped with a wheeled and motorized chassis, underslung between the engines, so that upon landing, they can be winched down to the ground and taxi away.

### So what's an Outdoorsman to do?

Well, if you can live within the Rad limits, without cheating by removing your monitor wristband either occasionally or with compulsive frequency (until and unless you have been diagnosed with an incurable fatal or degenerative disease - why, then, reckless is the thing to be!) - if you can live within these strictures, and be satisfied, you can do a lot. Personal motor-exploring, occasional suited sorties to reach some near-path scenic overlook or vantage point. You can tell at a glance if you are the first to visit a site, or one of the few.

- Motor rallies with others and against a clock
- Motor races over prescribed routes
- Rock collecting and for-fun prospecting, always with the eye open for something rare and unusual and hopefully important
- Exploring near-surface and deeper lavatubes, many of which will play host to major settlement and industrial activity, as the Moon's most benign potential "habitats", the only (Nature-) improved real estate on the Moon
- Soar over the surface in lunar hoppers, and over great stretches of the globe in lunar suborbital transports



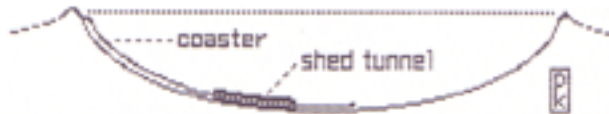
- Cruise long distance just over the surface, enjoying bird's eye views at a relaxed pace from a suspended cableway.
- Enjoy the scenery in smoother, swifter fashion in intersettlement Mag-Lev vehicles and trains
- Enjoy Earthset and Earthrise, and in between, the unimagined glory burst of the Milky Way from the lunar limbs, the peek-a-boo lands that alternate between nearside

and farside

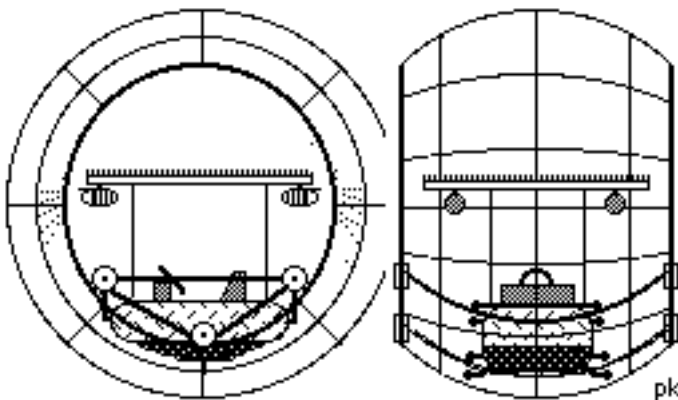
- Enjoy some incredible scenery from rille tops and crater crests, with the ever-changing patterns of inky black and dazzling gray-whites - the jaded will say so unsuspectingly "seen one crater, seen 'em all!" It's their loss, keeps the traffic down
- Visit a clear glass-composite enclosed waterfall and cascade down the inner slopes of some deep crater, part of a hydroelectric nightspan energy plan in which solar energy pumps excess water up the rille or crater slope during dayspan, to let it fall through turbines during nightspan
- Enjoy an evening campfire with a special fuel cell that uses an enclosed flame to combine oxygen and hydrogen to make drinking water



- Enjoy pressurized out-on-the-surface amusement park rides in giant roller coasters, accelerating slowly but without air and wind to put a limit on top speed, perhaps down crater ramparts thousands of feet high, maybe plunging into a shed tunnel near the crater bottom in pitch darkness, before emerging on the braking coast out onto the reassuring sun-baked surface.

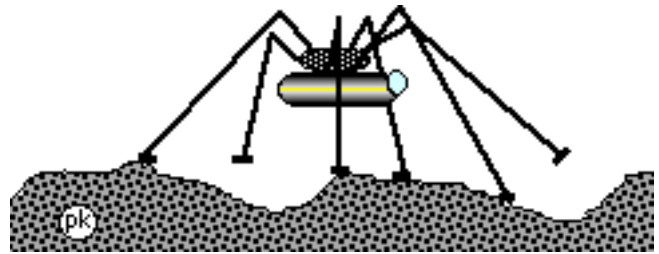


- Roll over the undulating terrain in "unitrack" squirrel cage "atlas balls" in which your seat rides an inner circular upright track within the ball-frame, well below the center of gravity. Work your geodesic cage along a rally course of crater-lets etc. Solar powered, the spheres would have a track riding buggy capable of generous side-to-side movement or banking - call it a unicycle, an auto-tracker, a cyclotrack, or whatever.

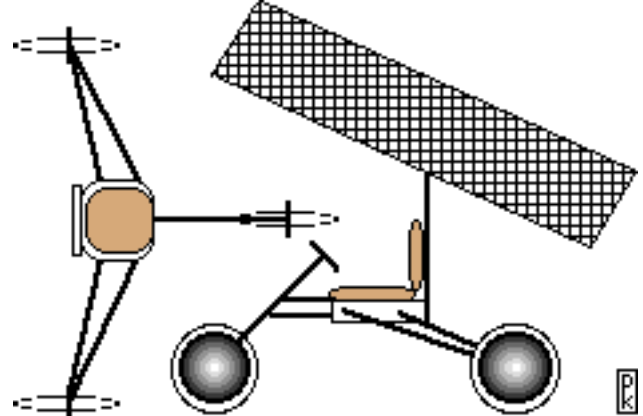


[MMM #81 DEC '94 p1 "Surrey with a Fringe On Top"]

- Scamper over rough terrain like a giant spider, in fact within a spider leg suspended cabin with great views. {MMM # 81 Ibid. p. 7 "Go Anywhere"}



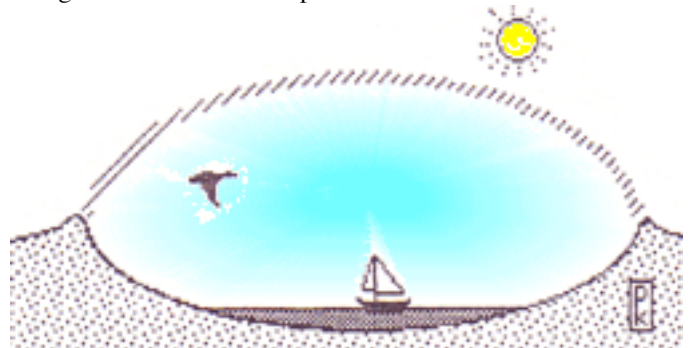
- Sail across the long congealed lava "Seas" of the Moon in electric powered lightweight moon dust outrigger trikes driven by solar energy, your spacesuit serving as cabin.



- Bungee jump with your spacesuit on, of course, from a bridge or cable car suspended over a rille or large crater
- Do a duty tour with the Frontier Authority's road, bridge, and cut building crews as a volunteer or as a court assignee (in lieu of jail)
- Serve on exploratory / prospecting excursions or new town site preparation
- Get a job at the settlement space port yards, or driving a Graymaster intersettlement coach, or over the road rig
- Get a job as a technician in repair, maintenance, instrumentation changeouts at a remote optical or radio observatory.

### Farther Down the Road, Way Down

- Fly again, go sailing and boating again, in a crater miles across, covered over with a glass-composite enclosed "hydrosield" dome-vault, à la Marshall Savage ("The Millennium Project") to create a spacious Earth-like Oasis on the Moon. Such a hydrosield will supposedly let in light and moderates temperatures.



- Ski, or toboggan, in your spacesuit with a break resistant visor and tear/ puncture resistant fabric, down a high mountain-slope covered with silicon powder (if only silicon were a true analog of carbon and we could have silicon buckyballs!)

- Go hiking, photo-hunting, picnicking, camping in a many miles long meandering rille valley, vaulted over and pressurized and transformed over decades into the first lunar National Parkway and Nature Preserve.



**And so?**

We have included in the outdoor menu above recreational, hobby, leisure travel, and occupational activities that outdoor lovers from Earth might enjoy in the "magnificent desolation" of the Moon, provided they have an open attitude. Temperaments and moods firm up by stubbornness are not easily changed. But then we are speaking to outdoor souls.

It will never be "just like on Earth". You can't substitute for Earth's forests and plains, for its rivers and lakes, and least of all for its global ocean, the mother biome of all life. But if the pioneer ceases to pine for what he or she has willingly left behind, and give it a chance, there may lie ahead plenty of moments of outvac satisfaction. The Moon is not Earth, but it has its own beauty, its own scenic wonders, its own awesome sights. In this now alien environment, people with "outdoor souls" will someday come to feel quite at home. They will learn to love activities they can indulge in on the Moon but could never do on Earth.

The Moon offers vacuum, lavatubes that are gargantuan by Earth standards, awesome craters and vast frozen lava flood plains. It offers stunning views of Earth, and the stars? Why Lunans will wonder how people of Earth could ever have been drawn on an epic journey to the stars that they could barely see. And hopefully, any sense of loss that lingers in first generation pioneers will sublimate into a drive, a passion to find still more ways to enjoy, relax, and have fun in the great outvac.

In the end, the prospective pioneer must choose. If there are activities on Earth that cannot soon enough be duplicated on the Moon, to which his happiness is pegged, it's best to be honest and call your self a stay-at-home Pioneer supporter. There is no point in being heroic. There is nothing wrong with being attached to recreational pursuits than will not translate well to the "new" world. The Space Frontier needs not only those willing to and psychologically capable of forsaking Earth, it needs real trusted friends who will stay at home and lend invaluable support that can only be given by people in the mother world.

<MMM>

**"One doesn't discover new lands without consenting to lose sight of the shore for a very long time."**

- A. Gide

## The Jovgo Jupiter Jet

By Francis F. Graham - Kent State University, Physics Dept

With the great interest in planetary probes recently engendered by the discovery of life on Mars (at some point) and the success of the Jupiter Galileo mission, it's time to bring up an interesting idea that I originally had in 1966, and developed somewhat in 1978 at a presentation in grad school.

I learned from the only book about Jupiter in 1965, "The Planet Jupiter" by Bertrand M. Peek, that Jupiter was surrounded by an immense atmosphere of hydrogen, helium, methane and ammonia. Two of these molecules, molecular hydrogen and methane, are flammable if mixed with oxygen. Hence it seemed logical that the best sort of Jupiter probe into the atmosphere would be one that was able to fly around the atmosphere of Jupiter using onboard oxygen (or an oxidizer) and sucking in the Jovian atmosphere; in other words, *a jet airplane that carried its own oxygen rather than its own fuel, and drew in the fuel, rather than oxygen, from the outside.*

Earth's atmosphere  
(oxygen)

jet plane with  
fuel supply

Jupiter's atmosphere  
(hydrogen, methane fuels)

US.

jet plane with  
oxygen supply

The "Jovgo" as originally proposed would be a heavy probe capable of many tasks, and would be boost to Jupiter on a Saturn V, aerobrake into the Jovian atmosphere and unfold variable-geometry wings. It could then spend several days using a supply of oxidant to fly around the 0.1-100 bar level of Jupiter's atmosphere, from equator to poles, taking samples and performing unique analyses. The size of a fighter jet, it would have a one-way range of about 40,000 miles near the Jovian cloud tops, with careful choice of rising and sinking columns.

By 1978, post-Pioneer 10, it was clear the belts of Jupiter and zones of Jupiter were ascending and descending atmosphere. Thus, the Jovgo probe could extend its life by gliding up on zonal upwelling, and overflying some of the belts. Slowly, as Jovgo approached the poles of Jupiter, it would begin to glide into the denser layers of the planet and finally succumb to the high-pressure, high temperature auto da fe that did in the entry probe of the Galileo spacecraft last December. With Jovgo however, the atmosphere of Jupiter would be more rigorously explored by a probe that would give a cross-section of the atmosphere from the equator to the poles.

Hopefully, the Jovgo concept is an interesting one and perhaps it may see fruition someday. In any case, the design of aircraft for planets other than Earth is an interesting challenge. The Russians launched two balloons in the atmosphere of Venus in 1985, it is to be noted, from their Vega spacecraft, perhaps the first extraterrestrial "aircraft" per se.

### Cosmic Attitude

If the forces of creation deserve our worship, they do so from every corner of the universe, not just from this nest-world we call Earth.

This we cannot do by staying home.

Go and fill ye the empty cosmic spaces  
and let your soul sing in praise  
in endless new ways. - Anonymous.

## ***Making a "World" out of the Moon***

**The long road from "Magnificent Desolation" to another "Home Sweet Home"**

by Peter Kokh

"But the Moon is a World!" Yes, and no. The Moon IS a world only in the most skeletal, purely geological sense of the term. The Moon IS a physical siteplex that *could become* a "world" in the sense of a contiguous manifoldly-diverse set of human horizons.

The Earth World, of which alone we are intimately familiar by direct experience, hosts one many-lobed global ocean and several geologically diversified continents with distinctive climates within shifting zones. Biological diversity of plants, animals, and their ecosystems. Diversity of human cultures and civilizations, of cities and architectures, of languages and arts, of customs and laws.

In contrast, the Moon has but one global climate (except for the polar permashade areas), and a limited range of geological land forms. There are no ecosystems at all, let alone distinctive ones with locally characteristic flora and fauna. There are no cultural or linguistic or political borders - the Moon is *not yet* a human world - except in the imagination of visionaries and novelists.

Different individuals will miss different things about Earth, not present or available on the Moon. *All* frontier pioneers will surely "miss" one transcendental given on Earth, not given on the Moon. The Moon is not a "World-Plex", a contiguous set of very diversified horizons, hyperlinked in innumerable ways. Even for those who during their lifetimes do not stray far from their hometowns (e.g. Emmanuel Kant never ventured more than 50 miles from his home in Koenigsberg, East Prussia), the Earth World is experienced as immense. In contrast, even for those early Lunan pioneers who explore far and distant reaches of their new globe, the Moon will be experienced as small. Earth is vast in the innumerable dimensions of the ways one "here" can differ from another. The Moon is small in the few dimensions of ways one "here" can differ from another.

To begin with, Earth's active "hydrotectonic" geology ("the" one thing that transforms a world into an "Earth-like" planet) has lead to a much greater diversity of host land forms and oceanic basins. Then life, with its seemingly inexhaustible nuances of expression, has covered and filled different niches with highly distinctive plant and animal species. Add the third layer of human cultural, architectural, and technological achievements of even greater diversity and level of achievement.

Earth the World has an incredible number of distinctive nooks and crannies. In contrast, without life, without man, and with a stunted range of geological activity, Luna the World is drastically impoverished by contrast.

### **Vectors of Diversity Introduction**

The lunar environment will impose characteristic

constraints on settlement layout plans, on utility and transportation infrastructures, and on architectures and construction methods. In this light the new visitor from Earth may be quick to conclude that "when you've seen one lunar settlement you'll have seen them all." Undoubtedly such shallow caricaturizations will gain some currency. But in fact none of the applicable constraints will be totally definitive. [MMM #5 MAY '88 "Lunar Architecture"; MMM #53 MAR '92 pp. 4-6 "Xity Plans"; MMM #54 APR '92, pp 5-6 "Xity Plans, Part II"; MMM #55 MAY '92, p. 7, "Moon Roofs"]

In each field there will be aspects that are left indefinite, indeterminate, up to the inspiration and tastes of individual urban planners, architects, and builders. These are each to be encouraged to explore the full wealth of opportunities for individual material expression that are left open to them. To the extent they succeed, such rushes to judgment will but expose the cranial vacuity of the speaker.

The most obvious and basic way settlements can differ is to play to their individual sites, not erasing their contours with excessive grading, but following them. Large boulders can be left in space, pressurized town squares built around them, etc. Nearby crater rims or escarpments or hills or mountain peaks can sport integrated revolving restaurant lookout towers. A rille running through the townsite, or along side it, could be a tremendous asset for future vaulting and development as a nature area. Use your imagination. The temptation to be avoided, is to pick a site that is perfectly flat, featureless, bland. Scenic opportunities in the surrounding area should be played to, maybe even to the point of making the final townsite and spaceport selections so that the coach ride from one to the other passes a scenic overlook on a crater rim or rille shoulder.

Even if the settlement largely burrows into the regolith blanket for protection from the inclemencies of the cosmic weather, periscopic windows, sundows, light tubes, and other devices can bring the glory and interest of the local moonscapes down inside. The settlement should fully interface with the host globe on all levels.

As to Xity\* plans, each settlement must maintain a certain *very* generous ratio of vegetation biomass to human population, and of water reserves to living biomass. But how these land use areas are arranged is largely unconstrained, open to artistic management that can be special to each settlement. Agricultural areas can be peripheral to the "urban" concentration, for example, or integrated within it, providing green rings around and through neighborhoods, integrated with parkways and parks. (\* as we would call cities that must provide their own biosphere.) (MMM #8 SEP '87 "Parkway")

Reserve water can be kept in tubes and tanks, *or* allowed to move through open canals stocked with game fish, water lilies, and even canoes. Tied to such a "double duty" system can be waterfalls, rapids, and fountains whose pleasant white noise sounds and air-misting fragrances will do much to instill a sense of well-being and enjoyment to life. (MMM #67 JUL '93, p. 6 "Reservoirs")

### **Climate Variety, Flora & Fauna, & Seasons**

Nor, would it seem, will frontier biospheres be limited in their choice of climate, or flora and fauna ecosystems,



though some choices will be easier than others to make real in confined conditions. The larger the biosphere, the greener and richer it is likely to be, the closer to “Nature” its inhabitants will feel. [MMM #15 MAY ‘88 “Rural Luna”]

And, it is a truly human town, it will have animal life as well - if not livestock as a protein source, then at least pollinators and other wildlife species integral to the ecosystem chosen. On Earth honey bees “earn their keep” as food processors, converting pollen into honey. Silk worms spin silk fibers. Surely there are other examples. Then there are species which could be bred to be effective harvesters or gatherers, e.g. squirrels (nuts, seeds, berries), saving precious human labor. There are then animal populations whose presence has significant positive economic effect.

Yet, some misguided and stingy spirits, (e.g. Lovelock in “The Greening of Mars” would [have Martian pioneers] leave no room for animal life, and speak about it in a way that shows their disdain for our fellow travelers through time. In fairness, Mars’ situation *is* special. A feasible early goal of human intervention on Mars would be to raise the minimum low temperature only a few degrees to the point where the large reserves of CO<sub>2</sub> (carbon dioxide) now frozen out of the atmosphere at the poles would be permanently returned to the atmosphere. Thickening Mars’ air (97% CO<sub>2</sub>) by a factor of ten (still only a tenth as thick as surface air pressure on Earth) would allow cold-hardy plants to thrive outdoors (at least under UV-resistant glass canopies or in glass greenhouses). Plants, unlike animals, need only CO<sub>2</sub> to thrive. But they would have to be self-pollinating.

This does not change the fact planets can only be caricatures of “human” worlds if they are devoid of animal life. Vegetarianism and its cost-effectiveness are not the point. There are *other* uses for animals than meat, fur, hide, etc. Besides pollination, food processing, preharvesting, and other ecosystem-integral duties, there are transcendental benefits to human culture and civilization and personal development beyond such necessities, for which there is *no* substitute, at *any* price. Animals are part of our roots; they have shared much of the path of our emergence. The educational value of their presence on the frontier will be priceless. I personally feel sorry for those stunted psyches who, free of excusing allergies, cannot let themselves interact with pets. [MMM #8 SEP ‘88 “Animal Life”]

### **A World-like Variety of Options**

So the sundry lunar towns and outposts can differ as well, not only in climate, but in the pockets of “nature” that re-encradle their inhabitants. Lunans are likely to be able to visit other towns that have a quite different feel and ambiance to them, not only from their architectural choices but from the Earth biomes they have chosen to incorporate.

In each settlement, according to its climate, and plant species, the gardener, horticulturist, and pocket park landscaper will have major roles to play over and above food and fiber production. It is up to them to expressively display the full range of colors, shapes, textures, and patterns the flora of each designer ecosystem will allow. In doing so, they will make these new “worlds” fuller, richer, more beautiful, more enjoyable, uplifting and healing than they otherwise might be.

With biosphere climates will come seasons, an important aspect of the “world”. For we experience time not simply as a forward arrow, but as a helical progression, with seasonal cycles that introduce both variety and comforting familiarity.

To suit the needs of plant life, the captive climates within controlled settlement biospheres must be designed to cycle through the seasons the plants expect: temperate four-season climates, tropical two-season ones (dry, wet). With the seasons will come changes of vegetation and landscaping colors, seasonal food treats, and agriculture-tied festivals (first planting, harvest time), changes of attire, arts and crafts based on harvest stuffs, etc.

On Earth seasonal weather operates with apparent randomness within broad temperature ranges. These weather fluctuations are one of the common greases of conversation (along with sports, news, politics, etc.) It would help if some computer introduced randomness of temperature, humidity, precipitation, breezes, associated, aromas and even intermittent “cloudiness” (changes in light levels) could be mimicked.

Perhaps we do not think of it much, perhaps many people have never thought of it, but it is the seasons that impose agendas and imperatives in life. It is a matter of being ready for known coming changes. Without them, procrastination and crass laziness would be much more rampant. Without the seasons, much of human technical progress would never have occurred. We might have no calendar, even, perhaps no mathematics.

The pre-human Moon is essentially without seasons, without annual rhythms. On Earth the year is king. On the Moon, it is the lunar day, the “sunth.” If we are to make the Moon livable, to give it the characteristics we associate with “world” we need to introduce real and prominent seasons into our mini settlement biospheres.

Add to this yet other vectors of difference and glory. Lunan customs and culture will surely display some things in common that mark them as human acculturations to the Moon’s environment. [e.g. MMM # 7 JUL ‘87 “Moon Calendar”] But there are many kinds of customs and cultural manifestations in which they can diversely specialize. Lunar apparel fashions, limited in fabrics available, environmentally-friendly processes, and methods of adornment and decoration, may well differ from one town to another. [MMM #13 MAR ‘88 “Apparel”; MMM #15 MAY ‘88 “Threads”; MMM #22 FEB ‘89, “Hair”; MMM #27 JUL ‘89 “Footwear”; MMM #55 MAY ‘92 “Agri-Garments”] In addition to the plastic arts, music will bear the mark of instruments that can be fashioned from lunar materials\*. And dance will share with sports characteristic adaptations to one/6th gravity. [\* MMM # 3 MAR ‘87, “Moon Music”]

Arts and Crafts may follow different schools in one settlement than another, not only responding to the local availability of differing suites of raw materials, but choosing to follow the special inspirations of those pioneering new media and forms in their own locales.

Sports are another vector of difference, especially in the early years of free-for-all experimentation before some uniquely lunar-appropriate games and sports gain widespread, even global popularity. [MMM #9 OCT ‘87, p.9 “MoonSports”]

## Widening the spectrum of opportunities

The incentives for creative self-expression in arts & crafts will be more powerful on the frontier than perhaps at any other place or time in human history. Frontier markets, with imports from Earth being discouragingly if not prohibitively expensive, will be very small markets indeed, especially by Earth standards of our time. As such, they will be sorely challenged to provide diversity of product offerings. Individually artisan-finished mass manufactures of “issue” wares (usable-as-is but nondescript) will be a major source of satisfaction of the need for the custom-made, the distinctive, and the personal. [See MMM # 3 MAR ‘87, “Moon Mall”]

Growing economic diversification will bring with it the multiplication of entrepreneurial niches and opportunities. There will be more occupational choices not just for entrepreneurs but for workers and others. Add to this the inevitable industrial and business specialization of the different settlements, and lively trade is likely to arise. [MMM #56 JUN ‘92 pp. 3-4 “Harbor & Town”; MMM # 32 FEB ‘90 pp. 3-4 “Export-Import Equation”]

On this intralunar trade, tourism will piggyback, as it always does. The Lunan tourist will find a growing variety of human venues to explore, with “scenery” refreshingly different from his/her home town. And no longer will visitors from Earth be able to return home after visiting but one lunar port, to claim that they had “done the Moon”.

## Fonts of inspiration and resourcefulness

Each Lunan settlement needs to be endowed with a complete library of primitive arts & crafts, architectures, building materials, etc. Why? These primitive forms, while more likely than not scarcely translatable into the idiom of local materials that the Lunan pioneers have to work with, are superlative models of resourcefulness. Such libraries will be most cheaply provided in electronic form.,

A settlement museum is one seeming luxury that is in fact vitally necessary. Its mission is not just to bring alive for later generations of native-born Lunans how their pioneering ancestors lived in “the early days” of the Lunan frontier. [see MMM # 102, FEB ‘97, pp 7-8 “Luna City Museum: Visitors’ Guide 2097”]. The museum should also portray Earth’s natural geological regions and its ecosystems with their amazingly diversified and adaptively evolved plant and animal life forms. For only the most token of samples of these will be transplanted in the various lunar settlement mini-biospheres. “Stuffed” and other inanimate museum representations will cost the settlement much less to maintain than equally complete zoos and conservatories.

But above all, the lunar museum needs to portray episodes of frontier pioneering on Earth, in which waves of new settlers had to adapt to new climates, altered suites of raw materials, new edible plant species, new game species. They had to do this often against great odds, and usually with little preparation. Such models of resourcefulness in the face of adversity will be a source of unending inspiration to Lunan youths.

Finally, the library and/or museum should have archive records of sundry disasters throughout history. Geological, climatological, and meteorological calamities;

epidemics; human inhumanities such as the diverse ravages of war or slavery; the recounting and portrayal of these will provide inspirational models of recovery from doom. For surely, Lunan pioneers will suffer their own series of setbacks and seemingly insurmountable catastrophes.

## Global Village II

Diversification, of course, is just one of the forces operative. The hearty inter-settlement trade and economy in manufactured goods and artifacts will encourage sharing, and the spread of styles, fads and fashions pursued in common. This will tend to dampen the rule of King Variety. Scholarship and apprenticeship exchanges between settlements and outposts, business, tourist, and recreational travel and exchange of knowledge and tastes, will help reinforce and personalize the commonizing forces of global print, radio, television, video, and Internet media. Luna will be one world in a sense, a world with many common distinctive themes. Yet it will also have become a world with a respectable “world-like” wealth of nooks and crannies, a chip off the old block. In doing so, it will have become livable. Lunan pioneers will no longer be “world-sick” for Earth.

## Racial and Ethnic Diversity

One of the World’s vectors of diversity is racial and ethnic differences. Perhaps a majority of people profess a belief in a common supreme being, but this belief, in perhaps most cases is easily shown to be a lie. For few act as if *we are all brothers*. Yet the only way we could not be so is if there were *more than one* “God the Father”. By the way, the conclusion of universal siblingcy *must be extended as well* to any “alien” intelligent species we ever encounter.

Racial diversity is an everyday fact in many locations. In others, during the normal course of day in day out life, one runs into only “one’s own kind”, and diversity is more of a theoretical fact. While the subject is commonly avoided among space supporters, it’d be surprising if for some, one of the more individually effective appeals of the prospect of establishing new human communities out in space (where they will be much more mutually isolated than on Earth) is the possibility of escaping this diversity. It is important to be aware of these mis-motivations.

How ethnic and racial diversity is repeated, reduced, or increased (in terms of mixing) on the Moon, will depend on how potential settlers are chosen. Will they be principally self-selected, *and* self-financed, mostly from affluent societies, or will they be recruited by ticket-paying agencies that strive for healthy diversity?

## From Fixed & Finished to Open-ended World

Save for the imperceptible pace of contour-softening erosion due to the eons-long but ever so gentle micrometeorite rain, and for the rare and very scattered addition of new pockmarks on its surface, the Moon has been a “finished” world for a long time, a world in which no process have been operative to introduce qualitatively new aspects or features.

The Moon may seem “barren”. This is an “at first blush” myth, perpetuated, to their discredit, by “space enthusiasts” who would concentrate their energies on another, more richly endowed world, Mars. The truth is that the suite of

resources the Moon offers would-be pioneers is much less rich than that with which we have been blessed on Earth. But the truth is also that, with resourcefulness, we can learn to rely on these fewer resources to a major degree, very probably adequate to produce sufficient export lines with which Lunans can earn enough income with which to purchase what they cannot make for themselves. Being resource-challenged is not fatal. The Mars Partisans make a major mistake in dismissing the Moon on these grounds. *Japan is, and always has been, severely resource-challenged.* The nation of the Rising Sun has had no trouble turning this apparent contraceptive liability into an enormous asset. End of argument. Squelch.

That the Moon is “barren”, then, is no more than a half-truth. Barren till now, just as is a virgin, *because no one* has made it a “mother” world. So the Moon is “finished” only in a conditional sense, “so long as” it is not ever resourcefully pioneered.

As conditionally “finished”, the Moon does not boast one of the “prime marks” of “World”. For the World, as host to life, is necessarily unfinished. A “finished” World would be one in which there could be no sense to individual human lives. Of the scriptures I’ve read, Judeo-Christian, Muslim, Hindu, Buddhist - none seems to have put it so well as a wise man in Ursula K. LeGuin’s “Left Hand of Darkness”:

“Praise be the Darkness, and Creation Unfinished.”

Evil, misery, imperfection, conflict all create opportunity for good. It is in contributing to the unfinished world that each of us finds meaning.

Through the ages, the World has developed, grown, and diversified with human cultures. It has experienced our changes, our growing pains, our moments of tragedy, disaster, recovery, and glory. It can no more be summed up and dismissed than can man. The World IS the common correlative of the individual. No man, no World, and vice versa.

The Moon is a secondary planet that is called a world only in the unexpressed assumption that humans *could* explore it, wonder at its landscapes, and cope with its inhospitableness *first hand*. It is a world only in *Let’s Pretend*. It is up to *us* to make it a world in reality. We can do that only by accepting the considerable challenges it offers.

A minimal government “outpost” on the Moon, *will not* make the Moon a human world. And any celebration would be piteously premature.

Rather, we must return to set up an “Interface Beachhead”, a “Settlement Incubator”, a “World Seed.” [MMM # 88 SEP ‘95 pp. 3-4, “Bursting Apollo’s Envelope”] We must return with an ongoing, open-ended mission, “reclamation”, by which the “World Seed” established in our “pregnant beachhead” grows and grows to someday encompass the whole lunar globe. [MMM #110 NOV ‘97, p 3, “Reclamation”]

We must go back *as settlers*, as suitors of a virgin world with an unsuspected capacity for Motherhood. We must not go as an alien garrison, as withdrawn strangers to a strange land “outpost”. If “Mother Moon” can be no more than a stepmother, that does not preclude a thriving relationship. The first pioneer immigrants will start an unending journey that will occupy their descendants through the generations and centuries.

<MMM>

# The Out-Vac Sculptor

by Peter Kokh

Human acculturation to the Moon involves *more than* just using lunar materials to build with and express ourselves creatively within tight-hulled minibiosphere settlements. There is *no need to confine* the material evidences of human interfacing with the Moon within “reservation” “ghettos”. We will also build roads, roadside inns, solar flare sheds, repair garages, outfitting supply general stores, and so on, *in between* settlements. We will build scenic overlooks along crater rims and other high points. There will be rural retreat houses, and small rural “intentional communities” or communes (we’ve suggested the name “tarn” from the Old Norse for a small mountain lake in its own isolated mini-basin or cirque - after all, such rural outposts are isolated oases with their own water reserves.)

Over and above all this, it will be legitimate for Lunan artists to express themselves creatively in the wide open spaces of the out-vac in a way which both complements its “magnificent desolation” and which also celebrates the new stepmother-stepchild relationship of Mother Moon and the new frontier human settlements and communities. Out-vac sculptures will proclaim the mutual adoption of both for one another. In many cases such 3-D creations will serve useful functions. Both raw “magnificent desolation” and human artifacts give glory to the Creative Energy at work in the Universe through everything, through each according to its nature.

## Available Sculpture Stuffs

Sculpture comes in many forms: carvings, castings, assemblages, and simple arrangements of found items. Different materials can be used or worked in varying ways to form 3-D creations. What lunar available materials might a transplanted sculptor pick for various large-scale out-vac art creations? On hand, usable almost as is are these:

- Boulders, rocks, and breccias (rock composed of angular rock and glass fragments melded together): Large boulders can be used as landscape accents, or, engraved, as milestone markers, sign posts, etc. Smaller rocks can be used as is, or cut into blocks or slabs, even polished. Question: would their surfaces sparkle with fluorescence under black light?
- Simple mold-sintered regolith, in various natural regolith shades perhaps gathered from remote sites to provide enriching contrast with the local soil.
- Sintered mold-shaped low-performance creations of iron fines. These fines are fairly abundant in lunar regolith from which they can be harvested with a magnet. Sintering does not impart great strength, but out-vac sculpture creations which undergo only dayspan/nightspace thermal stresses should endure.
- Iron castings and wrought iron, prior to the availability of steel alloy ingredients might make durable sculpture materials outside rusting atmos-pheric of settlement interiors. (Items could be steam-rusted in pressurized studio compartments before being placed in permanent out-vac locations as an option if rust color is desirable.)

- Native glass spherules might be used in various surface treatments in sun-catching ways.
- Manufactured glass of various crude to refined formulations: poured, cast, blown, reinforced with clear or colored fiberglass, prisms and colored sun catcher creations; mirrors.
- Cast basalt, a onetime actual industry in Central Europe which could easily be pre-pioneered anew in states like Oregon, Washington, Idaho, Hawaii, etc.
- Ceramic pavers, glazed or unglazed
- Gunitite: a mixture of lunar cement, and rough-sifted regolith with glass and small aggregate inclusions, sprayed over forms to create lightweight simulated lunar rock. Terrestrial Gunitite™ is used to make lightweight “rock” outcrops in zoos, for example. (may be the standard faux rock in space settlements).
- Cast magnesium (unalloyed, dangerously reactive in oxygen), where we would use bronze on Earth.
- Aluminum, steel, and titanium, once these are produced on the Moon.
- Welded salvage scrap metal and abstract or form-suggestive junkyard creations, using discarded metal objects originally forged on Earth.

### Some Out-Vac Applications

Sculptures and sculpted works might be placed in the out-vac for a number of reasons. For the enjoyment of travelers, “sculpture gardens” would provide welcome interest in areas where the native “scenery” is especially monotonous. On Earth, we find sculpture gardens on the grounds of museums and, in some states (e.g. Nebraska) concerned with interrupting soporific driver fatigue, boredom, and mesmerization with the road, at scattered highway waysides. But these are *within* the given biosphere, enjoyable in “shirtsleeve” comfort, as is everything on Earth. So such use provides no easy parallel on the airless Moon. There, travelers are not going to don individual spacesuits to exit their protective motor-coach or other vehicle just to peruse a bunch of sculptures. Too much hassle.

Like façades of corporate headquarters deliberately sited alongside busy interurban freeways, and meant to be enjoyed in fleeting glimpses, such “freewayecture” provides a better model. Items in a lunar out-vac “sculpture garden” could be placed *in a well-spaced row*, say in a “boulevard median”, to be enjoyed in quick glances out their coach windows by people on route from spaceport to settlement gate and vice versa. Deliberate distractions of this sort would seem especially appropriate along stretches with little “competing” natural scenic attraction. The sculptures chosen would have just enough detail to be appreciated on the fly, yet enough to be enjoyed over and over on repeat passings. This generalization would seem to be pertinent for all out-vac sculpture.

Monuments commemorating historic sites (first “overnighting” on the Moon, etc.) and historic events could aptly be set out on the naked surface along well trafficked corridors, aimed at catching the eye just long enough to stir the soul, no more. Of course a monument could be tall enough, *and/or* set on high enough ground, to be observed with more intent interest for an extended time and for many miles as vehicles approached the site, passed by it, and then receded.

For example, a very large scale sun-catching monument of polished stone, polished aluminum, mirrored glass, clear glass, or prism shape, etc., erected to celebrate the achievement of independence by the Lunan Frontier Republic might be placed atop a mountain peak that stands prominently out from other nearby surface features from well beyond the general horizon. Mt. Piton, an isolated 7,500 ft. high massif in ENE Mare Imbrium is one such example. From atop this perch, a monument such as we’ve described could be seen above the horizon for many tens of miles from a busy road passing to its sunny south between Mare Imbrium and Mare Serenitatis, where it could mesmerize passersby. Such a road could very likely become the busiest east-west travel corridor on the Nearside. (This previously published suggestion is not mine. Ben Bova’s?) Again, freeform and abstract design would work better than anything demanding closer inspection to be fully enjoyed.

Decorative options combine with utilitarian function to provide many other non-commemorative chances for out-vac sculptors to express themselves and delight others. Graded roadways could have their right-of-way edges clearly demarcated by rows of gathered smaller boulders, rocks, and breccias. These could be left natural, art limited to selection and serial arrangement, or they could be cut and polished to better catch headlights during nightspan, or along shadowed stretches during dayspan. This both decorative and utilitarian technique could then be applied to the slopes of road cuts, embankments, and retaining walls as well, which could be covered and/or stabilized with cut rock “pavers”.

Question: certainly some Apollo moon rock researcher has tested both moondust and various rocks and breccias, intact or cut, for fluorescence in “black light”. [If any reader is familiar with such research, would they please acquaint the editor with the results?] If this fluorescence exists and is high enough, maybe black light headlights would be more appropriate along lunar highways, at least during full nightspan, than normal halogen or other visible light lamps, especially on the farside, out of reach of “Earthlight” (which should provide illumination enough). After all, the roadway is unlikely to hold other obstacles, and if it did, radar, more easily linked to automatic warning or steering correction devices) could more easily and spot these and more accurately access them. On Farside, the use of blacklight only would allow drivers and passengers to enjoy the full splendor of the intensely star-spangled lunar heavens.

Early lunar highways, when they come to rille valleys too long in either direction to detour around without major inconvenience, will probably simply angle down one slope and back up the opposite one. Eventually, in high traffic areas, more expensive bridges and causeways may be justified. While these will be basically utilitarian in their design, there will still be several basic structural design choices, as well as elements of each design not constrained by function. Such elements will provide sculptural and decorative opportunities: side bumper walls, lampposts, mid-bridge scenic turnout markers, etc. Roadside signposts in general (milestones, junction directions, “Place of Business” signage), offer decorative occasions beyond the simple “rock pile and post” wherever they are put.

Out-vac sculpture can be Government or Sponsor-Commissioned or privately financed, even artist-donated. A prime example of an opportunity for privately financed sculptural decoration will be the home-pride and/or image-conscious need felt by some to mark the exterior regolith mound shielding their own home, neighborhood, entire settlement, or their corporate headquarters or other place of business *in some distinctive fashion*. This can be as simple as raking patterns. Or distinctively colored thin top-layers could be applied (e.g. very dark ilmenite-rich soil, calcium oxide lime, to suggest two cheaper choices). Or the mound slopes could be accented or even fully paved with cut rocks or molded cast-basalt tiles, even faux “shingles” etc. [See MMM #55 MAY '92, p.7 “MoonRoofs”.] Luxuries like this will obviously be more common in close proximity to surface roads from which they can be appreciatively noticed. This would fit the sad but common dishonesty on Earth where only traffic facing façades are given special attention.

Out-vac sculpture of all these sorts, and of kinds we have not imagined, will allow frontier pioneer artists to put a human touch on the lunar surface in the areas where human presence has been or is being securely established. These artifacts will proudly proclaim a clear message:

“This magnificent desolation is ours. It is home.”

The role of lunar-derived artforms and crafts in making settlers feel at home will be major. <MMM>

## The Inadequacy of Robot Scouts

by Robert Gounley, JPL

excerpted from “The Unanswered Question”  
in the 12/97 issue of Odyssey, newsletter of OASIS

It isn't enough to send probes to the Moon.

The tracks of a robotic explorer would look strangely out of place alongside the human footprints of an earlier generation.

No matter how well we can bring pictures of space into Earth's living room, it is not our own eyes doing the viewing.

People work to their best when they can experience a new environment directly.

The act of standing in a different place gives a sense for the place of all things that images and measurement can only approximate.

As for the human act of discovery, the pleasure of seeing a photograph from the top of a mountain is minuscule compared to the ecstasy of having climbed one.

## PROJECT “U-LUCY”

Founding the

### University of Luna in Cyberspace

An ISDC ‘98 Mission Control™ Workshop

Milwaukee, WI, May 24, 1998 - by Peter Kokh

An enormous backlog of homework stands in the way of *timely and efficient* transition from a first beachhead outpost to economically viable lunar frontier town. We've learned a lot about the Moon during Apollo and since - but not nearly enough. If we don't want the Futuristry of the Moon to be one long “hurry up and wait” sad song, we must get serious about doing tons of groundwork. *Technologies must be ready as we need them*, not decades latter.

We need to know more about lunar-appropriate mining techniques and processing lunar regolith soils into all of the various elements we need - not just oxygen, silicon, and the four engineering metals; but also alloying ingredients. We need to know how to produce with the minimum of capital equipment, a workable suite of alloys, and other regolith-derived building materials: glass composites and “lunacrete”, etc. The **chemical engineer** will be the unsung hero of the space frontier.

We need to learn how to fashion these into modular building elements so outpost-into-town expansion can rely as wholly as possible on local resources. We need to learn how to build all the various types of shelter we will need with minimum outdoor man hours. We need Moon-suited **architecture**, not just to design shells, but all the various working features and components as well: windows, sundows, airlocks and docks, and utility system components.

For those needed items, not all of whose parts can be made from elements feasible to produce on the Moon, we need an **Institute of Lunar Industrial Design** to design items to be easily be assembled on the Moon from minor lightweight components made on Earth and major heavier components “Made on Luna”.

We also need a more thorough knowledge of the Moon itself, so various mining and manufacturing operations are sited to best advantage, so that our settlement sites are as ideal as they can be. We need the **Selenographers** and **Selenologists**.

We need to know what are the best off-Moon sites from which to source elements that can't be economically produced here. We need a very good **Economic Geography of the Solar System**.

We need a pool of expertise to assist the speedy diversification of products for both domestic and export markets. We need a school of **enterprise formation and product development**.

We need to develop a whole family of surface **vehicles**: coaches, trucks of all sorts, regolith movers and various other mobile construction and mining machines. But we also need to develop equipment and methods of landing imports on the Moon's surface and exporting value-added exports from it.

We need to learn how best to harness **solar power** on the Moon's surface, for domestic use and for export, using equipment largely locally made. We need to maximize **helium-3** extraction, to develop a suite of methods to store power produced in dayspan for **nightspan power** use. We need to figure out how to produce **nuclear fuels** on the Moon, to bypass the likely ban on export of such materials through the Earth's atmosphere. This is vital for the opening of Mars and the rest of the Outer Solar System.

#### **Human Resources - Tanstaaf!**

We need to learn to blend the work output of cheaper **manpower from Earth** with more expensive work that can only be done on site. Concepts such as telestaffing for routine administrative chores, and teletutoring need to be considered. Shadow crews on Earth can help find solutions to pressing on site problems in **simulation exercises**. Yeomen work can be done here and now to pioneer new Made-on-Luna building materials, art/craft media, and so on.

If we are to transition to actual settlement, ways to **minimize the onsite supervision** burden for **youth and seniors** must be developed. We must identify useful **chores and assignments** for them to free able adults for more productive work.

Some culturally significant matters also need attention: adoption of a Moon Calendar that pays attention to the lunar **dayspan-nightspace rhythms of the 'Sunth'**; testing appropriate **arts and crafts media**, and suitable performing art forms: **dance** and ballet; **sports** and games developed for sixthweight; adoption of unique frontier **holidays and festivities**.

**Political institutions** need attention. Stage by stage granting of home rule; interaction with international agencies on Earth, such as UNESCO, and the U.N. itself; a blueprint for a future federal lunar frontier republic; a reconsidered Bill of Rights; economic regimes to further timely development of lunar resources with due consideration for protecting global scenic and geological treasures, and maximizing the return for the local population.

#### **Urgency of this Workload**

A major fraction of this considerable workload does not have to wait until we have returned to the Moon with a token crew, let alone with a sizable pioneer population. Much work, at least much footwork, can be done by dedicated hard-working people on Earth, here and now, earning their honors as **"Ancestors of the Lunar Frontier."**

#### **Founding "U-LuCy" Now!**

Today the time is ripe. We have a marvelous new tool for organizing work and for publishing innovation: the cyberspace of the World Wide Web. What follows is a trial balloon proposal, to be sent to a number of Moon-interested organizations for feedstock, to set up and found **The University of Luna**, here and now on Earth for all the preliminary work that can be done now, in/on a **Cyberspace Campus**.

Interested parties are hereby invited to a very special and **historic ISDC '98 Workshop** to be tasked with agreeing upon the first concrete steps in **getting the U-LuCy Project up and running**.

## **Nature & Structure of U-LuCy**

We propose U-LuCy exist on two levels:

- The **Undergraduate** level would develop **curricula to teach** current knowledge of the Moon and the steps and stages of how we might settle this new frontier.
- The **Graduate** level would be charged with advancing our knowledge and preparedness for the Lunar Frontier by soliciting and archiving masters level and doctoral **Student Theses** in the many areas needing attention.

Two other means at U-LuCy's disposal might be **design competitions** and assistance in developing **"spin-up" business plans** whereby a technology needed on the lunar frontier is developed *now* - for its various profitable terrestrial applications.

**Money** needed for website maintenance and construction fees, for stipends to overseeing faculty, and for publication and promotion can be raised by a **"Friends of LuCy"** support organization, as well as from endowment solicitations, and various "spin-up" technology licensing fees and royalties.

We leave review of the above proposal and the working out of details, amendments, additions, etc. to the ISDC '98 U-LuCy Workshop. We ask input on whether or not the Workshop should be **two-tiered**, with a fee for active participants, no fee for silent auditors (notes can be passed to the Workshop Secretary) auditors. The workshop can have morning and afternoon, and if necessary, evening sessions.

#### **Workshop Agenda**

The agenda of the workshop is under development and open to constructive suggestions from any and all interested groups and individuals. The following is a starter list with no attempt at logical sequence *or likely breakout into working groups*.

- Capacity of Website needed (very large)
- Selection of a Web Server, Webmaster and crew
- Funds for maintaining the website
- Preliminary website structure
- "Departments" and "Schools" within U-LuCy  
See Appendix for Proposal
- Faculty, reporting protocols, nominal "salaries"
- Endowed Chairs
- Backup strategies for uncompleted tasks
- Publication of the Website
- Graduate level "recruitment"
- U-LuCy publications
- Intellectual Property of U-LuCy assisted developments of methodologies and technologies; Licenses, Royalties
- Initial Board of Directors - starter list
- Initial Board of Advisors - starter list
- Initial Board of Governors - starter list
- Corporate Sponsors and Endowments
- Cooperative MOUs with other Space interest organizations - Charter Memberships
- Cooperative MOUs with various leading space research Universities - Charter Memberships
- Cooperative MOUs with various Industrial companies and consortia - Charter Memberships
- Adaptation of the existing Space Research Matrix™ for

keeping track of R&D work completed, work in progress, work needing (basic/additional) attention

- Initial timetable goals. Reports at successive ISDCs
- Use of the ISDC as venue for the U-LuCy and Friends of U-LuCy annual meetings
- Research Scholarships

**An Open List of Invited Parties**

(Charter Member Co-hosts)

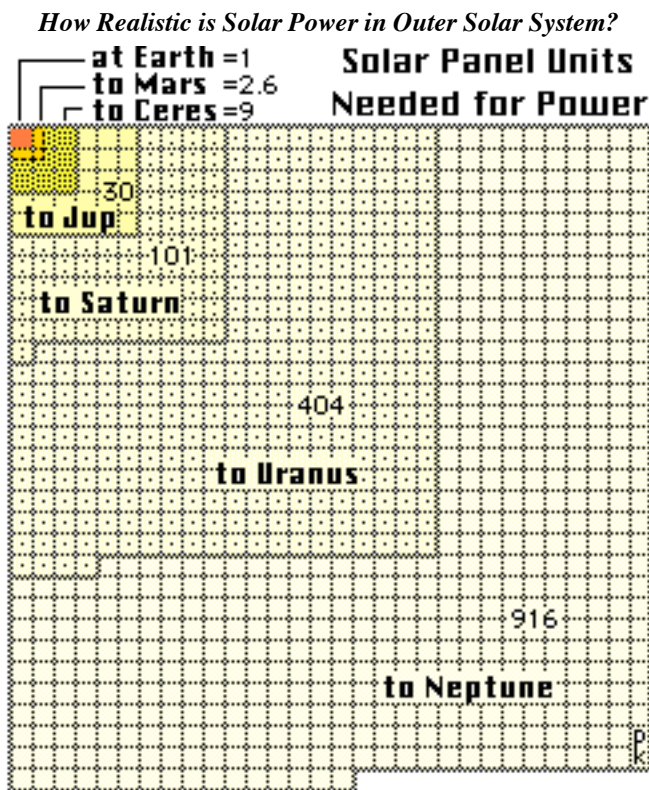
- The Lunar Reclamation Society, Milwaukee
- Artemis Society International, Huntsville
- Lunar National Agricultural Experiment -LUNAX

(Charter Memberships Offered to:) (in alphabetical order)

- American Lunar Society, East Pittsburgh
- The Apollo Society (Delphi Project), Honolulu
- Biosphere II, Inc., Arizona
- Exitus, Inc. - Cuyahoga Valley SS, Cleveland
- Institute of Lunar Technology
- Institute for Teleoperation, Portland
- Lunar Enterprise Association
- Oregon L5 Society, Portland
- Oregon Moonbase, Portland/Bend
- Seattle Lunar Group Studies (SLuGS)
- Space Explorers, Inc. (Moonlink™), Green Bay
- Space Studies Institute, Princeton NJ
- Students for the Exploration & Development of Space/SEDS
- Other Moon-interested NSS Chapters
- Any and all other parties who would like to participate in this ISDC '98 Workshop

To comment on any of the above, offer assistance, request participation in the workshop, and for other inputs and requests:

KokhMMM@aol.com (414) 342-0705 (Peter Kokh/Voice Mail)



**University of Luna in Cyberspace**

Proposed Schools & Departments [s]

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**SCHOOL OF SETTLEMENT TECHNOLOGY**

>> **Selenography & Selenology**

- viewpoint, needs different from IAU, independent
- Feature and Place Name REGISTRY
- ECONOMIC SELENOGRAPHY
  - Lavatube Teledetection PROGRAM
  - Astrobleme Teledetection PROGRAM
- Teleoperation, Telepresence, Buppets etc.

>> **Mining, Processing, Chemical Engineering**

- Element Production Suite Demonstration PROGRAM
- Glass, Ceramics, Cement, Metal Alloy Ingredients PROJECT
- Alloying & Coloring Agents Production PROJECT

>> **Consolar Resources Studies**

- Exo-sourcing
- export-import relationships
- exo-market development
- Comatose Comet Wildcatting PROGRAM

>> **Industrial Design and Manufacturing**

- Stowaway Resource Maximization
- Diversification Strategy and Timing
- MUS/cle DESIGN PROGRAM

>> **Plastic Arts and Crafts**

- Furniture, Furnishings and Decor Prototype
- Mare Manor PROJECT
- Craft finishable generic manufactures
- Lunar-appropriate media development

>> **Biospherics, Agriculture, & Horticulture**

- Modular Biospherics
- recycling system and strategy development
- environmental attention
- Food Production
- Fiber Production
- Pharmaceuticals

>> **Architecture, Infrastructure, Urban Plans**

- Incl. construction, remodeling, and expansion
- Modular Element Testbed Assembly PROGRAM
  - Visual/Solar Access, Utility components, Ramadas, Panorama Domes etc.

>> **Transportation technology**

- Mass Driver Program
- Harenobraking Program
- Road Construction and facilities
- LunaR Fuels and Engines PROGRAM
- Dust Engine PROGRAM
- Lunar skimmer PROGRAM
- Tourist arrangements, destinations, facilities plan

>> **Energy Generation and Nightspan Storage**

- He3 extraction, Lunar Solar Power Arrays
- Nightspan Storage, nuclear fuels

## >> **Astronomy and S.E.T.I.**

- Farside radio astronomy
- Optical astronomy program
- Lunar Amateur Astronomy Extension

## >> **Enterprise Formation and Assistance**

- Terrestrial opportunities - Spin-up tech PROGRAM
- Domestic Lunar needs
- Export opportunities and market development
- solar system trade economics

### SCHOOL OF PIONEER RESOURCES

## >> **Earthside Telestaff Project**

- Recruit Homework & simulations Program
- Junior, Senior Productivity Program
- Teletutoring
- Friends of U-LuCy Outreach Extension PROGRAM
- Traveling Annual Settler Training CAMPS

## >> **Human Resource Utilization**

- Junior, Senior, Gene Pool expansion programs

## >> **Space Frontier Culture**

- Tanstaaf and human resource utilization
  - settler youth, universal service, seniors
- dayspan/nightspan/sunth and Calendar
- plastic/performing arts
  - Simulated Lunar-appropriate plastic arts:  
(paint, sculpture, ceramics, etc.)
  - Performing Arts
    - + Sports development simulations PROJECT
    - + Lunar dance and ballet simulations
  - Posthumous & contemporary Honors AWARDS

### SCHOOL OF LUNAR FRONTIER POLITICAL SCIENCE

## >> **Interior Affairs**

- Lunar Federalization
- surface turf allotment, global subdivision
- settlement hinterlands
- province hinterlands
- national, scenic, selenologic, resource Preserves
- subdivision charter requirements
- Lease Terms (terrestrial R&D, Science concerns)
  - (free if equipment, organic waste left behind in usable condition)
- Manufacturing, Resource Removal licensing STUDY
- Scenic / Selenographic easements requirements

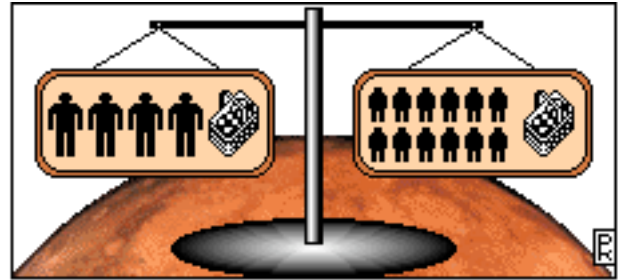
## >> **Frontier Republic Charter & Constitution**

- Conditions, stages of autonomy and home rule
- Bill of Rights
- Executive
- Legislative
- Judicial
- Internal Security
- External Security

## >> **Earth Political, Economic, Cultural, Relations**

- UNESCO, WHO, affiliation, interaction, interfacing with other international agencies
- Urban Tropics Energy Market Affiliation STUDY

## MMM #113 - MAR 1998 - MARS



### ***Bold Tack in Casting the 1st Mars Crew***

The obvious choice is to pick a crew of healthy males representative of participating nations. There could hardly be a more striking instance of the obvious tack being “dead wrong”. Every aspect of the Mars mission can be designed so that brains are everything, brawn irrelevant. We can send *more* “Little People” with *the same supplies* and thus accomplish much more mission for our precious bucks. See “More to Mars” below.

### ***IN FOCUS*** ***In a word:***

***Marsandback, No!***

***Marstostay, Yes!***

We’ve all heard it: “those who do not heed history are condemned to repeat it”. Yet, evidently, for many, if not most of us, it is a quote that has gone in one ear and out the other.

It is now more than 25 years since the last human set foot on the Moon. But what did we expect? The Apollo program was explicitly aimed at putting a human crew on the Moon *and bringing them back safely*. Period. Moonandback. One word. Period. Those of us who knew there should be more, kept fooling ourselves into thinking that there would be more. Right building. Wrong foundation.

Many of us have also for a long time realized that Mars would eventually be the most populated world in the Solar System, Earth itself, of course, excluded. To us few old timers there are welcome legions of reinforcements as the brilliant work of breakthrough mission architectures such as Robert Zubrin’s “Mars Direct” wins new converts.

Yet there is plenty to worry about. No, we don’t refer to the shallow media or the myopic Congress or administrations who follow the masses rather than lead them. I refer to a far more insidious faction, ourselves. Seemingly oblivious of the need to pick means that are suited to the goal, we who inwardly sing the mantra Marstostay, outwardly lead the public and its demagogues in a sing-along “Marsandback!” “Marsandback!” “Marsandback!”

So we urge the government to adopt the goal of manned *exploration* of Mars. Have we not learned that Congress does not budget open-ended programs? To Congress, manned Mars exploration is at best a limited set of missions - flags, footprints, enough token science to quiet the protesters.

***Game Ended.***



Have we learned nothing? Why should we expect Marsandback to be any more pregnant with the future than Moonandback? Human presence on the Moon must now literally rise from the ashes. Twenty five years and counting! We don't know how much longer it will be. Those who expect the government to do the Phoenix trick may find that the tradition of postponement is the path of least resistance. Economics alone will open the Moon.

So why do we now chant in zombie unison "Marsandback!" "Marsandback!" "Marsandback!" ?? There is a need, caution some, to sell the ladder one rung at a time. The public won't swallow the Martian frontier. We have to get them over the anxiety of putting that first toe in the water. We have to sell them on a human expedition to Mars. Once they have accepted that, once that mission is successful, then we sell them the next rung, then the one after that, and so on. To this learned advice we say, "balderdash!" Remember the Moon! "Those who do not heed history are condemned to repeat it."

If we get our sorry way, all we'll earn is another hiatus, this time one guaranteed to be longer and deeper - there are no more attractive worlds than Mars to get things started again in a different theater. And the stand down from the Moon is not the only ominous portent from the pages of history. Look at how our leadership (the individuals change, but somehow the anthem remains the same) has succeeded in bringing about the era of L5 colonies in space and solar power satellites, etc. We decided on the strategy of selling our goal, one rung at a time. And where are we now? About to get a space station which is *not* a stepping stone back to the Moon to retrieve lunar resources to use in building space settlements and solar power satellites. No, we have a "station" (different meaning, same word, much like the cold war semantics of "peace"), a station which is not a depot to anywhere, not a staging point, not a construction yard. It has been sold on other points, *none of them germane* to our goals. Yet we officially continue to boost the station and even to boast of the irrelevant things it will accomplish.

We *can not, must not* sell space one rung at a time. We have to sell the whole ladder. If we do otherwise we will end up with rungs that do not fit together as steps, and thus are not rungs at all, just cul de sacs. Alas, cul de sacs achieve one thing very surely, they preemptively tie up discretionary money achieving something with no real relationship to our original goals. Yet we do not learn our lesson. The players come and go, but the holy Game of selling space one rung at a time is never challenged. Everyone, even declared mutual enemies, accepts the Game as transcendental.

Well that simply means that if someday Mars is settled, we do return to the Moon to stay, there are real human communities beyond Earth - that all this will have come despite those who play the timid Game, not because of it.

So let's cut this talk of human exploration of Mars! Let's start pushing the "settlement of the Martian frontier", and picking means that lead to this end. Logically, it is a simple thing to do. Not to use the right means to the end, is to play into the hands of those who will be only too happy to see our efforts come to naught. We have to stop being our own worst enemy through our carefully organized and compulsively

pursued klutzery.

Just below, we comment on several instances of buzz word language that we find unfocused, weak, ill-phrased to support the goal. On the pages that follow, we will try to show what a real Marstostay program should look like.

After the lead-thud finality of the termination of the Apollo Program set in, we told ourselves that the fatal flaw was the Saturn V. Too expensive an infrastructure to maintain. Yet now like bush league baseball fans wildly cheering every foul ball, we seem prepared to uncritically swallow the government's virtual Mars Program, that is, the Mars Program the government will end up approving based on the inappropriate elements now in place.

With chemical rockets pushed to their design limits taking many months for a Marginal journey, offering little shielding to their cavalier occupants, and without artificial gravity to keep them in shape for the taxing job ahead, we *will* succeed in getting brave roundtrippers to Mars. But this is a transportation infrastructure which cannot support an organized effort to "open" the Martian Frontier.

We need faster nuclear thermal rockets which in cruise mode will separate into tether-bound rotating sections. By providing Marslike gravity for the transit, we assure that when the crew arrives, they will be fit to work immediately, without wasting precious oh-so-expensively-purchased surface time in unproductive bed rest.

We talked about the kind of rockets we really need to open Mars in force in last month's Cassini editorial. We need nuclear rockets that do the job with comfortable ease, rockets that become marginal both in performance and in crew protection only far deeper into the outer Solar System.

We must bite the bullet as well on biologically assisted life support, especially in modules destined to become Mars surface habitats. We need to begin food and fiber production right of the bat.

Well before leaving Earth, we will need to successfully fly a suite of precursor robotic probes that will show us where the resources and assets are, so we can site our outpost where it can best continue to grow into a thriving settlement. We will need surface vehicles able to range swiftly and widely over the whole planet, not ploddingly, tentatively within some shy base perimeter.

Our goal should be to land on Mars "**the first Martians**" *not yet another batch of "returning heroes"*.

But the number one thing we need to bring along is people with the *real* right stuff. Dare we say it? We need to limit Mars crews to true, deeply committed Marstostay people, not Marsandback people. Our goal should *not* be to produce *returning heroes!* It *should rather be* to send *the first new Martians!* Radical? If you can't buy this, you're lost to us. You counter that we must crawl before we run? Well, we squelch that by reminding you that we did it your way on the Moon.

To those who will say, and they surely will, that we have to learn how to stay on Mars before we dare send anyone to stay, we reply that *there is no way to learn except by doing.* There is no way around it. We must take the plunge from the outset - or we are dead. **Game Ended.**

Marstostay does not segue from Marsandback.

Marstostay must be pursued *instead of* Marsandback.

Not enough, we need also to set our brave new worlders down on a site with the resources necessary for them to succeed over the long haul - not on a site picked for its "great geological interest". If we are on Mars for good, we will get to explore the whole planet, in due course, and thoroughly. We must not sacrifice the odds of success to the impatient idle scientific curiosity of those who have no interest in whether or not a Martian frontier is opened. We will learn far, far more in the end, if we go *to stay*. So the "Mars scientist" supporting Marsandback instead of Marstostay is a pathetic hypocrite. If the shoe fits.

There is a long list of hardware development, propulsion breakthroughs and all around general brainstorming homework ahead of us before we will be ready to go to Mars to stay. Nothing less than such preparation will do. There is no point in going before we are ready to do it right. To hurry, to set a target date by which we "will" go to Mars, only ensures that we will go before we are ready - that we will go in order to return, not in order to stay. Jumping the gun may satisfy our impatience in the short run, but will produce a devastating disappointment in the end, as a similar sadly still much admired crash program did on the Moon.

*We call on Space Activist Organizations and other parties truly interested in the Martian frontier to end the current "Mars Madness" campaign.*

Alas, the only trick we seem to know is trying to get the government to do things *for* us, thereby entrusting the insanity of the political process with the proper conduct of affairs for which we should not be so ready to abdicate such a serious responsibility.

We close with this paraphrase of a modern proverb:

*"If it looks like a Marsandback,  
"quacks like a Marsandback, and  
"waddles like a Marsandback,  
"it probably is a Marsandback. "*

If I have embarrassed anyone, it is because I support the emergence of *the real Marstostay you inside*. Search for it, nourish it, and become a spiritual ancestor of the Martian pioneers!

<PK>

## ***MMM comments on frequently stated Mars Policy Points & Buzz Words***

by Peter Kokh

### **√ On Robotic Mars Exploration**

The present method of determination and definition of future Mars missions seems to be a test of which bedfellow alliance of idle scientific curiosities best fits the current funding window.

Future missions should be designed instead to fill in *the knowledge gaps in the way of colonization*. What geographic and geological features, what mineralogical and topographical maps do we need to plan the initial waves of Martian settlement to best insure success. Rather than blanket support for additional probes, we have to be specific about what we most need to know from a strategic point of view.

### **√ A program of field exploration**

All out exploration of Mars will come *after* settlement, not before, for simple logistical reasons. Much more "thorough" exploration can be supported from settlements on Mars, than from Earth far away and infrequently aligned.

### **√ Establishment of a permanent human outpost**

An "permanent outpost" is a contradiction in terms, for Mars and the Moon alike. Nothing that is not underpinned *by viable self-supporting settlement* can be "permanent". Per se, outposts are at the mercy of unpredictable political fads.

### **√ Cheaper access to orbit, advanced propulsion for cheaper interplanetary transportation, and resource utilization technologies to allow increasing self-sufficiency on Mars**

We also need Mars surface transportation technologies that will open Mars on a global basis.

### **√ A humans-to-Mars program**

Space programs are creatures of political fad. We need to put the opening of Mars on an independent economic footing so that it becomes something unstoppable, whether or not it remains in favor among the masses determined to remain at home.

### **√ Inspiring our children to educate themselves for careers in science or engineering.**

An old horseblinder cliché. Opening space depends on much more than mechanical engineering and physics. Its success depends far more on chemical engineering, green engineering, and human factors engineering and students should be guided accordingly. "Space curricula" designed to steer students towards hardware engineering and physics is woefully inadequate.

<MMM>

## ***MMM Mars Policy Statement***

### **Precursor Missions and R&D for a successful "Mars-To-Stay" Campaign**

by Peter Kokh

>> Programs and missions that work towards a Working **Economic Geography of Mars**: RESOURCES: Permafrost, Ores, Lavatubes, Geothermal hot spots

- Mars Permafrost Explorer pre-calibrated by a prior run in Earth orbit in conjunction with inexpensive ground truth calibration
- Mars Prospector, twin of Lunar Prospector, to produce a global chemical map of Martian soils.
- Mars Lavatube Explorer - radar detection of near surface voids
- Mars Topographic Mapper to show potential basin and watershed relationships for settlement siting and to route transglobal surface corridors

>> **Planned Permanence** of a beachhead on Mars with pioneers ready to stay, and with the capacity to grow

- Yolk Sac Logistics - prior in situ manufacture of needed volatiles, including oxygen, methane, ammonia, and water reserves as well as building material stocks for a multi-Mars year reserve. Prior landing of a thorough and

generous spare parts supply. To attempt to open Mars with an Umbilical Cord Strategy relying on resupply and rescue windows more than 25 months apart would invite disaster and tragedy.

- Development of cheaper, faster, safer transit to Mars, drastically reducing immigration costs.
- Toad-style amphibious landers that will provide ready surface motor coaches and hovercraft trucks
- Bioengineered Mars-hardy plant varieties for surface “redhousing” - food and fiber production
- A Mars Industrial and Agricultural Diversification Strategy to accelerate attainment of self-sufficiency goals
- Continued work on a Rationale for a Positive Trade Balance with Earth and with off-Earth outposts on the Moon and elsewhere: “The *Economic Case for Mars*” has yet to be made!
- Development of a pocket “General Hospital”
- Founding the University of Mars in Cyberspace
- A Charter for Staged Autonomy, home rule, and eventual independence, and relations with Earth and with other off-Earth settlements
- A Federal Frontier Constitution trial document to set relationships between multiple settlements, and establish a regime for scenic and geological preserves and easements

<MMM>

# Yolk Sac Logistics

## A Strategy Tailored for Mars

by Peter Kokh

### Foreword

Mars, which orbits the Sun independently from Earth, ranges 146 to 1037 times as far from Earth as the Moon, with launch windows every 25-26 months apart, and with one way journey times of 6-9 months. The Moon, orbiting Earth directly, is accessible at all times, by trips 2-3 days long. An “umbilical cord” logistics system for resupply, repair, and rescue may work well enough for the Moon. For Mars, however, a similar strategy would presumptuously tempt fate, risking almost certain disaster and tragedy - with make-or-break resupply, repair, or rescue arriving far too late - little more than a futile guilt-appeasing gesture.

Any opening on Mars must be supported from an amply supplied forward station, preferably one deployed in advance of first personnel arrivals. Such a forward base could be set up on one of the Martian moonlets, Phobos or Deimos. But it would be more securely placed on the surface at the intended focus of operations. Humans bound for Mars would then depart from Earth secure in the knowledge that all the supplies necessary for their long term survival on Mars were already in place at the landing site.

In Robert Zubrin’s *Mars Direct* proposal, a precursor mission would land a nuclear plant to pre-generate all the fuel needed for a return to Earth flight prior to first crew departure from Earth. This is but the first investment in a Yolk Sac Logistical Support installation. This first Martian factory could continue producing methane and oxygen - not for extra “return fuel” but to propel Martian surface vehicles. But for this there will have to be additional tankage, “on loan” from the Earth return vehicle.

### A Radical Game Plan is a Must

You see, the very first underpinning of any *in earnest* opening of Mars, must be the presumption that *everyone* goes “to stay.” If you have a need to return home - ties to family, friends, climate, vegetation, wild life, pets, hobbies or recreational activities - if you are not able to forsake Earth to begin a new world, if you are not cut out to follow in the footsteps of an earlier Adam or Eve, you have no business volunteering. It will be a long time before the Martian frontier can afford tourists even those with the most papered scientific credentials.

Hardware and people sent home are lost investments in the frontier. Hardware can be reused, reapplied, cannibalized. And people? There will never be enough people for all the jobs that need filling on the new frontier, never enough talents for the tremendous backlog of work facing those who would begin civilization anew. Trying to colonize Mars with pioneers who return home in a few months is like trying to fill a swimming pool with a fork.

No, we *don’t make sure* we can survive first! We go there with the knowledge and tools and faith to fill ourselves with the gut conviction that we can. As Yoda said, a long time ago, a long ways away - “there is no ‘try’, there is just ‘do’”. If we don’t leave the choice of additional precursor Mars probes to idle scientific curiosity, if we make sure they are equipped to tell us what we *need* to know, not just what we *want* to know, and if we do all the other first things first, and do them right, there will be no doubt among those that go. People prone to easy discouragement or pessimism will be weeded out. So will the optimists, blind to the challenges of reality. The frontier needs the “meliorist”, the one who sizes up the situation, accepts it, and goes on from there.

### Yolk Sac Basics

We will also need substantial water reserves. Some water will be squeezed out of the Martian atmosphere as a by-product of the methane and oxygen production cycles. If we have chosen our site well, it will be handy to permafrost deposits, and we will have pre-landed equipment to begin tapping this frozen aquifer. An automated hydroponics facility can be using this water, closely recycled to begin food production. A Pantry of freeze dried food items, to serve as emergency survival rations, can be built up gradually. Freeze dried foods weigh only 12-15% of corresponding fresh foods and, in advance of established farms, will be the cheapest way to provide the pioneers with food.

The nuclear thermal plant needed to power the fuel and volatiles production from the atmosphere should be gangable so that other units landed subsequently can be used in tandem to provide a scalable energy production plant. Excess

power can be stored as chemical energy e.g. used to electrolyze water reserves that can later be combined in fuel cells to recover that energy as needed.

A “Compleat Tool and Parts crib” to fit the needs of landed and soon to arrive equipment and installations will be needed. Resupply can be 6-25 months away, a critical delay that could well defeat the pioneer effort, perhaps ending in tragedy as well.

### **Amphibious Crew Cabins**

The cabins of all landing vehicles could be designed with minor weight penalty, in amphibious fashion, fitted with wheeled chases so that they can serve as surface vehicles. There will never be enough of these, and every crew cabin that returns to Earth will be felt on the frontier as a mortal wound. This concept was first developed in our 1991 paper on Lunar Hostels<sup>1</sup>, delivered in San Antonio.

Some of these cabins could be mated with hovercraft chases, surely a challenge in the thin Martian air, but perhaps engineerable with the assist of hydrogen buoyancy bags. “Skimmers” could traverse the boulder strewn fields as if they were clear-paved, thus opening up distant reaches of the planet to easy and swift access. They would complement Mars craft used as suborbital hoppers for longer cross-planet journeys, as planned by Zubrin.

These hoppers could be used to “plant” intermittent lightweight solar-powered “stations” along logical routes across the Martian terrain between distant settlements. These would produce and store power and fuel and provide emergency communications terminals. We need as light an infrastructure as possible to open the planet globally. With hoppers, skimmers and intermittent self-tending stations, there would be no early need for country roads and highways. Paving efforts will be pretty much confined to early “urban” settings.

### **Stowaway Imports**

Eventually, Martian mining companies will be able to process copper, chromium, and platinum - and other relatively uncommon metals without which modern industry would be impossible. In the meantime, it would be immensely helpful if these one way crew cabins we have proposed could be outfitted with as much copper, brass, stainless steel, and platinum as possible. Once on Mars, such items could be replaced, if need be, with items manufactured locally of ceramics, glass, and basic steels. This would give early Martian industry a steady supply of copper, brass, stainless, and platinum for manufacturing those items for which substitutions are not satisfactory. While blanket use of lightweight metals and plastics would make the crew cabin lighter, requiring less transport fuel, at least part of the fare for “co-importing” these materials stow-away fashion would be paid by such a substitution. In this way such strategic metals can be added to the Yolk Sac.

On the Moon, there will have been strong incentive to “smuggle in”, in similar fashion, simple hydrocarbons, as packaging materials for example, because the Moon, polar icefields or not, was shortchanged from birth in the volatile elements like hydrogen, carbon, and nitrogen. Such an urgency will not apply to Martian needs.

### **The goal - and inevitable “leakage”**

The “Mars to Stay” plan is an ideal. There will be some “leakage”, of course. People with unsuspected medical conditions that cannot be treated on Mars; those who despite rigorous screening, prove not to have the right stuff. These will have to wait patiently for the next launch window, perhaps for the next lander that can be spared. For the sake of argument, let us suppose that a successful healthy opening of the frontier had a leakage rate of one in ten. Of every ten pioneers and of every ten landing craft, just one ended up returning to Earth. There will be no resentment, first because a 90% “conversion” rate will be an icon of success, second because homeward bound craft will carry value-intense goods for hard currency trade with Earth, to purchase the equipment and fares needed for the ninefold ship cabins and ninefold passengers who stay.

What’s the hurry! It’s simple. The faster the frontier opens, the more bearable will be temporary hardships and sacrifices, the sooner will come the perks and compensations, the things that will support the conviction that coming to Mars was the right life move. The slower the frontier opens, the one-toe-in-the-water-then-wait-thirty-years NASA pace, the more certain the odds are that the effort will be stillborn or miscarried or aborted in unfulfilled frustration. Here the conservative is sure to fail, the all-ahead-with-industrious-preparation precipitous “fool” likely to succeed.

### **High Morale is Quintessential**

Morale in a community obviously expanding, flourishing with ever newer, bigger opportunities, with ever more consumer goods in greater variety and of improved quality, with ever more social horizons, with ever more occupational choice, etc. - morale here will be high. By contrast, in a NASA outpost where every added cubic foot of space and every increase in crew size will be argued about for years by a succession of political committees of spurious jurisdiction, morale must soon sink beyond recovery except for those who will have come with no expectations other than the journey itself. If we go to Mars with a commitment only to explore, and that only in a short timeframe, there will be no reason to expect political forces to turn this timid tentative opening into a bold unstoppable one. We must not go to Mars, not at all, unless we “go to stay” from the outset.

Mars is *not* “another Earth” - those who pretend it is lie, to others and to themselves. Mars’ seasons range from very cold to cold beyond utter. Its atmosphere is too thin to offer protection from cosmic rays, solar flares, and raw ultraviolet radiation. In this respect, early Martians will follow the Lunan precedent in burrowing into the surface, relying on a regolith blanket instead of an atmospheric one, for basic shelter. It will be centuries before the gross aggregate of accidental and intentional human activities change this mole-life into the open sky life we terrestrials enjoy. Lunans will have pioneered a suite of ways to bring the outside safely indoors, to enjoy the sunlight and the marsscapes.

The new Martians *will* have it better when it comes to agriculture. They can grow crops under UV-resistant glass, *so long as* all the seed crops are protected from genetic damage from cosmic rays in fully shielded farms underground.

Mars will be a hard frontier. We can't expect pioneers to survive, their spirits unbroken, *unless* the pace of growth and improvements is *appreciably fast*. If nine out of every ten go home, instead of the other way around, the rate of betterment will be so lethargic, that very few will succeed in finding compensation for all the earthly creature comforts they will be forsaking if they choose to stay. It will be folly to expect of such a halting start anything but inevitable collapse, perhaps even final failure.

**“Just-in-case” vs. “Just-in-time”**

On Earth, to reduce the costs of warehousing, we have gone to a system of *just-in-time* resupply of inventories, the opposite of the *just-in-case* system we propose for Mars. Even with the most carefully planned resupply missions in the 25 month pipeline, unexpected emergencies on Mars will create situations from which recovery is not possible, to which speedy reaction would require warp drive and transporters, all fictions that no untwisted read of physics will support - not now, not ever. The umbilical cord just won't stretch over the 56 to 400 million kilometers, nor over the 25 months plus wait between favorable orbital alignments. We must switch to a Yolk Sac Strategic Reserve philosophy. If this makes the cost of doing business higher, it also insures it against catastrophic failure. Yes, failure may not threaten right away, planned resupplies may work just fine, until ... One cannot roll a pair of sixes with every shot. The odds are quite contrary.

**Isolationism as a consequence**

The Yolk Sac philosophy is, however, likely to sire a pronounced isolationism in the Martian spirit and outlook. While the Moon must trade and keep developing new markets, the better endowed Mars is likely to reach a quick plateau of self-sufficiency. Mars is hardly likely to be motivated to open the rest of the Solar System. The ochre desert world will, in time, become a bright new home for humanity, a place where human civilization and culture will have been successfully *reinvented to thrive in the dry and cold*. Countering the millstone of substantial *just-in-case* warehousing will be very fast growth, diversification, and enrichment of Mars frontier life. The Yolk Sac burden will prove a reasonable price to pay.

The reader is encouraged to contribute to this discussion, and identify additional ways in which the Yolk Sac strategy can be implemented to advantage. Send your thoughts on this topic to: kokhmmm@aol.com

<sup>1</sup> Proceedings of the Tenth Annual International Space Development Conference, May 22-27, San Antonio, Texas. pp. 75-92 (specifically pp. 76-8 The Visiting Vehicle), “The Lunar ‘Hostel’: an Alternate Concept for First Beachhead and Secondary Outposts”, P. Kokh, D. Armstrong, M. Kaehny, J. Suszynski. Reprinted in MMM #s 48, 49-50. Republished in MMMC #5 <MMM>



**The Role of Creative Smuggling in the Building of Marsport**

Peter Kokh

**Relevant Reading from past issues of MMM**

MMM #65 MAY '93, pp 6-8, MUS/cle Substitutions; “Stowaway Imports” [republished in MMMC #7]

The subtitle above is not meant to suggest that to succeed in “Pantry Stocking” we have to put one over on mission planners and controllers on Earth. They know that they must provide supplies at least for an additional 25 months, should something go wrong and the planned Earth-return window be missed. That would be common prudence. But! ...

- Crew cubicles that would go empty on the way home (if some crew stay). Ditto unneeded wall dividers, work stations, even tableware, anything ...
- Tare items: crates, pallets, packing stuffers, made of materials easily cannibalized, reshaped, or reworked to serve other useful functions on Mars.
- Every item needed for the return that can be replaced by something easily fabricated on Mars can be made of some material that will be hard to come by on Mars in the near term (e.g. copper)

All these items can either be designed for reuse on Mars *in the same or some other* application.

Or they can be made of materials otherwise hard to come by for the infant Martian industrial economy.

Thus we wish to suggest, as we have done before (reference above) that there are ways to creatively “*put more*” on the manifest without appreciable weight penalties. In this way, nothing takes off for Mars that is not chosen or designed for maximum continued usefulness to the extended mission.

If we are in “Marstostay” mode, and return missions are skeletal not only crew wise but in equipment, most landing vehicles can be designed to serve new purposes as shelter, storage, even expedition rover cabins (our amphibious “toad” concept).

Taking a page from the New Testament miracle of the “loaves and fishes”, we should especially bring along materials that can more easily be combined with local resources to produce extra pantry items. We concentrate on the crucial “ingredients” missing or unavailable to early pioneers, i.e. a “No coals to Newcastle” policy.

That's only “Common Sense”. <MMM>

**“The Economic Case for Mars”  
(How Mars will pay for imports)  
has yet to be made!** <MMM>

# ***"More to Mars"***

## ***Sending 12 men to Mars for the price of 4, or 24 for the price of 8***

**A Radical First Exploration Mission Plan  
that Should Not be So Lightly Dismissed**


by Peter Kokh

Some years ago Robert Zubrin first showed us how to get much more Mars mission for our buck, in his **"Mars Direct"** mission plan proposal. We could make the fuel for the Earth-return leg on Mars itself. In contrast, bringing that fuel along with us to Mars would either mean much heavier and more expensive ships, or less equipment to use on Mars, or both.

Now it is time to show that there is a Mars Direct *"compatible"* mission plan option that could double or triple of the size of the crew - virtually for free - resulting in a first Mars exploration mission with two to three times as much productivity. We call this the **"More to Mars"** mission architecture.

All previous Mars mission plans assume without examination that crew personnel would be selected according to established NASA standards in all respects. Built into these standards is a self-hidden visceral chauvinism that does not let us examine other options, nor even suspect they exist. But in looking *a better way to do Mars*, this hidden parameter deserves as much attention as any other.

Five years ago, in MMM # 64 April '93 in our annual "World Watch" by AFD\* News Service (\* April Fools Day), we ran the following "new story".

 BOULDER, COLORADO: Pygmies and Dwarfs should crew our first exploratory missions to Mars say Doctors Erin Keebler and Tung Yhn Tshieq of the Willy Ley Institute in a report to the National Space Council which they will present at next month's Case For Mars V Conference in Boulder, CO.

Pygmies and Dwarfs, or Little People as they are now more commonly called, have greatly diminished body mass but fully normal brain size and intelligence. The Mars Mission, they say, can easily be engineered so that brains count for almost everything, brawn for next to nothing. A crew with a combined body mass 25% that of the average astronaut crew of the same number would have a tremendous advantage in two ways. First the crew would need only a weight-proportionate amount of consumables: food, water, fresh air reserves.

Second, while the mass and volume of needed spaceship systems and work stations would remain unchanged, the size, volume, and associated mass of both private and common quarters and walk space could be proportionately reduced. Keebler and Tshieq contend that for otherwise identical missions, one crewed by Little People and designed to be so, would have a fueled

launch weight 40% less than one planned for full-size crew members.

This savings can either be reflected in a cheaper, quicker mission, or "cashed in" for extra payload and a longer duration stay on Mars, or for a larger crew. This becomes an attractive win-win-win situation.

The only drawback, the authors admit, is the need to sell the idea to a public that has not ever really accepted either Pygmies or Little People as *real* people.

For individual space supporters, the vicarious pleasure of identifying with our pioneers and explorers is a big element and the choice of so 'unrepresentative' a crew could demand an overdue attitude shift.

**AFD News Service**

In fact, we were dead serious about this proposal. Yet the disheartening lack of subsequent feedback to this piece only served to show how most readers apparently took it as a joke. Yes, a sad joke *on them (on you, if the shoe fits!)* The hint not taken five years ago, it is now time to declare ownership of this idea and to publish it anew. This is one of those times, dear reader, to either lead, follow, or get out of the way.

As pointed out in our "tongue-in-cheek" AFD story, the substantial weight savings from selecting substantially smaller humans of undiminished capacities and abilities can be "spent" in three ways:

- **Less massive Mars ships, same size crew, mission**
- **Same size ships, more consumables, longer stay**
- **Same size ships, larger crew, larger task load**

If the cost of the first Mars mission is a major political stumbling block, the same size "ground mission" can be achieved with a smaller rocket and less fuel - at substantial cost savings.

If the government(s) has (have) accepted conventional costing, what we get for that price can be doubled or tripled by either remaining option.

The objections sure to arise to such a plan are the following, neither of them defensible:

- "Subsize humans have inferior intellects and lesser technical and manual abilities"
- "The public will never identify with these "toy"- sized humans and thus lose interest."

The first objection is truly facetious. There is plenty of time before the first Mars mission (20 years or more) *to identify now* dwarf and/or Pygmy individuals with the sufficient aptitude, and then to educate and train them *from early youth* to perform as outstandingly as any more advantaged candidates.

The second objection is reminiscent of racist objections to the introduction of blacks into the major sports. Sports history in the past half century gives this thesis the lie. The public willingly and very quickly takes to its heart *whoever performs* in outstanding fashion. We would sell the public short, perhaps to disguise hidden unexamined attitudes in ourselves.

I am not suggesting here that Mars be *settled* exclu-

sively with diminutive individuals, only that making our initial *exploration* crew selection from their ranks could be the smartest thing we can do.

In time, improved transportation options will make emigration to Mars affordable to individuals of more commonplace stature and body mass. “The” important thing, however, is to break the ice on Mars, and to do as much pioneer scouting and pave-the-way scientific investigation as possible *in one shot* given the money available, *so as to lead to the opening of the Mars Frontier in the timeliest fashion possible.*

**“More to Mars” is our best chance to make the most of what may be a solitary opportunity.**

The purse-holders of the world may not pay for a “second Mars Exploration Mission”, whether or not additional missions have been *planned* as part of a total exploration package.

***The one thing that is vitally important is to accomplish all the exploratory and investigative tasks necessary to pave the way for the opening of the Mars Frontier to settlement in the first mission, lest we get no follow up opportunities.***

Whoever thinks that this is not important, has learned nothing from the politics of Apollo. If we do get the chance to send humans to Mars, it may very well be a solitary chance. “More to Mars” is our best chance to make the most of it.

I urge the prospace and pro-Mars communities to take the suggestion as seriously as it is meant, and to constructively brainstorm it further. “More to Mars” is a second watershed in the history of Mars Mission Planning. In the end, through our decisions, we shall deserve what we shall get - as always.

In the process, Little People and/or Pygmies could earn lasting and long overdue respect. Just as their outstanding participation in the performing arts and major sports has won Afro-Americans widespread and genuine, if limited respect in today’s world, a successful mission to Mars crewed by more diminutive persons will do much to erode the major cultural barriers that these populations now face.

In the end, we must ask ourselves that age-old question:

***“Is it better to be on top of a small hill, or half way up a tall mountain?”***

In becoming *all* that man can be, it is vital that we employ all the varied talents that are out our disposal. Every time we collectively exclude full participation by a minority population, we self-betrayingly choose “the smaller hill”. Dwarfism may be one of humanity’s infrequent and most unsuspected talents. A successful one-shot Mars-opening mission lies in the balance.

***Three or more millions of years ago  
3 foot tall proto-hominids scouted the way  
for the human rise to ascendancy  
on our home planet.***

Does it not seem poetically fitting that a “race” of little scouts turn the trick once again - this time on Mars?

<PK>

# Dwarfs & Pygmies

***Just the facts, please!***

**Dwarfs** are not a race. “Dwarfism” is a nonhereditary genetic condition found *among all races*. Children of dwarfs who marry are usually of “normal stature”. Thus dwarfs are “where you find them”. Intelligence and manual dexterity are unaffected. While the “supply” is smaller in terms of numbers, so is average height (less than 3 ft/1 meter) and weight (30-45 lbs.)

**Pygmies** are members of two “races”, the

- 150,000 Negrillos of central Africa, and approximately
- 35,000 Negritos of Southeast Asia and Oceania.

The former average a half foot shorter (4’-4’8”) than the latter (4’6” to 5”). Both these populations are more “normally proportioned” than are “dwarfs”, and they are heavier: 60-80 lbs and 80-100 lbs respectively.

**The Upshot for a “More to Mars” Mission**

- Interior habitat configurations can be made more compact, starting with personal sleeping cubicles, elbow room at work stations, etc.
- Shifts and hot-racking will stretch common spaces, and multiply the in-flight work that gets done.
- Crew rovers can be downsized, making room for twice as many.
- The Mars outpost could be “bigger” staff wise, or we could have outlying tended camps to support more far-ranging exploration and prospecting.
- The list of talents and abilities represented could be doubled, or even tripled.
- The physical mission will be designed to call for hands and brains, not muscles, and there will be more of those.
- In “More to Mars” a *first* mission could achieve the goals of the first three “conventionally-manned” missions.

***Its a win-win-win situation.***

*A reasonable man adapts himself to the conditions that surround him.*

*An unreasonable man adapts the surrounding conditions to himself.*

*All progress depends on the unreasonable man.*

- George Bernard Shaw

**“The Best Way to Predict the Future is to Invent It!”**

# SUSTAINED SORTIE EXPLORATION OF MARS

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Human exploration of Mars must proceed rapidly (once such a program is started) and achieve major goals *within a politically acceptable time-span* or it will never be approved. Similarly, the price-tag to achieve major goals must be within acceptable levels. However, minimizing development costs at the expense of maximizing recurring costs (as in Apollo and the Shuttle Program) will inevitably prevent sustained exploration of Mars.

Unrestricted global exploration of Mars will be needed to understand the planet's global geology and climate history, search for past and surviving life, and inventory and exploit its global resources. *Proceeding rapidly to creation of a permanent manned surface base would cripple access to the rest of the planet and squander resources on studying one, relatively limited area.\**

Sustained global exploration of Mars can be achieved by the following steps:

- 1. Determine whether Phobos and Deimos have usable supplies of extractable water** beneath their impact-dessicated regoliths.
- 2. Develop hardware to obtain oxygen and hydrogen (or methane) from the martian moons** to provide propellant to support sustained operations at Mars.
- 3. Design and build a Mars Orbital Base**, using minimally modified space-station hardware where at all possible. Test it in Earth orbit, mothball it, then send it to Mars unmanned and place it in a stable orbit near Phobos (or Deimos, if Deimos has significantly better resources). A rotating habitat may be needed to provide gravity to maintain crew health.
- 4. Design a fully reusable Mars Orbital Tug**, using minimally modified Earth Orbital Tug hardware where at all possible, that can use propellants manufactured at Mars. It should be able to leave the orbital base and aerobreak into low polar or equatorial Mars orbit, carrying large payloads including Mars Excursion Vehicles, *or launch Earth/Mars transfer vehicles on earth return trajectories*, and then return to the orbital base. Place two of these in Mars orbit with the Orbital Base.
- 5. Develop a fully reusable aerobraking Earth/Mars Transfer Vehicle** that can be launched from Earth or Earth orbit, aerobreak into Mars orbit, and rendezvous with the Tugs and be taken to the Orbital Base. Launched from Mars orbit by a tug, it would aerobreak back into Earth orbit for rendezvous with a Low Earth Orbit Space Station or Tug.
- 6. After a contingency fuel supply is placed in Mars orbit**, on the initial mission to Mars, the crew would activate the Orbital Base, start oxidizer and fuel production, explore Phobos and Deimos in person, and explore Mars by teleoperated Rovers and Flyers.

**7. Design a fully reusable Mars Excursion Vehicle** that can land on Mars from low orbit, carrying reusable crew or cargo modules, then return to low Mars orbit with its payload for retrieval by a tug. They should be capable of landing at any latitude and during any season (except probably polar winter). Send two to Mars, aerobraking them into Mars orbit for retrieval by the tugs.

**8. Sustained sortie-exploration** of the entire martian surface will be possible, once the Mars Excursion Vehicles are available, limited by the

√ time needed to maintain and outfit the Excursion Vehicles and Orbital Tugs between missions

√ the propellant production rates. Addition of modules to the Orbital Base and Propellant Factory, plus additional Orbital Tugs and Excursion Vehicles can build up a robust exploration and operations capability at Mars without incurring the high recurring costs of building and discarding throwaway vehicles.

**9. After the initial landing on Mars**, additional sites can be visited once, retrieving samples and deploying fixed science stations and teleoperated/robotic rovers for traverses to later landing sites. Field camps can be established at certain sites and visited occasionally. Reusable shelters and supply depots can be set up at some field camps, then be mothballed between visits.

**10. After some years of sustained, low cost exploration of Mars from orbit**, a site can finally be picked for a permanent Mars Surface Base (probably a field camp), and a base can be progressively constructed and outfitted over a period of a few years until it becomes continuously habitable.

<ES III>

## EDITOR'S COMMENT:

Mars can be explored globally either from an orbit home base, by shuttles that can land anywhere, or from a surface home base, either by suborbital hoppers or using "ground" vehicles capable of traversing vast stretches with relative ease.

- ☑ The problem with the orbital "home" approach is that it lays *no foundations* for global settlement.
- ☑ The problem with the surface "home" approach is that the location picked for "home" *might* not be the best.

Thorough unmanned exploration by robotic probes should suggest a short list of prime sites or nodes for *exploring and opening the globe*.

Thorough unmanned exploration of Mars can be done *more expeditiously by teleoperation of a fleet of landed probes from a manned forward base on Phobos or Deimos*.

*We are/will be under the gun of time*, but we have to not only explore, but to establish an unabandonable human beachhead *before the purse strings close*. Once we, the new *Martiani*, are there to stay, there will be the rest of time to explore in greater detail, our new "home" world. We are now bogged down with "*one space station*". Why repeat? — PK]



## ***First Lunar Memorial Flight is a Humble Step Towards a Historic Spiritual Milestone***

by Peter Kokh

To date, efforts to “bury” humans off planet are little more than symbolic first steps. The two Celestis orbital flights are not much more than gestures. In each instance not even 1% of the individual’s ashes are involved. More sobering is the fact that these orbits will decay; the “symbolic portion” of the ashes involved *will return to Earth*.

With the **Lunar Prospector** launch, we do have the 1st ever launch into space, “*never to return*” of human remains. A “symbolic portion” of Dr. Shoemaker’s remains *will crash onto the Moon. Yet 299/300ths of his remains will rest on Earth*.

We are taking steps, but we are not quite there. A major psychological milestone in the epic of mankind will be reached when the first person’s full remains (intact body, freeze dried body, cremated ashes or cremains, or cremains of internal organs set in freeze dried body shell) are permanently laid to rest somewhere else in the universe other than Earth.

See MMM # 105 MAY '97, pp. 6-7, “Burial off Planet”

### ***“The Silence of the Lambs”***

A personal expression of outrage by Peter Kokh

Suddenly out of the blue, some self-appointed American Indian “tribal spokesmen” took NASA to task for “desecrating” the Moon with human ashes *because* the Moon is sacred turf to them. *Don’t even try to reign me in here. This was the height of arrogance. The Moon cannot possibly belong to any tribe or combination of tribes. It orbits overhead of all Earth and all nations. And even if it did hover exclusively over some native homeland, legal precedent established in the case of the World Court-rejected Brazilian claims to sovereignty over the section of geosynchronous orbit directly over its territory, it would mean nothing. If these tribes get away with this, others might well demand a royalty for all use of solar collectors, “the Sun is sacred to us!”*

Equally outrageous and *equally arrogant* was NASA’s response, “Oh! Whoops! We didn’t know! *We won’t do it again!*” (Read: “We won’t *allow* it again!”) Nowhere can NASA find it in its mandate *to decide without political debate* to bow down before absurd native claims. Nowhere can NASA find justification for its *summary interdiction of the human race’s right to settle* and expand in normal human fashion into Earth’s orbit-bonded hinterland.

I don’t know whether this “apology” came from a secondary NASA official, or from Dan Goldin. It doesn’t matter. It deserves and commands extreme contempt. *This is a political question*, one that it is inconceivable to imagine would ever be settled in favor of the pretentious, superstitious, and arrogant native claims. For some NASA spokesman afraid of his or her own shadow to pledge that *any* humans who may someday be based on the Moon, or who go there to pioneer and settle, cannot bury even the ashes of their own *locally*, is worthy of outright disrespect.

I would tell that to Goldin’s face if I had the chance. *This is too important a matter to be buried out of concern for diplomacy and tact.* I know many readers think that NASA is necessary to get us into space. But *here* is a case where the agency has made a political decision *on its own* to *slam the door in the face of future lunar development and settlement*. If ever there was evidence that NASA might rather be a *roadblock* to the future, here it is.

What troubles this writer even more deeply than the arrogance of the Indian tribal spokesman, or than the arrogance of the NASA spokesperson, is the “Silence of the Lambs” in the press, - even in the pro-Space press, over this matter.

What is the matter with everybody? Are you all weak kneed sissies? This is wrong, wrong, wrong!

*Why isn’t everyone screaming?* We fought the Moon Treaty successfully. Now we are ready to turn over and go back to sleep after this double arrogance threatens to wreck everything. <PK, proudly>

**MMM # 114 - APR 1998**



### ***Venus — 35 years of Embargo is Enough!***

Its time to quit our over-prolonged pouting tantrum since learning that Venus was as close to the traditional picture of Hell as we might ever fear to visit. IF we put aside our crushed expectations and take another look, trying to see apparent extreme disadvantages in another light, we might just find the door ajar for human presence and activity after all. All it takes is an open mind and imagination. *More below!*

### **JN FOCUS Earthday 28:**

#### ***Lessons that will only be learned in Space***

We Earthlings have been down on ourselves for sometime when it comes to our environmental conscience. It seems we may have inherited from our common ancestors a bad habit legendary among our Primate relatives: we are quite content to foul our own nest. Primates cannot be housebroken. And some times it looms certain that we humans can’t be planetbroken. We are quite content as pigs in mud befouling our one and only “habitable planet.”

A big part of the problem, something that must not be overlooked as it bears on any ultimate solution, is that thanks to gravity, water rolls down hill, carrying waterborne pollutants and garbage out of our own tribal territory into that of our neighbors while, thanks to the Sun-driven winds, whatever we

belch into the once fresh air is likewise dispersed “somewhere else”

Those who feel humans should not go into space lest we trash every other place we come to as we have our homeworld, overlook one radically different characteristic of all potential human townsteads out there. There are no biospheres to pollute, we must make mini-biospheres of our own to shelter and reencradle ourselves, and within their very finite limits, there is “no place else for our untreated discharges to flow downstream, to blow downwind”. Future Lunans, future Martians, future asteroid beltters, future space settlement citizens will *all* do something *no* human has ever done before. They’ll live immediately downwind and downstream of themselves. As such, their environmental sins, should they be so foolish to commit them, will haunt not their neighbors, nor their grandchildren, but themselves - not a couple of generations hence, but right away - that morrow if not that same day.

We are used to living in a transcendently planet-wide biosphere. We see no ready distinction between planet and its air and water envelopes that sustain life everywhere, so easily. Everywhere, even in superheated, sulfur-saturated deep ocean waters near sea bottom volcanic vents. Everywhere even in the boiling mud lakes of Yellowstone Park. Everywhere even in the oxygen-deprived methane soaked oozes of the ocean bottom. Everywhere, even under the ice shelves off Antarctica. I once recall, while en route from Milwaukee to the ‘88 ISDC in Denver, driving into NE Colorado through endless rolling hills of nothing but scrub brush and tumbleweed, saying to my car mates, “how godforsakenly desolate this place is!” Then, suddenly realizing my mistake, “how silly of me. On the Moon, this would be a lushly verdant National Park, a planetary treasure!”

Indeed, there is *no* life out there. We must take it with us. It is not just humans who would live in extraplanetary exclaves. But humans reencradled in the very Gaian Earth Life that encradles us now. Our existence is a symbiotic one, and it is a matter of emphasis whether we’re taking representative terrestrial flora and fauna out there with us, or whether we are just the gonads of Gaia, pubescent with technology, the sole means by which Earth life can spread to worlds once barren and virginal, letting them glory in the joys of motherhood for all time previously denied them, motherhood of and to life.

Out there, humans must survive in a radically new situation, a situation turned on its head, in mini-biospheres close-coupled with nature, with nowhere to throw anything away - “immediately down wind and downstream of ourselves”. It will be sink or swim time, from the gitgo, from then on forever so long as humans shall survive beyond Earth. Failure is radically intolerable. We must get it right, get it right all the time without fail, things we’ve never got right before - *because we did not have to get it right!*

Biosphere II’s was a bold daring mission. Nothing less than learning how to live in harmony with nature. It was an expensive project, funded by a wealthy individual - hardly an economically duplicable experiment. We *did* learn something. But this is not the way to learn more. We just *won’t* spend the money, we *will not* take the pains, all for the same simple reason. *We don’t have to*. The penalty for failure is too remote,

too postponable. We can be bothered to inconvenience ourselves trying *only so long before* we shrug our shoulders. And there are many other oases of environmental inspiration about the globe from Lindisfarne to Bloomington, Indiana. Valiant efforts that in the end tilt against the windmill of postponed punishment for failure.

True, many of us are moved to pursue space development in search of ultra clean space-based energy schemes promising inexhaustible pure energy for Earth, relieving this planet of the single most dirty activity of all, in its gross effect, producing energy, by damming rivers and ruining valleys, by mining and burning coal and oil and uranium. With clean energy we dream of bringing Earth’s unprivileged billions to the table of cornucopia, with enough reserves for all to share the good life sustainably.

Important as these possibilities are, they come at a high upfront price and hence themselves beg to be postponed. And what politician can resist? But there is another environmental benefit from the near term establishment of viable human communities on the extreme and unforgiving shores of the barren sister worlds of our solar hinterland. This is a benefit that is not so easily given a dollar value, a benefit that cannot be traded on the stock exchanges of the worlds financial centers. It is the benefit of knowledge, of know-how, of “having learned how, at long last, to live fully at peace with nature, transplanted life within our hull-contained mini-biospheres, on acres “reclaimed” from the lifeless wastelands of cosmic ray-washed shores. Lessons learned *because we had to learn them*, had to or die. We have to get it right, right the first time, or our beachhead will become another in an already long list of human ruins and ghost towns buried in the sands of time.

“Spin-offs” are available from any high technology initiative. Asteroidal wealth may never come. Inexhaustible supplies of space solar power, of lunar and Uranian Helium-3 may take generations to tap. No benefit is so certain and so powerful as that without which none of the others can be attained. Getting our symbiosis with nature right - for the first time. Not even in the idyllic pastoral times of the mythical past did we do it right. Now it will be different. We will succeed because we have to. And this knowledge, more than all the energy in space, more than all the technological spinoffs, more than all the asteroidal wealth, this wisdom will save our beloved Earth. - PK

[In the aftermath of Lunar Prospector’s apparently positive find of indications of water-ice at both lunar poles.]

## **CARBON & NITROGEN ICES**

**More than Water and Hydrogen are at stake**

by Peter Kokh

The inclusion of carbon and nitrogen ices is strategically just as important as the finding of economically significant water ice deposits.

By unanimous expectation, lunar polar ice deposits are a relic of cometary bombardment of the Moon over geologically long time spans. But comets, as most of us have long known, are not just giant snow balls, but “dirty” snow-

balls. Analysis of cometary halos and tails shows plenty of dust, but also various carbon and nitrogen compounds such as carbon dioxide, methane, nitrogen oxides, and ammonia, all being vented by the comet in gaseous form.

We cannot automatically expect this same characteristic composition to be reflected quantity for quantity in the Lunar Polar Icefield deposits. Some cometary volatiles will have been more easily dispersed by an ever present solar wind than others.

Just the same, it would be mind-shattering for a lunar polar lander to find *pure* water ice. What we *can* expect to find is “clathrate ice” in which molecules of carbon oxide ices, for example, are intermixed with the frozen water molecules as a significant secondary component. And there should be other volatiles present as well.

This is *more than* a scientific curiosity and/ or a *mining nuisance*. Indeed, the inclusion of carbon and nitrogen ices is economically potentially as important as the finding of economically significant amounts of water ice.

To the rocket jockeys who see the ice solely as the use-once-and exhaust-forever source of quick cryogenic hydrogen and oxygen rocket fuels, these other volatiles are an irrelevant nuisance. But to anyone interested in the establishment of a permanent industrial human economy on the Moon, the inclusion in the same hoard of significant amounts of carbon and nitrogen ices is a tremendous bonanza.

Settlement means industry. Industry will need recyclable amounts of carbon and nitrogen, just as it will of water. Settlement also means food and fiber production, agriculture, and a biosphere. For these we need carbon and nitrogen just as critically as we need hydrogen (water).

Indeed, *in comparison to the proportions that would be needed to sustain a settlement, the Moon and its regolith soil, apart from the polar ice field deposits, is more deprived and deficient in carbon and especially nitrogen, than in water (hydro-en)*. That is to say, if all we were to find at the poles was water ice, this would just shift the “settlement showstopper role” to carbon and nitrogen. We would still have a significant problem in supplying our proposed industrial settlement with basic needs.

As to oxygen, yes, it will be less energy-expensive to extract oxygen from the polar ice than from rock and dust. But there is plenty of oxygen and enough energy to get all we need from the latter.

*The presence of these ices at the poles is NO indication that this is where we should build our industrial settlements.*

The real treasure of the Lunar Polar Icefields is elemental hydrogen, carbon, and nitrogen. Again, we cannot say it often enough, the presence of these volatiles at the poles is *no* indication that this is where we should build our industrial settlement, anymore than we would rebuild Los Angeles on the Alaska North Slope. We will need far larger tonnages of other elements - silicon, aluminum, magnesium, iron, titanium, etc. for our lunar industries than we will need of hydrogen, carbon and nitrogen. And the latter are more easily mined elsewhere.

We need a polar refining operations feeding a pipeline network to settlements elsewhere.

What we want at the poles is a mining and refining

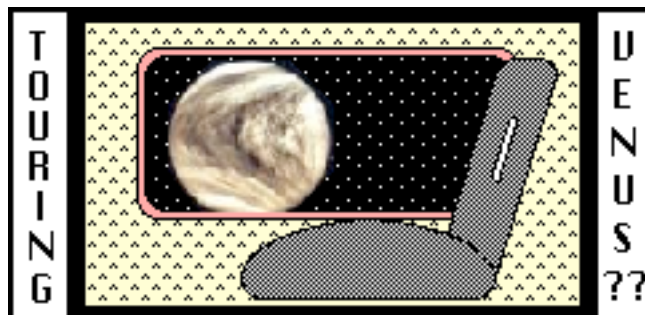
operation feeding a pipeline network to other parts of the Moon better suited for major industry. Pipelines? Yes, and that very mode of gaseous transport points exactly in which direction we need to go: our polar icefield refineries should be producing **Methane** (CH<sub>4</sub>) and **Ammonia** (NH<sub>3</sub>) and surplus **Oxygen** (O<sub>2</sub>). These gasses are all easily transported via pipe without heavy leakage (in contrast to pure hydrogen) and will be easily maintained in the gaseous state through the entire temperature range such pipelines would be expected to experience.

At various terminals and taps, the methane and ammonia could be used as is, or burned with the incoming oxygen to produce water, various carbon and nitrogen compounds, and recover much of the **energy** from the refining operation inputs.

*Our prediction is* that lunar settlement will start in some highland / mare coast area, using “primage” techniques to extract solar-wind-borne hydrogen from the soil *as this regolith moon dust is moved routinely*. Then, *as the lunar economy grows enough to inspire confidence*, the somewhat more attractive lunar polar deposits will become the scene of major infrastructure development: mining operations, refining, and pipeline systems. Then Lunar settlement and industrialization will really begin to mushroom.

Lunar settlement could someday well outgrow the scope of this endowment. But the lunar polar ice-fields confirmed by Lunar Prospector, will have primed the pump. Additional volatiles can later be brought in from dormant comets to feed the settlement once it is an established proposition.

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## A Fresh Look at a Forgotten World

by Peter Kokh

Prior to 1960, we basked in our mainstream expectation that underneath Venus’ perpetual cloud cover, we would find a very warm oceanic world with scattered islands covered with steamy jungles and forbidding swamps. Writers like C.S. Lewis and Robert Heinlein made Venus a common setting for Solar System interplanetary adventure tales.

Suddenly, crudely, without warning, in the early 60s, Earth-based radar shattered this unsuspected illusion. Venus was dry, self-cleaning-oven-hot, cursed with an unbreathable brimstone-dosed carbon dioxide atmosphere of crushing density.

Overnight, Venus was “off the list.” Off the list of places to explore. Off the list of places to tour. Off the list of worlds that might harbor life. Off the list of human coloniza-

tion. Off the list of human horizons altogether. Venus remained in the heavens, of course, as an astronomical object, as an environmental object lesson, as a deceptively beautiful siren beacon, and as a significant gravity well useful for redirecting and accelerating objects bound for the outer solar system (like Galileo).

This once-upon-a-time paradise world of C.S. Lewis' "Pearlandra" was suddenly the perfect illustration for medieval concepts of the Hell of the Scriptures. As a "purely" scientific curiosity, (don't you believe that for a moment!) Venus remained high on the priority list as a destination for our probes. We "wanted to know" not only what Venus was really like: its topographic features, contours of could-have-been continents and could-have-been ocean basins and mountains and trenches and volcanoes and impact craters. Down deep our aim has always been to "terraform" our lost Sister Planet, at least in our imagination. We would dissipate its excessive atmosphere and radiate out into space all that trapped heat, and refill its oceanic basins drop by drop with comet water.

Still smarting from our loss, we masochistically needed to know how much of a Sister World we could have had, had not something gone terribly awry. Even though Venus is closer to the Sun and gets twice as much solar warmth, that does not explain why it is many times twice as hot on the surface, nor why its atmosphere became so crushingly dense.

Practically, while as "dispassionate, uninvolved" scientists we still wanted to know more, we all personally resigned ourselves to Venus being off the list as a target for future manned exploration, future outposts and farther future settlements, and, of course, as a future tourist destination.

If we but clean up our radar screens of emotional noise, Voilà! Venus reappears! A planet that can support manned scientific outposts, and an exotic tourist stop.

Okay, we have had 35 years to pout. It is time to grow up and take another look. We did it for China, and Russia. We are doing it for Cuba. Why not Venus too? And what do you know? Suspend our wounded spirits and Voilà! Venus reappears, both on the screens of human expeditions and outposts, and on the screens of tourist destinations. Yes, despite the fact that it remains a "hell hole"!

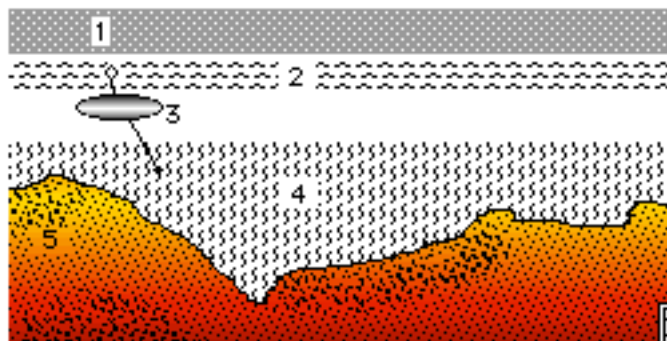
In MMM # 60 NOV '92, pp. 3-6 "PUSHING THE ENVELOPE: Aerostat Xities 'afloat' in the atmospheres of Venus, Jupiter, Saturn, Titan, Uranus, & Neptune", we pointed out **some advantageous facts lost in the static of woe-is-us reports about Venus**. The thick and visually impenetrable cloud deck over Venus is very high up over the surface compared to clouds on Earth - indeed about 30-40 miles up (150-200,000 feet. *Just below this cloud deck it is* (1) *clear*, affording panoramic views of the surface free of any obstructing clouds; (2) *not so dense*, in fact, about as thick as our own atmosphere at sea level; (3) *not so hot*, well within temperature ranges we find comfortable on Earth.

NOTES: "Aerostat" means a *buoyant* structure such as a balloon, blimp, or dirigible, capable of staying airborne indefinitely so long as its relative buoyancy is maintained. On Venus, sufficient buoyancy can be provided by either hydrogen, helium, or less efficiently, by carbon monoxide.

"Xity": a communal habitat beyond Earth's life-sustaining envelope that must provide and maintain its own biosphere.

NOTE: Venus and Titan are the most favorable worlds. It would be *very difficult* to sustain buoyancy in the low average molecular weight atmospheres of gas giant planets: Jupiter, Saturn, Uranus, Neptune.

The following is from the article in MMM # 60.



FLOAT LEVEL OF VENUS AEROSTAT XITY: 1) Space and vacuum above the atmosphere; 2) Unbroken cloud level 30-40 miles above the surface; 3) Venus aerostat xity floating just under the cloud deck about 30 mi (150,000 ft.) above the surface in cool CO2 atmosphere at the 1 ATM pressure level with a clear view of the surface. An upper atmosphere meteorology station is borne on tethered balloon above while a lower atmosphere station is trailed by tether below; 4) super oven-hot super dense lower layers of the atmosphere; 5) Very hot surface of Venus: continents, empty basins, volcanoes (live and dormant), craters, mountain massifs, valleys and trenches.

Back to our subject — Tourism

So where does this leave us? Obviously, *we should be as busy* planning a floating science outpost over Venus as we are planning science outposts on Mars' surface. From such an outpost, with a variety of instruments, we could study the Veneran surface below from relative proximity, with both visual and other instruments. Tethered probes could sample lower atmospheric levels and those higher up. *And, if we could devise thermally hardened instruments* that would survive for days or longer on the surface, we could *teleoperate* them from our aerial perch. Even teleoperated rovers are not beyond the realm of the possible, using greaseless magnetic bearings, etc.

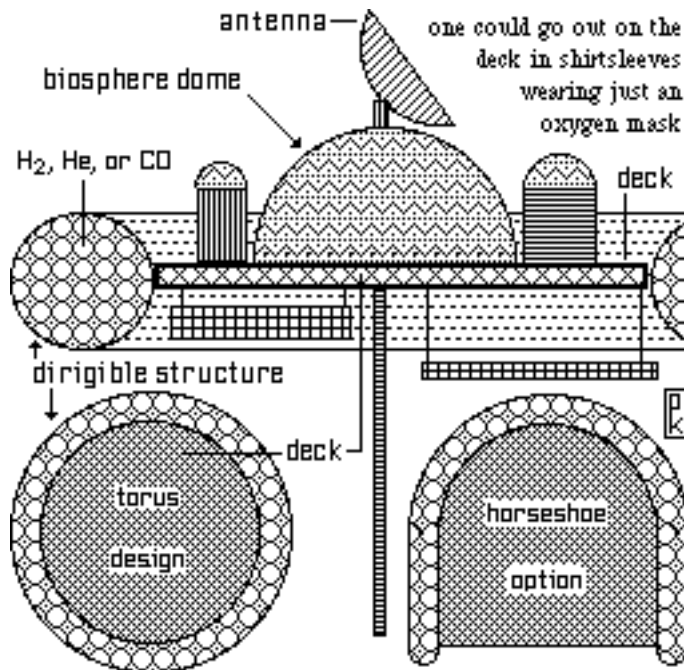
Okay, but we promised to talk about tourism! While surface excursions remain as far-fetched as they have been for the past 35 years, tourists *could* descend by ship through the upper atmosphere to rendezvous and dock with a floating hotel just below the cloud decks, staying long enough to get the feeling of Venus topography - or as long as it takes before the return-to-Earth window opens.

**GRAVITY/WEIGHT IN VENERAN AEROSTAT XITIES**

Earth	100%	110 lbs	150 lbs	200 lbs
Venus	91%	91 lbs	136 lbs	182 lbs

From a gravity point of view, visitors to Veneran aerostat stations would feel quite at home.

"Valentine Heights" from the MMM #60 article, conceived as an aggressive interactive outpost engaged in science and industries based on atmospheric feed stocks.



**A VENERAN “SUBNUBILAR” AEROSTAT XITY**

: Cutaway of a large torus or horseshoe float with cellular ballonets and bladders providing buoyancy support for the Xity. Hydrogen gas is preferred, but carbon monoxide processed more easily from the atmosphere will do. The torus directly supports the central main spaceframe platform. Standing on the platform are a central residential-agricultural-environmental dome & auxiliary domed vertical cylinder structures. Below this deck is suspended an elevator to a lower meteorology station and two open-air platforms: the one on the left supports teleoperated refining, processing, and manufacturing (e.g. kevlar) from atmosphere-sourced chemical feedstocks; the one on the right is a landing & takeoff platform for drone unpiloted aircraft for close near-surface observation and teleoperated surface sampling and mining. The original structure is made of Earth-produced metals to be cannibalized later. New structures would be of Kevlar made *in situ* from CO<sub>2</sub>

The plan above, or any of many conceivable alternative architectures could serve just as well as a tourist resort complex. OR, a science outpost could have facilities to host “a handful of tourists” coming to visit and be nosy from time to time. This makes sense, at least initially. Indeed, the few early tourists could prove very useful to the scientists stationed there, in a *work-study type of vacation*, fully accredited by universities on Earth. They could also relieve the regular staff in food-production and other distractions from their scientific tasks. As such these tourists would in fact “help pioneer” any next steps toward major expansion of this beachhead presence on the once Forbidden Planet.

**Ticket Co\$t - The Bottom Line**

How expensive would it be to make such a tourist excursion to Venus? *Less, it turns out, than a comparable visit to Mars!!* — Consider:

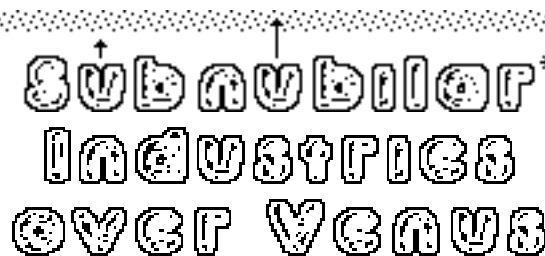
\* Using Economical Hohmann Transfer Trajectories

- Slightly less Delta V and Fuel Expenditure is needed to go from Earth to Venus and back (5.47 kps), than

from Earth to Mars and back (5.54 kps).

- Shorter in-Transit Times Earth <=> Venus (5 months) than Earth <=> Mars, (8.5 months avg) thus less exposure to the radiation hazards of space.
- Shorter at-Planet Stays Waiting for the Earth-return launch window to reopen, typically 11 months on Venus versus 18 months on Mars.
- Shorter Interval Between Launch Windows in either direction, 19+ months for Earth <=> Venus vs. 25+ months for Earth <=> Mars.

When? Sooner than we think! ***Before midcentury. MMM***



[\* sub NU bi lar: <below the cloud deck>]

**Economic Opportunities on Venus to begin with Atmosphere Mining 30 miles above its Torrid Surface**

by Peter Kokh

**ATMOSPHERE RESOURCES** — An “opportunist” is only as good as s/he is capable of seeing every first-blush-drawback as an advantage worth leveraging. Venus’ atmosphere, the only easily accessible local resource depository, is mostly (97%) Carbon Dioxide, CO<sub>2</sub>. That represents 70.5% Oxygen by weight and 26.5% Carbon. Less abundant elements represent some definite industrial-economic worth as well as disproportionately large greenhouse responsibility.

MOLECULE	%age	GREENHOUSE CONTRIBUTION	
CO2	97	55%	
H2O	0.1	25%	Water Vapor
SO2	<0.1	5%	
MISC.	2	15%	Cloud Stuffs *

\* CO carbon monoxide, HCl hydrogen chloride, HF hydrogen fluoride, H2S hydrogen disulfide, COS carbonyl sulfide, and SO2 sulfur dioxide.

**FUEL** — CO<sub>2</sub> can be reacted with available water vapor to produce methane CH<sub>4</sub> and oxygen O<sub>2</sub> to burn in rocket aircraft plying between the various aerostats, and in station-keeping/ attitude thrusters, and to fuel internal combustion engines.

**POWER** Aero-factories can tap solar energy filtering through the cloud deck to provide primary electrical power for industry, appliances and lighting. They may need to keep pace with the terminator so as to be always in daylight to maintain a constant solar power flux or use methane-oxygen generators at night.

**CARBON** — Oxygen is needed for aerostat-living space atmospheres, along with Nitrogen, which is the 3rd most abundant element present. But as an industrial keystone, the sheer abundance of carbon in Venus’ atmosphere makes it king.

Carbon along with hydrogen, oxygen, and nitrogen is a principal ingredient of living tissues. But here we are concerned with industrial significance. With the development in recent decades of Kevlar, a carbon-carbon composite, carbon emerges as a structural material of great strength and low weight, from which many things can be made, things formerly made out of metals, ceramics, woods, and plastics. It will be a challenge of heroic significance to chemical engineers to find chemical pathways from carbon dioxide to Kevlar fiber that can be implemented on an industrial scale.

The goal is modular building components out of which an original aerostat with modules made on Earth can be duplicated with local Kevlar equivalents. Interior furnishings can also be of Kevlar. The original aerostat can then be cannibalized for strategic metals. These are absent in Venus' atmosphere. Whether processes developed for use on Venus can be operated efficiently enough to produce competitive exports for other off-Earth products is to be seen. Graphite is also made of carbon, as is diamond, buckminsterfullerene and other less familiar materials.

**SULFUR-** Sulfuric acid  $H_2SO_4$ , sulfur dioxide  $SO_2$ , carbonyl sulfide  $COS$ , and hydrogen disulfide  $H_2S$  are far more significant both industrially, and as part of any future terraforming equation than their abundance in the atmosphere might lead one to think. We'll save the second part of that assertion for the next article. On Earth quite a few very serviceable products have been made of sulfur from building blocks to water-imperious hard shells from hot-sulfur-impregnated fabrics. Why not analogous products from hot-sulfur impregnated Kevlar meshes and gauzes. These might be less expensive than all-Kevlar products e.g. for making the shells of hydrogen gas buoyancy tanks that make aerostats possible. Worth exploring.

**ORGANICS & SYNTHETICS** — Carbon, hydrogen, oxygen, nitrogen! We can grow food, and fibers for clothes, bedding, and upholstery; make handy plastic products; even pharmaceuticals. We need more than structural materials alone!

**GOING DOWN FOR THE NITTY GRITTY** — Need, iron, aluminum, silicon, other nonvolatile elements? We can't advance further towards diversifying our brash sky-bound Veneran startup industries until we can access material on the ever so hostile, charring-hot surface. Scoops at the end of drag line tethers lowered thirty miles to the surface then hauled up with their booty, would be one way. A line loop anchored to the surface establishing a bucket conveyor would be another, binding the aerostat factory overhead to a particular site. *Chute dropped, helium balloon-returned scoops might be simpler and a more logical choice to start off, especially if only trial amounts of surface materials are required.* Methane and oxygen fueled sample rocket returns run up against the high temperature problem. We mentioned metals, but an earlier prize goal might be the *simple raw silicates which would yield raw glass stuffs and ceramic stuffs.*

Aerostat-produced products of glass, fiberglass, glass composites, ceramics, fiberglass ceramics, and sulfur/fiberglass composites would enormously diversify a startup industry whose prime products were graphite and Kevlar, and sulfur composites.

**Venus has major industrial potential!** <MMM>

# Geomorphing Venus

## How to make Venus an "M class" Planet

by Peter Kokh

In the first two articles, we have seen how the supposed fire & brimstone hellhole of Venus can not only become, in its subnubilar reaches, 30 miles or so above the surface, a venue for scientists and even hardy tourists, but how it can develop industrially from such aerostat perches to potentially support someday sooner than anyone imagines, a respectable population of committed Venerans. As full and as satisfying as life might become for these "Sky Folk" (remember when writers used to dismiss imaginary Venerans as fog-eaters, swamp rats, and such?) their dream must assuredly be to someday descend to a cooled surface and colonize its twin "continents" and many "islands", and to sail across rewatered oceanic basins. "Terraforming" will fuel their culture.

How will it happen? All the schemes we've read about to date seem to be cases of GIGO, "garbage in, garbage out". It is useless to theorize if starting assumptions are wrong or only half the truth. Seeding Venus' upper atmosphere with blue-green algae and hoping for "the big rain" is pretty Quiotic. There is not enough water vapor left on Venus to make such a scheme work.

**TOOL ONE** — The challenge seems truly daunting. All that heat buildup in a runaway greenhouse. That unimaginably thick carbon dioxide atmosphere. Ninety times too dense, an unbreathable composition. Not enough water. An task impossible? The facts themselves point the way and we can find it if we respect the facts. They are *not* a crushing set of disadvantages, but a rather happy set of leveraging points. The first tool we need is attitude, the right attitude.

**LEVERAGING OUR PRESENCE** — We'll have to be on site in numbers, engaged in significant economic activity in the pattern sketched in the preceding article. How we do industry there in the heights can be tweaked in our favor. Making maximum withdrawal from the atmosphere of hydrogen and sulfur in their several compounds will eat away at the source of 45% of the greenhouse effect. That is significant. Water vapor would be collected in aerial reservoirs to support extensive agricultural operations. This vapor is 25% of the problem. Cloudstuffs and sulfur contribute another 20%. Further, remove the cloustuffs, clarify the atmosphere from top to bottom, and you open the oven door, allowing substantial hear-radiation to space. Encouraged by the potential good side effects of our industriousness, to what does the rest of the problem reduce? "Too much  $CO_2$ , too little  $H_2O$ ."

**FIRST BLUSH** — The agenda would seem to be twofold, (1) blast the bulk of that crushing atmosphere into space, (2) bring in a zillion cometfuls of water-ice.

**REASSESSMENT** — On second look, that oppressively thick carbon dioxide atmosphere is not surprising. It represents about the same amount of  $CO_2$  absorbed into Earth's crustal rocks as carbonates. Indeed, if their were to be a runaway greenhouse here, all that potential carbon dioxide what be baked out of the rocks and released, "Veneraforming" the Earth. To consider is the apparent loss to space of 99% of Venus' one time reservoir

of water. Now there seems no magic button to push to make the events roll back in reverse. The water is largely gone, and without it as a catalyst, the carbon dioxide can't be reabsorbed into the surface rocks. We could bring in a zillion comets, a major undertaking. The clouds would soon thicken a hundred fold with water vapor. If somehow we could cool the place and just let it rain ...

**BACK TO THE INDUSTRIAL TOOLS WE WILL HAVE BUILT UP** — We will have mastered the chemical engineering challenges to wholesale extraction of carbon from the carbon dioxide. Why stop with producing Kevlar products for domestic aerostat civilization consumption. Can we extract hundreds, even thousands of times as much carbon as we'll need for these needs and somehow shoot it into space to the realm of the Venus-Sun Lagrangian point 1. Either as a thick carbon dust cloud or as some sort of Kevlar parasol, this carbon is available for blocking the Sun, and to thwart its heat maintenance engine. Meanwhile we will have been working on the source of the other 45 percent of the runaway greenhouse effect.

**HYDROGEN PIPELINE** — The atmosphere becomes less CO<sub>2</sub>, more molecular oxygen O<sub>2</sub>. Now for every nine zillion tons of cometary water ice we would have brought in, we need to find a way to bring in only one zillion tons of hydrogen. Combine it with the waiting hydrogen, the dissipating greenhouse effect, and Voilà, the big rain begins. If we were to bring in enough hydrogen to mate with all the oxygen freed by extracting all that carbon, we'd get an honest to goodness ocean many hundreds of feet in average depth - many times the volume of water Venus once had. We'd end up with a Nitrogen Oxygen atmosphere of similar ratios to Earth but about two and a half times the density. Anyway, it is beginning to look like a plan.

**WE ARE THE ANSWER** — An initial aerostat city uses made-on-Venus materials to duplicate itself. Two become four become eight become sixteen become thirty two and *now we see the parable* in the film 2010 in which the monoliths multiplied in Jupiter's atmosphere exponentially. Slow and insignificant at first, there is an inexorable crescendo as the Sun is blocked, the atmosphere changes in composition and cools and then dissolves in an incoming flood of hydrogen into the Big Rain. *There are problems!* But this makes much more sense than any previous plan. Best of all the human presence grows apace, *not waiting for the process to be completed.*  
<MMM>

R&D priorities. Closer to home we take on those who fear that, away from the poles, **lunar high noon** is too much to handle. Real attitude adjustments are crucial in both cases. Read the two articles below.



**IN FOCUS** **"Spin-Offs":  
the most impotent  
of all arguments for Space**

Commentary by Peter Kokh

Perhaps most of us have never examined just what it is that interests us about the outer universe of Space and our potential future beyond the atmosphere. There are so many aspects to the greater universe and thus many points of appeal and interest. What grabs one, will not catch another. Never having put our finger on what makes ourselves tick, we find it difficult to explain our passion to others, much less to infect others with it. That is too bad, because there is nothing that one can sell so convincingly and sincerely as precisely what enthralls oneself.

In absence of such personal testimony, we are prone to rely on "stock" tidbits of "witnessing" that we have heard from others. Foremost of these is the so-called "spin-off" argument. But if we are honest, while instances of beneficial spin-off from space research and development programs add frosting to the cake, without the cake, they are so much insipid sugar that neither wins new converts nor succeeds in disarming old enemies.

The reason this is so is that *any* high tech R&D program will produce technological spinoffs in new and improved consumer products or medical paraphernalia. Or at least, any high technology "crash" program can be maximized to do so. I recall during Jimmy Carter's unsuccessful run for reelection, his son was explaining that a vigorous space program was not necessary to produce desirable technological spinoffs. "Our plan is to pursue an aggressive program to produce major breakthroughs in solar power and other alternative energy sources in such a way that positive spinoffs will flow from them, much as they have from the space program up to now." *For me, this was a thunderbolt, because he was right!* Spinoffs are not an argument for space because there are other equipotent sources.

We do appreciate the gizmos we've gotten used to, but it is very easy for us to dismiss hypothetical ones we don't yet enjoy and on which we are not yet hooked. Thanks, but no thanks, is the all too easy, all too appropriate answer,

Why do we still hear the spinoff argument? It is a blatantly obvious "excuse", a *shameless way to get across the unintended message that we don't have a compelling "real reason"*, or, at least we haven't taken the time to examine what drives ourselves, what passion we experience, with which to infect others. "Know thyself!" This is the first rule of any approach to an active role in the world. *I have heard people say*

**MMM #115 - MAY 1998**



**Two of Space's  
Hotter Venues**

We continue our *fresh* look at Venus, too long 'off the list', sketching a promising tour idea, Veneran aviation, what we might get for our terraforming efforts, and top

that “spin offs” are what interested them in space. A lie. A Pity.

Turning to the spinoff argument is a case of monkey hear, monkey cry - hey, if the banana fits, peel it! Canned frosting type arguments only earn the contemptuous “So?” that they deserve. Not only do we not convince the public by this tactic, we may actually harden opposition to space programs, space exploration, space research, and space development. For by using this impotent argument, we encourage the suspicion in others that we have no “real reasons” why space is good. The spinoff argument is a knee-jerk defense mechanism. We use it in the same situations where we’d like to say “my big brother can beat the tar out of your big brother.”

So what arguments should we use? The best is to try to understand what first interested you in space? Looking at the stars and wondering? Reading science fiction? Studying astronomy? Hearing some visionary tell about his vision of the future? Go back to your roots. Look at not your present understanding of the opportunities and possibilities, but at what first got you hooked. Then read up on those aspects of space.

***You will always be more convincing affecting others with your vision than with the vision of others.***

Other visions you can add as frosting, to draw people in. But start with your own passion.

***Next, listen to the other person,*** and try to determine what his or her passions are.

- Robotics?
- Electronics?
- Arm chair astronomy?
- Social utopias and experiments?
- A yearning for the lost frontier?
- Environmental concerns about Earth?
- Concern for the desperate poverty in the Third World and a lack of ready solutions?
- Concern for the survival of the human race with all our eggs in the one basket-Earth?
- A desire to see the wondrous adaptability and creativity and resourcefulness of humankind reach even greater heights through new challenges?
- A desire to see and experience and explore new, strange, even alien surroundings and landscapes?
- A feeling that all the important roles are taken and that there is no opportunity to get in on the ground floor of anything meaningful?
- Some undefined feeling that the answer to whether or not “we are alone” is to start new separate human worlds?

There are lots of possible hooks if you are talking to anyone who is not totally shallow. (You will meet such people. Don’t even try. Nothing is to be gained.)

***Above all, listen first, and listen patiently and at depth. You cannot convert someone if you haven’t taken the pains to learn what buttons to push.***

If you just talk, you will talk past the other person, not to him or her. If you listen, and hear - it will take practice! - you will find the right approach.

Just remember, “spinoffs” are not it! Or if you find someone who miraculously does fall for that argument, you will have found a truly shallow person! PK

## A Rise by any other name

Uptight prudes search for “the” adjective  
“Venerreal” “Venusian” “Cytherean” “Veneran”  
by Peter Kokh, reprinted from MMM #60 NOV ‘92, p6

Alert readers will have noticed that NASA/ JPL-folk, when speaking of Venus, use the term **Cytherean** as an adjective, e.g. the “Cytherean atmosphere” or surface or whatever. Why? Because the adjectives for names originating in Latin, like Mars, Jupiter, and Venus, are customarily built on the genitive (possessive case form) stem of the word. Thus we have Martian from Martis, Jovian from Jovis. But apparently these prudes, or if prudes they’re not then these people scared silly of a Bible-toting public, are afraid to use the genitive of Venus. You see it happens to be Veneris, from which, oh yes, our word **Venerreal** — as in disease.

Now Science Fiction Writers, equally skittish about propriety, have gotten around the problem by using the nominative stem: Venus, **Venusian**. That seems harmless enough but the linguistic scholars howled foul. Now public servants in charge of space science would avoid the matter by using a totally different word from an obtuse beat-around-the-bush association. **Cytherea** was an island near the mythological ocean birthplace of Aphrodite, the Greek love goddess identified with the Venus of the Romans.

For our money, the Russians seem to have come up with the best solution. Use the genitive root, but add simply -**an** rather than an offensively suggestive -eal, -ean, or -ian. Thus simply “**Veneran**”. *The reason it works is because the stress now falls on the first syllable instead of the second.* A simple and elegant solution! If any one out there is still so uptight about his/her own sexuality as to be still squeamish about that, so be it. The use of ‘Cytherean’ is absurdly pathetic. So we’ve adopted the Russian use which is both linguistically defensible and innocent of other associations. <MMM>

## VISITS TO VENUS EN ROUTE TO MARS

by Peter Kokh

**STANDARD MARS TOURIST ITINERARY** — Spend 8 or 9 months en route to Mars. Tour till you’ve seen enough then hibernate for the rest of your 18 month stay until the return launch window opens. Send 8 or 9 months in space. Total time away from Earth two and a half to three years.

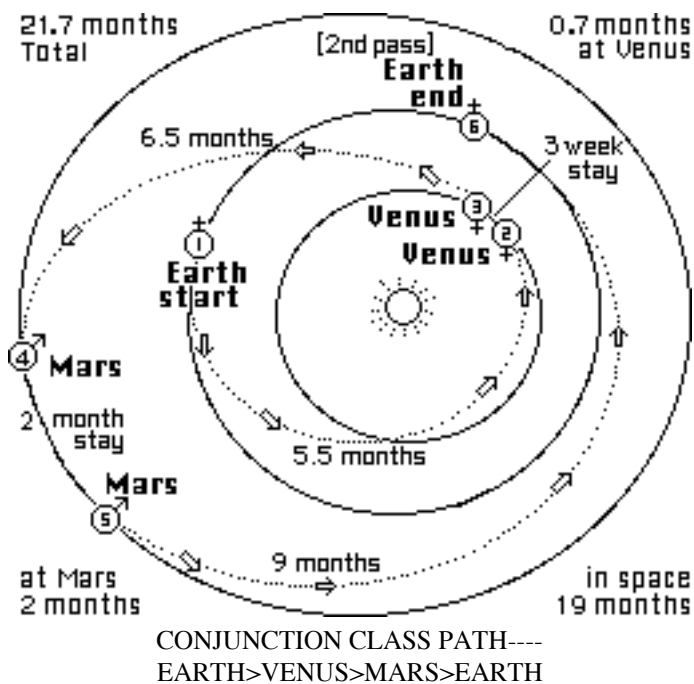
**STANDARD VENUS TOURIST ITINERARY** — Spend 5 or 6 months on route to Mars. Spend 11 months on an aerostat, looking at Venus’ surface features through telescopes, and work for the science crew there until the eleven month wait for your 5 or 6 month return trip to Earth. Total round trip time two years.

That’s the deal using minimum fuel expenditure Hohmann transfer paths to Mars and Venus. And the windows



open only every 25 months or so for Mars, and every 19 months or so for forbidden Venus. **BEHOLD THE TWO FOR LESS THAN ONE DEAL** — But if you had to get to Mars in between, there is a way using the so-called “conjunction class” trajectory to Mars, first swinging in toward Venus for a gravitational boost. It takes about a year in space to get to Mars by way of this detour. You’ll get there just two months before it is time to return home the ordinary way. Leave from Earth a couple of weeks sooner if willing to pop for the fuel to break into Venus orbit, and then launch out again three weeks earlier, and you get nice length stays at both worlds and still get home in under two years, less time than it takes to visit one. A deal which should prove very popular!

**VISITING TWO WORLDS  
IN LESS TOTAL TIME THAN JUST ONE**



# High Sky Aircraft for Venus

by Peter Kokh

## JOB DESCRIPTION

If we are going to have any number of science station and industrial aerostat hamlets in “the high skies” over Venus, we’ll need reliable, easily kept up, worry-free, locally co-manufactured<sup>1</sup> means of transporting people and cargo in between. That’s a mouthful of design constraints. Can we deliver?

With the surface off limits to casual ventures, aerial transit is it. And none of our Veneran aircraft will be “landing” or “taking off”. They *will be* “arriving” and “departing” — from midair docking gates.

Craft suited for such purposes may have very limited ability to cope with the greater pressures and heat levels of successively lower layers of the atmosphere. It would seem

essential to design into them passive fail-safe buoyancy systems to prevent such misadventures.

## FUEL & ENGINES

Methanox (methane/oxygen) is a serviceable fuel combination for both reciprocating prop engines and for rockets. Most importantly, both fuel and oxidizer can be processed on Venus from the atmosphere where its exhaust will return it in the form of the original ingredients.

As landing is not an option in distress situations, some form of back-up power for electric taxi props would be prudent. Another option, however, is to have the entire upper surface of the craft serve as a rectenna for guide-beam slaved Solar Power Satellite microwave transmissions. Such systems, it’d seem, would be pioneered on Earth long before we’ll need them on Venus, and by then be a stock item.

Where sprint-rescue speeds are not needed, propeller-driven craft promise the greatest fuel efficiency with adequate speeds as well as superior low speed performance for dock approaches and departures. Aircraft can safely fly at the 1 ATM aerostat level but need climbing ability to reach thinner air for more efficient cruising.

While fuel tanks should be ample for long range and extended cruising and bad weather and other emergency situations, again because landing is not an option, Veneran aircraft should have midair refueling capability. Midair docking capacity for exchanges of crew, passengers, and cargo would be an invaluable advantage, brining enormous flexibility.

To avoid construction of aerial runways that offering surface friction to assist braking and deceleration and provide a platform for acceleration to lift speeds, aircraft should either be buoyant or have some sort of Harrier or other type VTOL or hovering capacity. This would help in midair docking.

## CONSTRUCTION & COMPONENTS

Lightweight Kevlar components, manufactured in Veneran high sky facilities, will provide greater strength and lessen the weight to be managed in maintaining lift, buoyancy, and hovering ability. Small complex subassemblies (navigation avionics, other electronics, control & communication systems, airtight docking ports, etc.) can be imported from Earth to mate with Venus-made fuselages, wings, fuel tanks, cabin interiors, and other items designed for ease of on site manufacture and assembly.

A whole family of Veneran aircraft will be needed: small crew transports, smaller and larger passenger craft, craft dedicated for cargo, fast sprint rescue and response craft. Maintaining a “family” resemblance along with the maximum percentage of interchangeable parts will be of compelling benefit.

## FAIL-SAFE & JUST-IN-TIME LIGHTER THAN AIR

Obviously, the dirigible is one viable option along with other possible lighter-than-air architectures (there is now a renaissance in interest along with increased exploration of new design options). But full-time partial buoyancy and buoyancy-on-demand with fail-safe, dead man deployment systems will also work while allowing more streamlined designs and faster cruising speeds.

Hydrogen-filled bags that passively inflate whenever certain impeding conditions degrade will make the High Skies

safe for all Venerans to fly. These conditions include minimum speed, maximum desirable or tolerable air density and/or temperatures, as well as certain internal conditions (loss of fuel, power, active crew).

To more efficiently negotiate different altitude ranges as well as variable speeds. wing and/or lift surface designs that allow the loading to be varied are a downrange design consideration.

**SPECIAL DUTY CRAFT FOR SURFACE EXPLORATION**

On Earth, we have built oceanic submersibles that have withstood over 1,000 ATMs of external hull pressure. So it is temperature, not pressure, that looms as the most challenging hurdle facing would be surface exploration craft, including VTOL aircraft and wheeled gondola cabins lowered and lifted by collapse and store balloons. As an interim measure, mid-altitude aircraft could lower retrievable instrumented science/communications packages on tethers.

**COMMUNICATIONS**

How serviceable line-of-sight radio communications will be, is unknown. With less of a magnetosphere, solar or cosmic noise could be a big problem on Venus. Satellites could offer GPS navigation assist as well as communications relay. But so could heat and pressure-hardened surface relay stations.

On this as on other challenges above, the old adage applies. "Where there is a will, (and no defeatist attitude!) there's a way." "High Skies!" <MMM>

# Venus, Geomorphed

## Fast Forward X-Hundred Years What could we expect from our Project?

by Peter Kokh

### I. The New Atmosphere

Venus' new atmosphere would be a carefully selected residual of its old one. How closely can we get it to resemble Earth's? Our familiar mix is:

- 76.084 % Nitrogen    0.934 % Argon
- 20.946 % Oxygen    0.031 % Carbon Dioxide
- "up to" 1.0 % Water Vapor

The game plan is to end up with a breathable mix of nitrogen, argon, and oxygen, with just enough carbon dioxide to make a biosphere work, no more. Currently, Venus has about 3,000 times more carbon dioxide in its atmosphere than does Earth. This CO<sub>2</sub> is fair game. The tactic we've floated is to disassociate the gas into carbon and oxygen, O<sub>2</sub>, and use the carbon to produce Kevlar and graphite products and, in some fashion, to use the excess to create a giant parasol at the Venus-Sun Lagrange 1 point to intercept continued solar heating for as long as necessary.

The residual 60.5 ATMs of oxygen would be reacted with imported hydrogen to make water vapor which would eventually rain out as temperatures fell. Just enough oxygen would be preserved to create a breathable mix with the

Nitrogen and Argon in Venus' present atmosphere. That is perhaps 2 to 3 times as much N<sub>2</sub> and Ar as we have. An elegant way of reducing these gasses has not occurred to us.

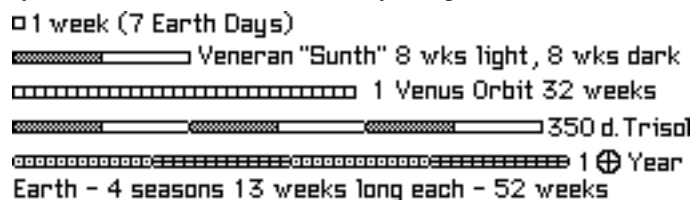
The upshot is an atmosphere that will still be noticeably heavier than what we are used to, and with a much greater capacity to absorb water vapor than has our own atmosphere. This water vapor will have a greenhouse effect, but one that probably cannot be avoided. Compensating, the planet should be just as overcast as it is presently, with water vapor clouds. A seasonal (see immediately below) pattern of winds, fogs, and thunderstorms should develop.

And, oh yes, the niche of friendly pressures and temperatures enjoyed by the interim aerostat-based subnubilar Veneran civilization (last issue) will have dissipated. That's a substantial trade off to be anguished over, as it will be irreversible.

### II. Where Day and Night are Seasons

Venus' year is 224 days long, covering 1.6° of its orbit each day. It rotates on its axis once every 243 days, turning 1.48° per day. If it rotated in the same counterclockwise direction as it orbits the Sun, as does Earth, its rotation would lag behind its revolution so slightly that it'd take 360/(1.60-1.48) = 2,960 days or 8.1 years for just one day-night cycle!!

Fortunately, the direction of rotation is just the opposite so that the daily 1.60° and 1.48° increments are *added* instead of subtracted, the smaller from the greater. 360 / (1.60+1.48) = 116.78 days or 58.39 days (c. 2 months) of daylight, alternating with 58.39 days of darkness. This "sunth" is not quite four times as long as the dayspan/nightspace "sunth" cycle on the Moon (29.53 Earth days long).



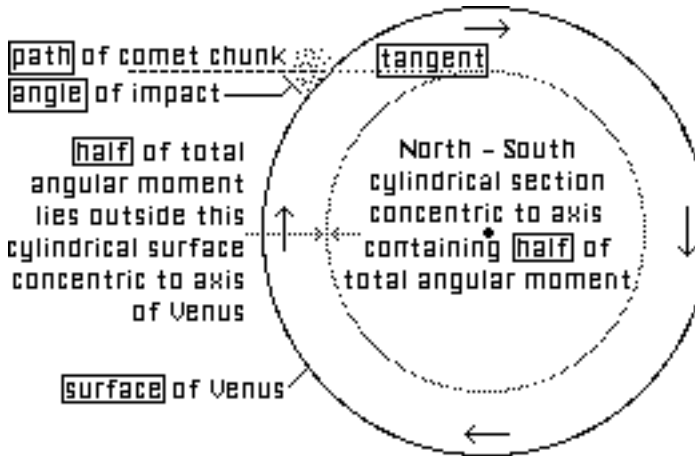
The upshot is that there are two day/night cycles per Veneran Orbit Year. Actually, not quite. Two Veneran "Sunths" are 233.57 days long, about 9 days longer than one Veneran "Versary". There are 25 pairs of Sunths (50) in a 26 Versary period.

Keep in mind that as Venus axial tilt to the plane of its orbit around the Sun is only about 2°, there is no "seasonal pattern" tied to the Veneran Versary or Orbital Year. It is the "Sunth" with its hotter 8 week long dayspans and cooler 8 week long nightspace that produces the true "Seasons" on Venus. We predict that Venerans will count their year-like periods as three sunth-sets ("trisols"?) of 3 x 116.78 = 350.35 Earth dates long. Their sunth would come out to an even 112 dates of 16 weeks if they marked dates as 25 hrs. 1.5 min. long. Or they could keep the Earth minute, hour, day, and week, but mark their own sunths and "trisols".

### III. Shortening the days/night cycle

IF we were ever to tamper with that cycle, by impacting comets at the equator and in the equatorial plane, at an angle of roughly 45° to "aim tangentially at" the subsurface point along which Venus' mean angular moment of rotation

lies, it would be far more effective to go with the flow and try to speed up the “retrograde” rotation, than to first slow it to a dead stop, then induce rotation in the “right” direction.



AIMING water-ice comets for max. rotation speed up

If we decided we wanted more water than to be had by reacting hydrogen with oxygen liberated from the carbon dioxide in the atmosphere, and we wanted it bad enough, we’d have to get it from comets or from dismantled ice-moons (Saturn’s Hyperion is already half dismantled from past impacts.) We could guide the comet ice chunks in their incoming trajectory to best speed up Venus rotation. We’d add this “extra” water *before* reacting imported hydrogen with atmospheric oxygen, i.e. while the surface was still dry.

Shortening the Veneran sunth would be an uphill battle. To cut it in half down to 58.4 days ( 4 weeks each of daylight and darkness), it would be necessary to speed up the period of rotation more than three times, from 243 days to less than 79.

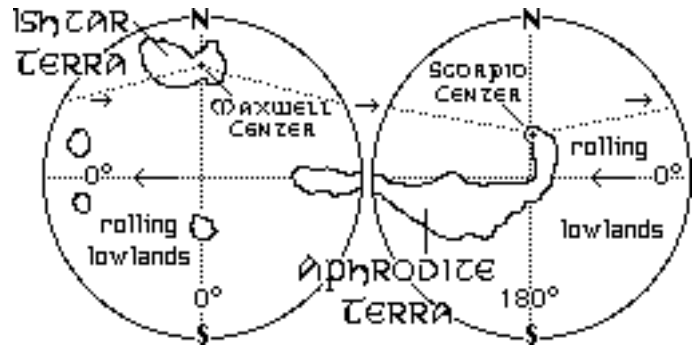
#### IV. A Tale of Two (Veneran) Cities

*There may be a very good reason to leave well enough alone.* Venus’ dayspan/nightspace cycle is slow enough that we are really dealing with a 2 month long daylight season and a 2 month long darkness season with substantial temperature swings. Now it is fantasy to expect that a terraformed Venus will have moderate temperatures. We’ll be lucky to have them on the underside of boiling. If we succeed in forming an ocean, it would be steam-room hot. There are people who find such an environment “renewing”, at least for an hour or two. I’m not one of them, preferring dry sauna heat instead. Extreme heat coupled with extreme humidity would be disabling, if not immediately fatal. So what can we do?

Can we find a surface beachhead or two of more moderate temperatures on our rehabbed Venus? Nightspace at higher elevations seems the best bet. Fortunately the highest spot on the planet, Maxwell Montes (pinning the 0° longitude) is paired at 180° by another high spot. When one passes into dawn, the other passes into nightfall. We could establish a pair of outposts from the very outset, and migrate from one to the other leaving each sunrise for sunset. Such a lifestyle is not so different from that of “snowbirds”, people who migrate annually from the snow-belt down to Florida or Arizona. On Venus there’d be three migration cycles in the space of one Earth year.

So we suggest these two settlement areas:

1. Maxwell Montes in eastern Ishtar Terra 0° longitude, 65° N — “**Maxwell Center**”
2. Tip of the “Scorpion’s Tail” in eastern Aphrodite Terra at 180° longitude 18° N — “**Scorpio Center**”



[Venus: two “continents” tower over rolling lowlands. As Sun rises in the West, migrations are to the East.]

#### V. Oceans & Continents

Venus’ new oceans and seas will be less deep than Earth’s, there being no deep abyssal basins on Venus. Further, the amount of water producible by reacting imported hydrogen (1/9th the mass of comet ice needed in other schemes) with oxygen liberated from atmospheric carbon dioxide (MMM # 114 MAR, “Geomorphing Venus”) is enough to produce a layer an average 800 meters or 0.8 km (2,700 ft.) deep. That’s less than a third as much water as Earth boasts, but still a respectable amount and we could look for depths of 4,000 feet as common.\*

\*[BOE (back-of-envelope calc.): 90 atms/0.91 G x 0.73 (% oxygen in atmospheric CO<sub>2</sub>) x 1.125 (with hydrogen added) x 15 lbs/inch<sup>2</sup> x 144 sq. in./sq. ft x / 64 lbs of water/cubic foot = a column of water 2,731 ft. high or c. 800 meters, i.e. if most Venus’ atmospheric oxygen was hydrogenated.]

As a result, the new seas will be subject to significant evaporation during dayspan, and heavy precipitation and refilling during nightspace. If it were not for this natural seasonal redistribution of the waters, we might choose to preferentially deep-fill select basins closest to the two suggested population hubs. But evaporated water will refill by rain any available basins, on cue from seasonal wind and rain cloud circulation patterns. Some seas will be “ephemeral” not lasting the whole of dayspan before becoming dried mud flats. Others will shrink noticeably in surface area as each day season progresses. Others, with steeper shores, will lose volume but not much apparent area. These will be the first targets for seeding with heat-tolerant living species.

Deep water forms of marine life in deeper basins may fare better than shallow water and surface water forms which have to cope with higher temperatures and considerably greater temperature variation. Other species will time their reproductive rhythms, even their feeding (and fasting?) patterns to the long dayspan/nightspace seasons.

On Earth, it is the Ocean, covering 3/4 of the Earth’s surface, that is the great thermal flywheel which rules the whether on a global basis. It would be a challenge to give Venus an ocean as extensive in area, even though, there being only two comparatively small continental elevations, and no

deep abyssal basins, it would take a much lesser volume of water to cover a greater expanse of surface on Venus than does Earth's multi-lobed global ocean.

To improve drainage and reduce the number of unconnected "landlocked" basins, an equivalent of our Army Corps of Engineers could channel thru basin sills and natural dams and dig canals to interconnect the various bodies of water and globalize the possibilities for marine navigation.

Biosphere-wise, jobs 1 and 2 are:

1. Seed the oceans with hot-water-loving microbial cultures, plankton, and nekton: the bottom of any future food chain.
2. Fix the soil with rain-hardy erosion-resisting algal mats. etc., and with microbes to produce good, fertile soil, and to reduce soil temperatures.

### VI. A Question of Goals

Whether the two settlement sites proposed above, or any other Veneran surface outposts ever become full-fledged human settlement communities or just the science stations involved in the great terraforming and biosphere genesis project is another question. Even if we were to succeed in cooling the planet, cannibalizing its present ponderous atmosphere for sunshade materials and for the oxygen portion of a reconstituted shallow ocean, and then successfully seed the latter along with the raw now rain-washed rock-strewn lands, it may well take centuries for the infant biosphere to find its new equilibriums. There may be false starts and global setbacks. Until the new Veneran biosphere settles down and proves itself stable, Venus may not be a sufficiently friendly place for a pioneering commitment.

Even with major changes in its atmosphere, significant heat reduction, and reformation of a significant ocean, as long as Venus remains as close to the Sun as it is, we might have to rest content with concreting a world where we can watch to see what happens. Indeed, Venerans will not see Terraforming as an episode that introduces them to a new future, but *as their future* for all foreseeable time to come. The process of making Venus a friendly place for Earth-derived life will be a very open-ended one. Indeed, it will give Venerans a sense of collective vocation and purpose that seems to be utterly lacking in most, if not all Earth cultures of our time. To turn Venus into an enormous biological and biospheric laboratory will be a tremendous feat, even if we never do settle the surface in numbers.

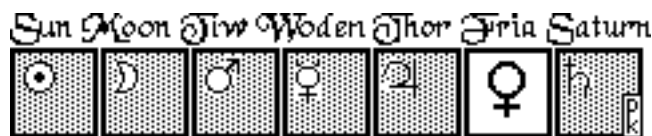
### VII. But what if we don't?

Our Veneran descendants may choose to keep their dearly won aerial civilization and to remain a cloud-top civilization like that teasingly illustrated in "The Empire Strikes Back", Part II of the Star Wars Trilogy. They might grow to cherish this "good life".

The terraforming strategy we've outlined may pay much greater respect to the given facts than any of the garbage-in-garbage-out schemes in circulation. But even with a philosophy of "going with the grain of nature", it would be a gargantuan "cathedral-building" task absorbing the energies of many generations.

Further, our radical departure proposal has yet to benefit from peer review. There may be show-stoppers. It may be impractical to make any kind of sunshade in space from

liberated carbon, even  $1.24 \times 10^{19}$  tons of it. The 89% mass savings of importing just hydrogen instead of water ice may be mooted by the technical and engineering difficulties uncovered. Let's first brainstorm every unexplored option, One thing we've got for sure is *lots of time*. <MMM>



## THE FRIDAY FILE

FRIA is the Norse Equivalent of Roman VENUS

## VENERAN RECLAMATION PROJECT STARTER LIST of R&D PRIORITIES

Calling all "Friends of Fria". Want to contribute by helping brainstorm, engineer and design aerostats, Veneran aircraft, surface probes & rovers, atmosphere mining, tourist opportunities, or terraforming scenarios? Send your *home-worked* ideas to: kokhmmm@aol.com

There are a lot of challenges to overcome in rehabilitating Venus. But the biggest of all is not out there, not in or at Venus or Venus' orbit, but in getting rid of our own mental blocks to "imagineering".

### A Starter List of Priority R&D Agenda Items

#### Industrial

- Kevlar from CO<sub>2</sub> — chemical engineering options
- Methane from CO<sub>2</sub> & H<sub>2</sub>O
- Sulfur extraction and byproducts
- Sulfur/Kevlar mesh composites

#### Power

- nuclear (imported plants, servicing)
- lightning harnessing via tethers?
- solar thru the clouds - SPS/microwave systems  
NB. no Venerosynch "Clarke" orbits  
NB. low 2° axial tilt means nightspan SPS eclipses

#### Sun shading

- VSL1 station keeping parasols
- VSL1 dust clouds

#### Surface exploration & mining

- heat-resistant sensors, electronics, gears, etc.
- ceramic and kevlar parts
- magnetic greaseless bearings
- Pressurized dewar-thermos crew cabs/habs?

#### Communications

- short wave radio transmission uncertain
- Orbital relays
- Surface relays (see above)

#### Transport: Airborne and to/from Space

- methane/oxygen fueled propeller craft
- methane/oxygen fueled rocket craft
- stall and hover ail-safe buoyancy bags
- midair docking & transfer of cargo, people, fuel
- Space arrivals - chutes/bags slow to stop & taxi
- Rockoon launching — aerostat spaceports <MMM>

# HIGH NOON

## Coping with Dayspan Heat

by Peter Kokh

### FOREWORD

There is much enthusiasm for a north or south polar Moonbase these days. Can't fault that, especially in the light of Lunar Prospector's positive findings at both lunar poles. The thin frost-mix of ice crystals with regolith powder moon dust grains is a real asset for any prospective base.

Yet one of the advantages stressed most by polar base enthusiasts is the relative ease of "thermal control" at the poles in contrast to anywhere else on the Moon where it becomes "impossibly hot" during the lunar dayspan, 14 and 3/4 standard Earth days long. The Apollo landers all touched down by local midmorning and left well before local noon. It gets well over 200°F out there.

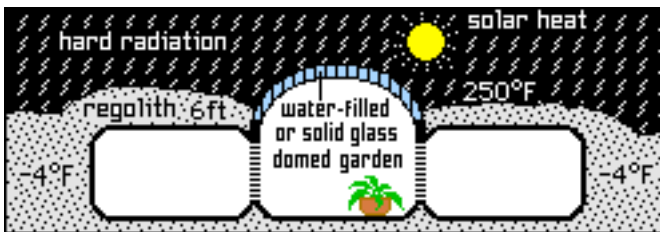
We are so endlessly tired of polar base aficionados and others pointing to the stifling dayspan heat. *So we can go to the Moon but we can't figure out to handle so simple a problem as superficial heat?*

Lah dee dah! Give me a break!

- The LEMs stood exposed on the surface, unshaded from the Sun. The astronauts they supported were only there for a few Earth days max.

Once people come for longer stay times and tours of duty of some months or more, it'll be essential to protect them from cosmic rays and solar flares. Covering their habitats and work modules with a blanket of moon dust six feet thick, will offer such protection. (For a lifetime stay you'd want to double that.)

Frosting on the cake, it happens that six feet down the temperature is constant year-round, some -4 °F. The soil is a poor conductor of heat, and the Sun's warmth does not penetrate that far down, not even with a full two weeks plus to do it.- and no clouds!



- **There is no atmosphere on the Moon to hold heat.** So surface temperatures are entirely superficial. It can't affect suited personnel by convection then, only by radiation, reflection off the surface.

That's why astronaut space suits have reflective outer-surfaces. Anything which baffles that reflection off the nearby surface and rocks is quite effective.

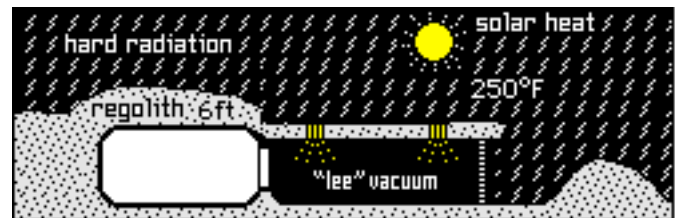
As for direct heating by the Sun itself, people at the poles catching the Sun full on from front, side, or back are far more exposed than those elsewhere who catch the Sun's rays from a higher angle.



**RAMADAS REVISITED** — Eight years ago, in the July '90 issue of MMM, pp. 3-4, we ran a piece entitled "Ramadas", illustrated by Dan Moynahan.

We pointed out that a significant fraction of out-vac activities come under the classification of routine chores associated with outpost maintenance and service, change out of volatile supply tanks, external warehouse management, and so on, done in limited definable spaces.

By covering these with sun-shading ramadas or canopies with a minimum blanket of moon dust on top, we in effect create radiation-free, UV-free "lee" space in which workers can do their jobs in lighter weight unhardened pressure suits.



But such ramadas can also filter or baffle the direct sunlight. Without air to convect heat, the surface temperature underneath can be whatever we want it to be (amount of modulated sunlight let through). Sunlight can be brought in through glass block, or by bundles of glass fibers, or chevron slat diffusers.



For landscaping aims, these service and warehousing "back yards" can be blocked from passing view by berms, mounds, by walls made of locally produced translucent glass block or sinter block. We need to look at what translucent materials or diffuser designs can be most easily produced from elements we can process on the Moon in near term.

What about various types of milk glass, or even Correlle. Can we locally produce low-E coatings to reflect infrared light back into space, cutting heat transmission? Are there ways to produce both serviceable minimum shielding and moderate diffused translucency for an easy to work under light-but-not-too-bright faux "sky" that would also greatly soften shadows?

And what is the cheapest, easiest way to locally produce the ramada "pan" itself that holds the shielding overburden and the light diffusing elements?

No one else is talking about ramadas and “lee yards”, yet any non-polar lunar outpost without them can be truly functional in its design. These are obvious and essential accessories. If LRS had the seed money to promote a nationwide design contest, high on the list of subject matter would be ramadas. Hopefully, such a design competition is something we will be able to arrange in the near future.

One might expect quite a number of innovative, creative, and resourceful designs, something on which entrepreneurs could then get to work, so that they are “on-the-shelf” and ready for future lunar base operators when the time comes. Moreover, some of these designs may even have profitable terrestrial applications or analogs, the profits from which could finance their development for lunar applications. This is an example of what we’ve been calling “spin-up”.

**SUN FENCES & SHADE WALLS** — For use at eastern and western exposures (rising early morning sun and setting late afternoon sun) as well as equatorwards at higher latitude locations (midday sun at low sky angles) simple shade walls will provide some relief. These can be made of perforated sinter block or glass block, in both cases letting some moderated light pass through - enough to see into the shaded area.



Lightweight unrollable fiberglass tight weave mesh sun-fencing would operate similarly, set up to partially shade areas where suited individuals are going to do geological field work or prospecting.

**MOBILE CANOPIES & AWNINGS** — Simple protection from direct solar heating is available for travelers and campers as well, just by doing what they would do on Earth. There’s no mystery. Keep in mind that there is no air to hold and transfer heat by convection or conduction on the Moon. So, except through boot soles or tires, heat gain can only occur through infrared radiation.

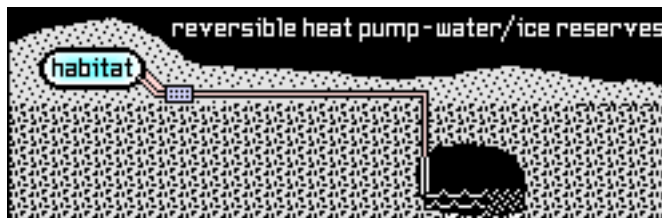
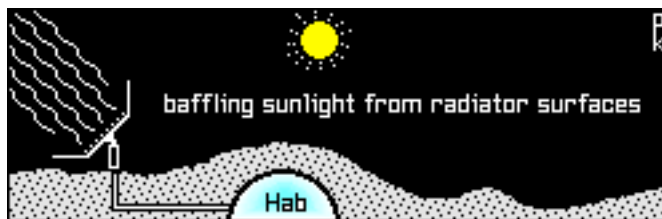
We must drum into our heads that, however counter-intuitively, this hyped up 250°F dayspan heat is only a superficial, easily managed effect. Again, because there is no air, and hence no wind, awnings and swiveling sun-tracking mobile solar collector arrays doing double duty as sunshades, can be very light weight, even flimsy.



**INDIVIDUAL PARASOLS** — Even space suited persons out in the field can minimize direct solar heating. While a helmet or headgear attached parasol might be quite impractical on Earth, the lack of air and wind makes even a gossamer helmet shade “no problem”.



**ENHANCED HEAT RADIATORS** — Absolutely the most lame claim of the “oh, it’s too hot!” crowd, is that it is difficult or impossible to radiate away excess heat to the black sky when the Sun is up. We are in the space business. We are alleged to have constructively creative imaginations and a “can do” attitude. The “can’t do it” response isn’t what got us to the Moon in the Apollo days, and as an excuse to divert attention to Mars, where that attitude won’t work either, it is not only dishonest but self-defeating. Enough, a picture is worth a thousand words. Here’s three of them to prime the brainstorming pumps.



The storage area could be any hollowed out volume. A lavatube reservoir would be useful for larger settlements with growth potential. Systems of this sort have worked well in northern U.S. areas over the last two decades, equalizing not just alternating cold and hot fortnights, but much longer winters and summers. We need reserve water. This would be a good use to which to put it when not in use directly.



Typically hundreds of meters in width and height, many kilometers long, cryo-cold lavatube surfaces could suck up a lot of heat. In short we need not cower before lunar dayspan heat.

If we are going to make it into space, it will not be courtesy of those who look at all the obstacles and disadvantages and cry “it is too much, too difficult, and give up. It will be courtesy of those who look at these same challenges and accept them as that, challenges to be overcome by human ingenuity.

“Tell me all the reasons why we can’t. Then tell me how we are going to do it anyway.” <MMM>

[Time to cool off!]



Inspired by an episode of PBS' European Journal, 3/8/98 Ch 36 Milwaukee, from Deutche Woelle TV



### HARVESTED ICE RESERVES

Any company in business to market lunar polar ice reserves will need to keep an inventory ahead of reserves if it is to take advantage of market opportunities as they occur. This reserve can be stored in pressurized volumes as liquid water, or as manageable ice cubes or blocks kept by controlled temperature and humidity from welding into a solid unmanageable block. Another very handy way to pile up such a harvest would be as snow, again at carefully managed temperatures and air moisture.

Now there are times when demand will be brisk, and reserves will run low. Harvesters will be hard put to keep up. At other times, they may get well ahead of the game. Question: how do you make money out of an idle reservoir of harvested ice just sitting there, waiting for a buyer? Why build a ski hill, of course!

In Florida-flat Holland, Dutch entrepreneurs, hoping to tap into a suspected market of would-be Alpine skiers without enough guilders to travel to the Alps, have built a ski hill! The hill is modest, as hills go. But without competition for hundreds of miles around, modest will do. To extend the season, they have covered their ski hill slope in a Quonset shed, the better to maintain just the right conditions. Could not lunar entrepreneurs do the same thing?

### CONSTRUCTING THE HILL

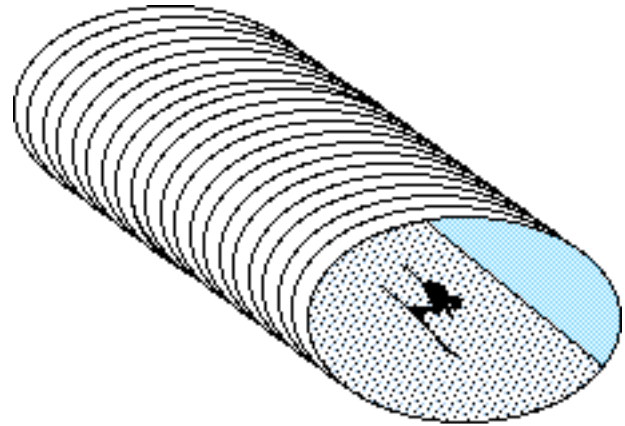


At the lunar poles, one would not have to construct a hill. Hills, in the form of the inner slopes of crater rims, abound. In fact they frame the permashade areas in which the ice reserves are to be found. Right structure, superlative size, right location. A little grading to smooth the beginners run, a little more to make the intermediate and advanced runs more interesting, cover it all with a shed, and Voilà! No, not quite. Pressurize it and the shed would blow off and the air would be gone. The shed has to be an ovoid or cylindrical tube that is pressure tight, bending to fit the graded slope bed prepared for it. Then, and only then, is the air tight cylinder pressurized, and snow piped in and deployed to the right thickness or better.

On the Moon where the lunar gravity is but a sixth that of Earth, even on "fast" snow, it would take time to build up satisfying speed. But even in sixth-weight, considerable speed can be built up - it just takes a longer warm up run. But the slopes of lunar craters can be thousands of feet, 2-3 kilometers long - plenty long enough, given the money, the snow reserves, and the entrepreneurial daring.

A permanently shaded equator-side inner slope of a near polar crater would make temperature control easy. Air pressure need only be high enough to keep the snow from subliming, but no higher, e.g. as high as Everest. And the

thinner air would actually mean faster terminal speeds than we achieve on Earth, where air pressure, not gravity, are the ultimate determinant.



The shed roof could be glazed for glimpses of starlight, but given enough artificial interior illumination to see where one was going (unless we use blacklight! - hey!) a faux firmament finish on the ceiling would be fine. Or even a matte sky blue for those who want to pretend they are on Earth. In fact, the setting could be engineered to change seasonally or on some other schedule.

### STAFF RECREATION & TOURIST INCOME

Who would ski the Moon? First, the people doing the harvesting and staffing the lunar polar operations - in their free time. It would be an enormous perk. Telecasts to Earth of this activity, or of intramural tournaments would lure tourists for the ultimate ski experience. Skiers are like golfers. No course is the same, and life is never boring as long as there is a run or course they haven't tried.

Skiing suits and equipment need not be much different, if at all, from what is currently used on Earth. In time, the special nuances of lunar skiing will encourage a unique specialization of wares and wears as we try to push the sport to newer limits.

### OUT-VAC SKIING ? WITHOUT SNOW ?

Skiing on lunar polar indoor craterslope snow runs may be only the beginning. This is one sport which few had suspected might ever have a lunar translation. But there could be other lunar-appropriate idioms in which "to ski" might be rendered. This may be but the beginning.

What about skiing in vacuum, on something other than snow, something slippery *and* non volatile. Surely I jest! Not that long ago (to an old timer like me) something new under the sun was discovered: "Buckminsterfullerene" a hollow, spherical form of carbon with the formula  $C_{60}$ . Yet it was only new *to us*. Carbon sixty had been there all along, and too boot, in a form we are all familiar with, soot! Could a slope piled with carbon buckyballs be slippery in vacuum? It would take a nifty experiment to determine if the answer is yea or nay.

But if so, where would we get the carbon? Right where we get the water ice. For the lunar polar ice reserves are a gift of the comets, and carbon oxide ices are the second most common volatile in comet cores. Lunar ice should be clathrate, a mixture of water ice and carbon oxide ices.

There are plenty of good crater slopes near the poles and away from them. The northern nearside maria have a number of famous mountain massifs: Mt. Piton, Mt. Pico, Mt. Bradley, to name a few. With bucky-snow in vacuum, the higher temperatures away from the poles would be no problem.

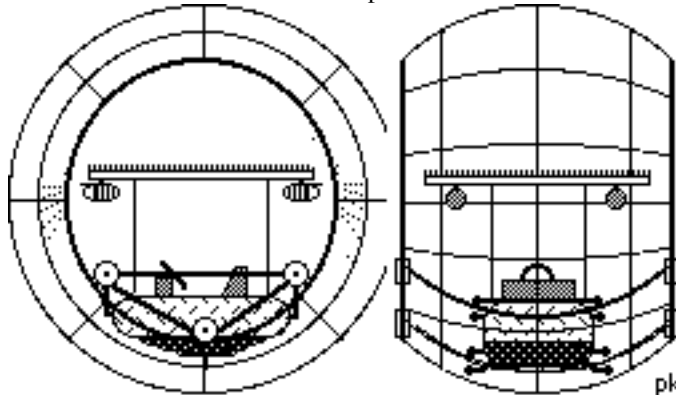
But let our imagination wonder yet further afield. Silicon is said to be an analog of carbon, both having a valence of +/- 4. Could there be a silicon analog? There's lots of silicon on the Moon. This rock-making element is second in abundance only to oxygen. But there probably is no analog - while the valence is the same, the bonding tendencies of silicon and carbon are quite different. Silicone chemistry does not mirror organic carbon chemistry for that very reason. It's unlikely that chemical engineers will be able to come up with "silisnow".

**FOR SOME - THE THRILL OF TEASING DEATH**

Regardless, skiing in vacuum would create risks and dangers that would attract only the most proficient and daring, those for whom the ultimate high is to risk death and win. In vacuum, over long enough slopes, speed would be limited only by the friction of the skis on the slippery medium, not by wind resistance. And at any speed, let alone very high speeds, a fall accompanied by a suit puncture could lead to speedy death. But if there is a market, ever more rugged and puncture resistant suits and helmets will be developed.

Or, instead of skiing or ski-boarding, devotees of the vacuum slopes could take to sealed and pressurized toboggans engineered to be roll-over safe at very high speeds. Or we could ride weighted cars inside wire or pipe "atlas-spheres" allowed to roll downhill where they will. We talked about a cross-country version of such a vehicle in MMM #81 DEC '94 p. 1 "Lunar surrey with the fringe on top".

Watched "American Gladiators" lately? Seen the "Atlasball" segment? Next time, picture space suited lunar thrill-seekers working their geodesic cages along a rally course of craterlets etc. Might be fun if the sweat and heat rom over exertion inside one's space suit could be handled!



Similar solar powered spheres could be equipped with a track riding buggy capable of generous side-to-side movement or banking. Such an "off-road vehicle" - call it a unicycle, an auto-tracker, a cyclotrack, or whatever - could open the vast lunar barrensapes to the sports-minded "outlooks" types and help avoid cabin fever.

But the idea here is to go "down", "fast"! Yes, there are the Nordics and the Alpines. To each his/her own. Never tried cross country, so I don't quite understand the lure.

**LUNAR AMUSEMENT PARK RIDES**

Then there are roller coasters. Pressurized cars plying an out-vac track that was high enough, could build up speeds never experienced on Earth where air pressure sets up an artificial "terminal speed" that can't be exceeded in an unpowered run. Some of the down hill run of the coaster could be above the lunar terrain, but some of it could be tunneled into the surface, perhaps opening into a lavatube, with a sphincter gate, resembling so much normal hum drum lunar surface, opening just in time to swallow the horrified passengers into the pitch darkness of the lunar netherworld.

In the sixthweight, with the absence of wind, towers could easily be built miles high. Bungee jumping, anyone? But isn't all this another article?

**OUR POINT**

Wherever there is significant gravity and a community of people settling-in, sports will rise to the occasion. Ever since we (most of us) were first flung into the air by our fathers as infants, the thrill of a gravity-polarized environment is a lesson that we have never forgotten. Of course, not all things that are possible catch on as lasting fads (e.g. going over Niagara Falls in a barrel!)

Maybe none of this will come to pass. But nothing imagined, nothing attempted. And nothing attempted, nothing achieved. So we take the first step and dare to imagine. Those of you who have never skied, never felt the rush of excitement that it brings, will not understand. Stay home! Those of us who have felt what it is like to challenge the slopes and control our paths will dare to push this sport to its furthest limit, even on the Moon.

<MMM>

**MMM #116 - JUN 1998**

**Redesigning LEO Habitats**  
 ¶ Maximum Science Output  
 ¶ Optimum Crew Morale

by Peter Kokh

NASA will do what NASA will do. The agency has a strong track record of contracting for advice from consultants, then rejecting that advice when it does not match preconceived internal assumptions. This is only human. We only listen to advice that tells us what we want to hear. So this essay is not meant to second guess what NASA, or any other government bureaucracy, is doing out of massive internal inertia and deeply ingrained culture. There will be other manned installations in low Earth orbit and beyond. This advice is for those who will listen.

**USING FACILITIES AROUND-THE-CLOCK**

Orbital habitats and laboratories and other manned installations are very expensive to build, and very expensive to launch, outfit, and maintain. Most of these costs are fixed



whether we man them continuously or not. Further, all this capital equipment has a limited useful lifetime, beyond which replacement makes more sense than repair and refurbishment.

It becomes imperative then to get maximum use out of this equipment - around-the-clock use. Any equipment, any workstation, even any sleeping space that is not used on a 24 hour basis is essentially a squandered resource. For those who have put up the money, be it taxpayers or shareholders, this becomes criminal waste. The International Space Station is a case in point - a very expensive capital investment that may go underutilized for one simple reason. It may not be manned, post for post, on a 3 shift basis. Commercial installations can not afford to follow suite. Commercial operators do not have bottomless pockets, assured funding regardless of profit and loss. This advice is for them.

Two things emerge.

1. We must have a big enough crew to continuously man all posts on at least a 2 shift basis.
2. We must have adequate sleeping, recreational, and other needed facilities for a crew large enough to keep all the equipment busy full time. If we do not, our overall plan becomes an absurdity.

In other words, "hab space" must be proportionate to "lab space". While such facilities are themselves expensive, the cost of providing them is less than that of letting capital equipment go idle.

### VIRTUAL ELBOW ROOM

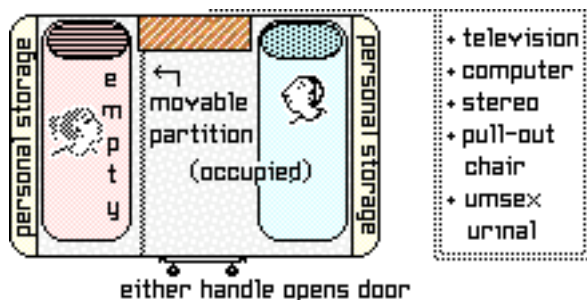
There are ways to architecturally finesse human space so that:

1. each space lends itself to alternating shift use
2. each space seems more spacious than it really is

#### MMM back readings on this topic

- o MMM # 28 SEP '89, p. 5, "Sardine Can Fatalism" [republished in MMMC #3]
- o MMM # 51 DEC '91, p. 2, Hybrid Rigid-Inflatable Structures in Space [republished in MMMC #6]
- o MMM # 80 NOV '94, pp. 9-10, Avoiding Sardine Can Syndrome: "Stretching Out": Usage, Layout & Decorating tricks to create Psychological Elbow Room in Limited Habitat Volumes [republished in MMMC #10]

If we can get beyond hot-racking in sleeping quarters to provide individual berths, we can still time-share dead space elbow room between adjoining compartments in alternate use - with movable partitions or with separate doors to shared space.



Crew members must have ample space for off-duty activities,

not only in common spaces like ward rooms but in their own quarters. This is one suggestion.

ABOVE: Time share dual compartment. The door has dual knobs and hinges. As occupying person leaves at end of 12 hr. sleep-relax shift, movable partition automatically shifts over and opposite door handle is enabled. Partition can be decorated to individual taste on both sides (colors, photos, paintings, etc.). Only the carpet color and works console is shared. Each person calls up his/her own monitor screen design and his/her own hard disk. Here, each person's quarters are more than doubled in free volume, while the space of the compartment *pair* is increased by only half. The partition could be folded back by mutual agreement.

These principles could be realized in alternative designs and with less generous or more ample shared space. For a small investment in volume, each person's personal elbow room is increased greatly.

One way to increase "spaciousness" is to cut in half, even to a third, the number of people in any area. We can time share not only work stations but common spaces like ward rooms, exercise areas, hobby areas, etc. Industries know the trick well, some even cycling work week/weekend times.

Other tricks suggested are the structuring of common spaces to support various activities, using dividers to break up total empty space into special activity areas to make the same volume seem larger. Breaking up sight lines is important. A volume that can be seen at a glance is psychologically smaller than an equal volume that needs to be "explored" - i.e. "maze is good". So is unpredictability, varied layouts of duplicated components. If there is more than one hab module, each can have its own layout, decor, and personality. Ditto with workspaces.

Side-by-side work stations can be baffled, offset, arranged at angles, etc. to personalize the individual work spaces. Clustering work spaces and separating with volumes for other use can also help.

Color is a great divider. Chosen to compliment one another, various hues can make a place so much more livable. Colors can also be changed from time to time. Electrosensitive colors can be changed on demand by the twist of a dial. Photo murals, forelit or backlit, relax the eye as well as the spirit. They too can be changed to suit occasion, mood, or season.

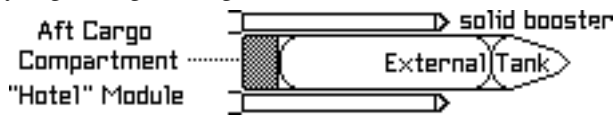
The bottom line is to provide full-manning at less expense. Around-the-clock manning means, in turn, plenary return on science equipment investment. So catering to human factors is NOT a luxury. Not to do so, to the contrary, is just plain stupid. Bureaucrats can afford to be stupid, there is no price for them to pay. Commercial operators have to fight wisely for every penny of profit, and cheating by cutting corners inevitably costs more in the end.

### CATERING TO MORALE

Much more can be done with a volumes that are more generous to begin with. Currently, we are planning to use habitat shells that can be brought to orbit in the shuttle orbiter's payload bay, restricting them to 15 foot diameters.

One neglected opportunity to hoist significantly larger pressurized volumes into space, identified more than a decade ago, is to strap a 27.5 ft. diameter squat cylindrical module

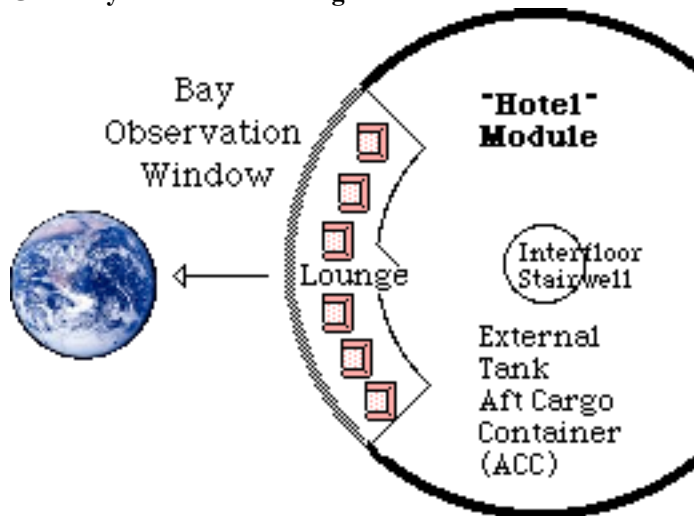
below the Shuttle External Tank between the protruding solid boosters. But of course, this would mean taking the ET to orbit, something NASA has been loathe to do. The total aggregate waste of volume and materials (Aluminum and Copper) that could have been brought to space and parked in a safe orbit for future use so far - by jettisoning ETs unnecessarily - is a crime against the future space frontier so great that it will one day be recognized as rivaling the burning of the Library of ancient Alexandria. This is an instance of deliberate avoidance of foresight. Foresight implies commitment which is something very frightening to Congress.



A two-floor 27.5 ft. wide ACC Hotel Complex opens up many possibilities. This is essentially the size and shape of Robert Zubrin's Mars' Habitats as outlined in his Mars Direct mission scenario.

Such a hotel would serve visiting reporters, scientists, political VIPs, lottery winners, etc. Such visitors will expect quarters less spartan than a Navy submariner would accept. One could think of a few welcome amenities such as a meter or two wide over-illuminated atrium filled with growing plants; or a gym area big enough to experiment with zero-G, a quiet pocket library for reading; an Earth observation lounge; a hobby room, etc.

**Glass bay window wall facing Earth**



**ESPECIALLY FOR GUESTS**

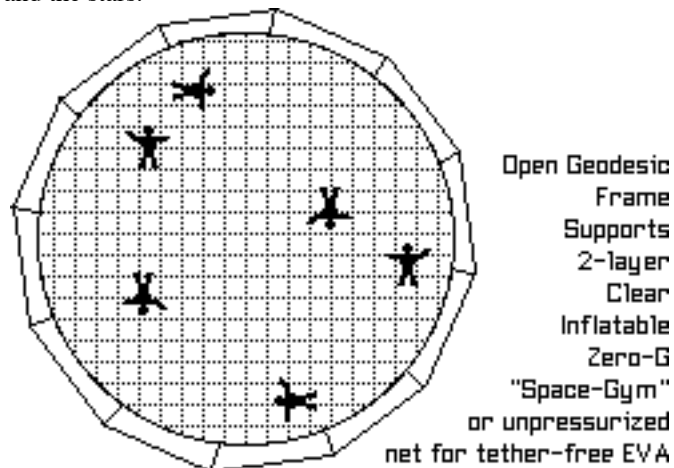
The View: Individual Quarters, or at least premium class ones, should have shutterable portholes from which to gaze on the planet below: land-forms, mountain ranges, rivers, coastlines, seas, clouds; and on the nightside pass, the ballet of lightening flashes and metropolitan city lights. Common areas such as a combo Dining /Assembly /Lounge/ Library should also provide generous space views.

Floating Free: For those able to adapt to it without space sickness (about half of the general population), the ambient zero-G will be something to enjoy. There should be some assists, however: velcro shoe soles with convenient attach points here and there, handrails, visual cues, color coded to help maintain orientation. A zero-G gym with exercise

equipment and a room for group activity: aerobatics even dance. For this purpose, the next step might be an inflatable torus, sphere, or cylinder for experimental Zero-G sports, athletics and gymnastics, even freefall dancing. Access could be via a port in the bottom of the ACC or any other node port adjacent to which there was sufficient unused volume (of external space i.e. within which to inflate the structure). Such a play volume would be great for the morale of the regular crew, and fun for most visitors, and make interesting footage for ABC's Sunday afternoon Wide World of Sports, especially as the level of expertise would clearly go up during each crew's stay term.

**OUT IN THE BACK YARD**

In the Tourism in Space Workshop at ISDC '94 in Toronto (Peter Kokh, Mark Kaehny, George French) Mark Kaehny's group came up with the idea of allowing untethered spacesuited EVA free form exercises in a safety-netted volume adjacent to an EVA port. The net could be kept in place and in shape by a lightweight tubular framework or even by an inflatable framework. This would allow regulars and guests a more direct Zero-G experience against the backdrop of Earth and the stars.



[From MMM # 78, SEPT. '94]

**HUMAN FACTORS**

New guests would find orientation clues very helpful. Bands of various colors could help, not only in the hard-hulled habs, labs, and hotel modules, but especially in less structured inflatable spaces.

**SUMMING UP - THE MARKET**

Activities likely to be supported in orbit by both governmental agencies and commercial/industrial projects are:

- Astronomy
- Life Sciences
- Space agriculture (centrifuge hosted-hydroponics)
- Micro-gravity research and processing.
- Manufacturing feasibility research, production

Personnel (in addition to regular station crew in their own habitat modules) coming either to work or tour and visit will need the following:

- zero-G safe facilities with locomotion/position-keeping aids and adaptation assists
- exercise facilities
- observation viewpoint
- added communications facilities for:

- = press interviews
- = conference & family calls
- = program origination broadcasting facilities

- assembly/dining/entertainment/gaming lounge
- audiovisual and reading library
- toilets, showers - hygiene facilities in general.
- half as many berths as design guest capacity, on a time-share shift-assigned basis for around the clock use of work, recreation, and sleeping facilities. Each pair would have movable partitions between berths to provide elbow room when occupied in turn. Six pairs, for 11 guests and one staff person, seems a reasonable initial size to support the early market.

*IF it is worthwhile* to do science and research in space, then it is worthwhile to provide a large enough crew for around-the-clock manning of all posts. It becomes vital not to skimp on crew accommodations and amenities. An unhappy or demoralized or stressed crew will not produce the best results, and that becomes much more expensive than the extra facilities. Max Science needs Max Hab space. Have NASA and others gotten that message? <MMM>

[In Cassini's Wake - A Lunar Prospector Encore]

## Uranium & Thorium

**Politics, not Economics, may force the birth of an early Nuclear Fuel Industry on the Moon. The "no-alternatives" stakes are considerable:**

- Radioisotope Thermal Generators for Probes
- Electric Power Generation Plants for Moonbases
- Nuclear Rockets to open Mars as a Frontier

Since January, 1998, *Lunar Prospector* has also been busy mapping areas richer in both elements.

by Peter Kokh

### IN THE WAKE OF CASSINI

The grass roots efforts to stop the launch of the Plutonium-RTG powered Cassini spacecraft bound for a 2004 encounter with Saturn and its great moon Titan, were unsuccessful. But they had enough of an impact on the media and the powers that be, that it would be surprising if a U.S. congressional ban, if not a ban enshrined in some global space treaty, forever banned the sending of activated nuclear fuels through the atmosphere, were not enacted or ratified in the near future, as the case may be.

For those of us who realize how nearly indispensable nuclear thermal generators, nuclear power generation plants, and nuclear rockets will be for continued exploration of the outer Solar System, and for manned installations and eventual industrialization on the Moon and Mars and elsewhere, this likely embargo presents a challenge that demands we rise to the full capacity of our brainstorming talents.

The hook upon which a practical workaround might be hung is that the embargo will likely be only of active nuclear fuel and nuclear fueled plants and engines. We should still be able to launch **unfueled** RTGs, nuclear power generation plants, and nuclear engines for rockets into space. As these fuel-using devices are *more complex to manufacture* than the prospective fuel itself, that is a very encouraging foot-in-the-door for those of us undaunted enough to dare open it after it has apparently been slammed in our face with a very finalistic sounding thud.

Two questions now pose themselves:

- Can we find suitable radioactive elements out there from which to make nuclear fuels beyond Earth's atmosphere? — **YES!** — on both the Moon and Mars, and probably on some asteroids.
- Can we do the engineering to mine and process source radioactive elements into nuclear fuel out there? - **YES!** — and with non-nuclear byproducts for diversifying lunar and Martian industries.

The nodule of the interstellar gas and dust cloud out of which the Sun and its planets formed had been well-doped with radioactive elements by the many nova explosions that had nourished it. They are a significant portion of Earth's crust, where their combined heat output over time has been enough to turn the mantle into molten magma. It is that heat that drives plate tectonics, continental drift, and vents itself in volcanoes. We can expect the same of any silicate world (includes Mercury, Venus, Moon, Mars as well as Earth, and the major Jovian moons.)

### LUNAR & MARTIAN ELECTRIC POWER NEEDS

We do not want to be restricted from further exploration of the outer Solar System by our probe spacecraft. But of much greater economic significance is the need for reliable power for manned installations on the Moon and Mars.

On the Moon, where twice the solar power flux per square unit of surface is available as on Mars, unavailability of "nukes" would be a blow, but not a fatal one. Solar power is quite practical for dayspan operations and uses, nor is there a problem producing a surplus. And there are several ways to store that power for nightspan use - none of them without challenging drawbacks — more to the point, none of them with showstoppers.

To make the problem easier, some considerable fraction of outpost and industry operations may be sequentially separable into more power-intensive and less power-intensive tasks, to be dispatched in a rhythm that works with the natural lunar dayspan-nightspace cycle, the "sunth". We can "do the Moon" without nukes, at least for nearer term beachhead establishment. That is encouraging.

Still, there will be industries and operations using equipment too dearly brought to the Moon to be allowed to lay idle half the available time, operations that need "full" power *at all times*. And once we begin building industrial and warehouse parks in cavernous subsurface lavatubes, nukes will be even more convenient. Long term, if not short term, we need nuclear power, fission or fusion, on the Moon.

On Mars, solar power will be much less efficient and

convenient, and occasional long-lasting global dust storms could pose a serious problem for any operation relying on solar without backup. Even before the first humans arrive, we will need nuclear thermal power to process rocket fuel for return-to-Earth flights. And the established availability of ready-to-use power on Mars, will make the prospect of sending the first human crews on an unabortable 2-3 year mission a lot less odds-tempting.

### THE LIMITS OF CHEMICAL ROCKETS

As we've pointed out before [MMM # 112 FEB '98, "In Focus: Cassini En Route: Time for Applause, Time for Pause" pp. 1-3] we may succeed in sending exploratory crews to Mars with chemical rockets. But we will be pushing this propulsion technology to the practical limits in doing so. Not only will chemical rockets never take humans out to the main Asteroid Belt or to Jupiter's great moons and beyond, but they are unsuitable as workhorses to open the Martian Frontier to droves of Earth-forsaking settlers and developers. They are just too slow, offering one way trip times of 6 to nine months. This is not the 16th century. People of today will not care that their ancestors once spent comparable time crossing the Atlantic. More importantly, exposure to cosmic radiation over such time periods is not trivial.

Robert Zubrin's scenarios for opening Mars to settlement, as do others', depend on the availability of nuclear powered spacecraft. If we can build them but not get them into space, that is a problem. The acceptance of the engineering challenges posed by the workaround suggested above is vital. We make it work! Or we watch our Martian dreams go poof!

### WHAT LUNAR PROSPECTOR HAS FOUND

Previously, the Apollo 15 and 16 Command Modules, staying in lunar orbit during the landing mission, carried a Gamma Ray Spectrometer for the first crude chemical mapping of the Moon, at least of the equatorial portions of the Moon which the module overflew (less than 20%). Thorium was one of three elements mapped. Concentrations in mg/g are richer in regions also heavy in KREEP deposits (Potassium, Rare Earth Elements, Potassium) as in the splashout from the impact that created Mare Imbrium. In all returned Apollo samples, lead, uranium, and thorium correlate neatly in their abundance. This tells us:

1. Trace lunar lead derives from thorium and uranium decay.
2. Where gamma ray spectrometers track thorium, we will find uranium.

Two Lunar Prospector instruments track radioactive elements. The Gamma Ray Spectrometer is mapping Thorium [#90]. The APS maps radon [#86] and Polonium [#84], but not Radium [#88]. The Rn and Po map will take longer to complete and publish.

Alan Binder, LP Principal Investigator, writes [June 6/10/'98] that "The Th map will be published in our preliminary science reports in science in a couple of months. Th and U, and hence KREEP, is most abundant in the Fra Mauro Formation, i.e., around the Apollo 14 landing site."

### WHAT IT WILL TAKE TO MINE & PROCESS

On Earth, thorium is found in the silicate thorite, ThSiO<sub>4</sub>. Common uranium ores are karnotite

(K<sub>2</sub>O•2UO<sub>3</sub>•V<sub>2</sub>O<sub>5</sub>•3H<sub>2</sub>O), autunite (UO<sub>2</sub>)<sub>2</sub>Ca{PO<sub>4</sub>}<sub>4</sub>•8H<sub>2</sub>O), uraninite and pitchblende (both UO<sub>2</sub> and U<sub>3</sub>O<sub>8</sub>). As the first two are hydrates, we surely will not find them on the Moon. Much of Earth's supply is in sedimentary deposits, redeposited material washed away from its original location by erosion and rain.

Until we have actual lunar samples from representative locations through Lunar Prospector, we can not be sure in what mineralogical context either uranium or thorium will be found. Until we know, we risk wasting time brainstorming detailed chemical processing pathways to the refined metals. We'll need a few "ground truth" landers to analyze samples and it is *not too early* to start brainstorming these missions and planning to make them real.

Mars global Surveyor may identify similar radioactive deposits on Mars. These would play a key role in the early industrial development and settle-ment of the Fourth Planet.

### FUEL OPTIONS

- Uranium 238 (99.27 %), Uranium 235 (1 part in 137) Both long-lived alpha particle emitters with radioactive daughter product series ending with Lead. Rare U-235 fissions directly, while the relatively abundant U-238 can be used to produce Plutonium.
- Thorium 232 + N => TH 233 - b => Proactinium 233 - b => fissionable Uranium 233.

### OTHER USES FOR U & TH

#### Uranium

- desirable colorant for glass and ceramic glazes "vivid fluorescent yellow"
- ferrous metallurgy alloy ingredient

#### Thorium

- minor ingredient in nickel-chromium alloys

### A NUCLEAR FUELS INDUSTRY ON THE MOON

Will there someday be a nuclear fuels processing industry on the Moon? If there is other industrial development of the Moon, for building materials for solar power satellites or lunar solar arrays, or helium-3 harvesting, nuclear fuels processing is likely to be part of a diversifying lunar economy.

The creation of such a nuclear fuels industry is likely to involve additional settlement locations, further globalizing the human presence on the Moon. At this time, we cannot say with confidence where such an industry would be best located. The Fra Mauro site, host to Apollo 14, may be joined by other good sites before Lunar Prospector completes its global map of U and Th. Proximity to locations chosen for other industrial activity on the Moon may have a bearing on the selection. Ease of access, shared logistics, mutual support, will all come into play.

Nuclear fuels will undoubtedly serve nuclear plants on the Moon as well as the fuel market for deep space nuclear space ships - unless helium-3 fusion becomes a superseding reality, of course. So accessibility to "coastal" sites, polar ice reserves, and to lavatube industrial complexes may be a factor. There are prior indications of Th abundance in some Farside locations as well, e.g. the double crater Van de Graaf ENE of Mare Ingenii, a site high on a short list for a Farside radio telescope array. For lunar nuclear fission power plants, both lavatube and deep crater sites offer built-in safety. <MMM>

# a MODULAR Approach to Biospherics

*Designing every Occupation Unit as an EcoCell*

by Peter Kokh

Moving off planet (Earth) is much more than a matter of engineering cheap transportation to space. It means moving out of the Biosphere that envelopes and involves Earth's global surface layers (air, the land, soil, water) and everything in them. It means moving to an area, whether in free space or on the surface of other bodies in the solar system, where we must create biospheres from scratch to live within.

Even the problem of "designing" "stable" minibiospheres seems quite daunting, discouragingly replete with too many parameters to be taken into consideration. The globally followed Biosphere II experiments in Oracle, Arizona were widely reported and still believed to be a failure. Such an attitude angers us and fills us with contempt at those who report or parrot such conclusions. First, nothing is a failure from which lessons are learned. Second, there is no other path to success than a pyramid of so-called "failures".

But what we did learn from Biosphere II is that finding a successful "equation" is much more challenging a problem than we had hoped it would be. We suggest that that is because we are going at the problem from the top, looking for a centralized solution or equation, rather than from the bottom. In nature, everything works from the bottom up. This means, of course, laying foundations, a step many people hope to avoid, in their impatience for results, in whatever endeavor they embark upon.

That looking for a central topdown equation for a stable self-maintaining biosphere should be an effort doomed to failure, should be self evident. If a solution were to be found, it could only be a "point" solution, a point in time at which just so many factors were in play: x number of species x', y number of species y', z numbers of species z' - and on and on for all the plant and animal and microbial species involves - and for the number of the human population included - and for the land area and air volumes of the biosphere etc. Now what good is a static solution for elements that can never be in stasis but always jockeying for position, as living ecosystems do?

That biospheres cannot be successfully designed from the top down should be no more surprising than that economies can not be so designed, much to the chagrin of those who persist in trying. Nature, it seems, is as democratic as economics. Perhaps, we should start from the bottom.

## HUMAN OCCUPATION UNITS - THE SPECIAL CASE

In Einstein's theory of relativity, the "special case" was much easier to formulate than the "general theory", preceding it in publication by some nine years, I believe. Similarly, we are here taking a look at one element in the biosphere, but an all-important one, human occupation units. Because these will ever be growing in number, and the volume and mass of the biosphere with it, and because they create the

greatest stress on any would-be "equilibrium", the problem occupation units pose is a paramount one. Coming up with an approach that greatly aids towards a "general theory of modular biospherics" would be an important first step.

By **Occupation Unit**, we mean any structure that houses sustained or intermittent human activity of any type *that requires a toilet*. - living units (homes, apartments, hotel units), places of work (factories, laboratories, offices, schools, stores and shops, etc.), and places of play (theaters, parks, playgrounds, sports facilities, etc.). Why is this important? Because the toilet is the point-source of one very significant demand on the biosphere's ability to recycle and sustain itself. If, as on Earth, we ignore the problem at the source, and shove it off on central water purification facilities, we make the problem and challenge of biospheric stability and self-maintenance enormously more difficult. If, on the other hand, we tackle this problem at the source, in every occupation unit in which there is a toilet, then the aggregate problem needing to be addressed on a centralized or regional basis is greatly reduced.

## THE INDOOR GRAYWATER SYSTEM

Several months ago, while convalescing with my shattered leg, I was watching one of our PBS channels on a Sunday afternoon and happened to take in an episode of "New Garden" that told about the unique "Indoor Graywater System" of retired NASA environmental engineer, Bill Wolverton. In the 70s, while working for a NASA that expected to put colonies on the Moon and Mars, Wolverton came up with a system that treats 95% of the problem of human wastes at the source, i.e. within each home or occupation unit. Each toilet feeds a long row of planters that accept the waste as nourishment, and in payment, not only remove 95% of the "pollutants" before the residue water exits to the exterior, but renews and freshens the indoor air, and provides an ambiance of luxuriant greenery. The planter sections adjacent to the toilet are planted with swamp varieties, then come marsh plants, bog plants, finally regular soil plants. The plants are content with low light levels - much less than full sunlight.

Wolverton's system has been operating in his Houston home successfully with no problems for over twenty years. While he invented this to meet then projected NASA needs on a since abandoned space frontier, he continues to work on adapting it to terrestrial needs. For examples, his planter "soil" is extended with "popped" clay pellets that are light weight so that his systems could be used throughout high rise buildings, providing fresh air, the ambiance of greenery, and precleaning the waste water, without adding undue weight loads, floor by floor.

Wolverton's system runs along the periphery of his home, to make use of ambient direct and indirect sunlight through rows of windows. Artificial light could be used. How could this translate to lunar and Martian or other extra-terrestrial applications?

In the case of surface-burrowed settlements, sunlight can easily be brought in by heliostats or fiber optics, making use of coatings to leave most of the heat outdoors. We have written about such possibilities on several occasions. A modular lunar home, office, lab, shop, or whatever, using filtered dayspan sunlight, and artificial light intermittently

through the two week long nightspans, could be combined with Wolverton's indoor graywater system to produce a home or occupation unit in which it would be a delight to live, work, or play: full of sunshine, greenery, fresh air - the perfect counterpoint to the alien, barren, sterile, hostile environment out on the surface itself.

In lunar or Martian lavatubes, artificial light, of wavelengths close to that of sunlight, would have to be substituted. On Mars, where sunlight is only half the intensity of that available on the Moon or on Earth, less filtering would be needed for surface-burrowed installations.

What such a system gets us, applied without exception across the board, is considerable. Each occupation unit becomes in effect a functioning cell of the minibiosphere, something much more than an inorganic construct of building materials. Each home or working unit now becomes an organic system as well as an inorganic one (of pressure hull with electricity, temperature controls, and plumbing). In such a system, we begin to look on the home or occupation unit in a whole new light - not as a foreign intruder in the biosphere that imposes an uncompensated burden, but as a place to live and work that is itself an integral functioning part of the biosphere. The indoor graywater system not only greatly reduces the environmental impact of each occupation unit, it contributes biomass and helps recycle the air, as well as the water, locally. The home or occupation unit thus becomes a responsible citizen of the minibiosphere. Further, the effect of such a system is to make all homes and occupation units much more delightful places to live - an incalculable plus on the space frontier where so much that mentally and psychologically sustains us on Earth - where we take nature and the biosphere for granted - has to be given up. Here is a living unit with a mission, a mission that works.

As we advertised, this is a "special case" start towards a whole new "modular" approach to biospherics, and approach in which we try to minimize the environmental impact of each element, natural or post-human, by addressing it at the source. This minimizes the residual problems that require regional or central solutions.

The modular approach to biospherics makes sense, because it lends itself to human communities, and their coupled minibiospheres, that can and will grow, naturally, as their economies warrant, addition by addition. Centralized biosphere planning may be narcotically attractive to those who would mega-plan topdown large fixed size settlements such as O'Neill colonies or all-under-one-dome surface cities. But such places, at first underpopulated, briefly populated just right, and then forever after overpopulated are fairy tale dream puffs that cannot deliver the idyllic livable picture postcard environments that artist illustrators have many accepting as the goal.

Modular biospherics is not only a better approach, it is the only approach that can work. Designing frontier homes and occupation units as living EcoCells is a big down payment in the right direction.

<MMM>

Order "Show # 707 Indoor Graywater System" from New Garden, New Braunfels, Texas for \$24.95 - allow six to eight weeks for delivery.

## LRS Builds Lightweight Table-Top Model of Sample Lunar Homestead Designed on the Ecocell principle.

by Peter Kokh, designer & builder

Using lightweight materials (36"x80" hollow core door, 4" sewer schedule PVC pipe fittings, and Styrofoam (i.e. regolith shielding), spray fleck paint, sanded paint, and other materials, and spending a bit over \$300, LRS put together an easily-transported\* table top model of a lunar homestead that previewed in the ISDC '98 Exhibit Hall, then was on display at the Discovery World Museum in Milwaukee for Jim Lovell's visit, and has since been seen by thousands at the Deke Slayton Airfest in La Crosse, Wisconsin and at a Twin Cities "Con."

[\* Despite the choice of low-weight materials, the whole model including cover weighs an estimated 80 lbs. are requires the services of two pallbearers (closed, it has the suspicious look of a wide, flattened casket!). The 80" length makes it a problem for many station wagons and small SUVs. It fit the maker's 1984 Audi wagon, however. We have toyed with the idea of shortening the model to six feet, or 72 inches, and equipping it with deployable wheels for one person handling.]

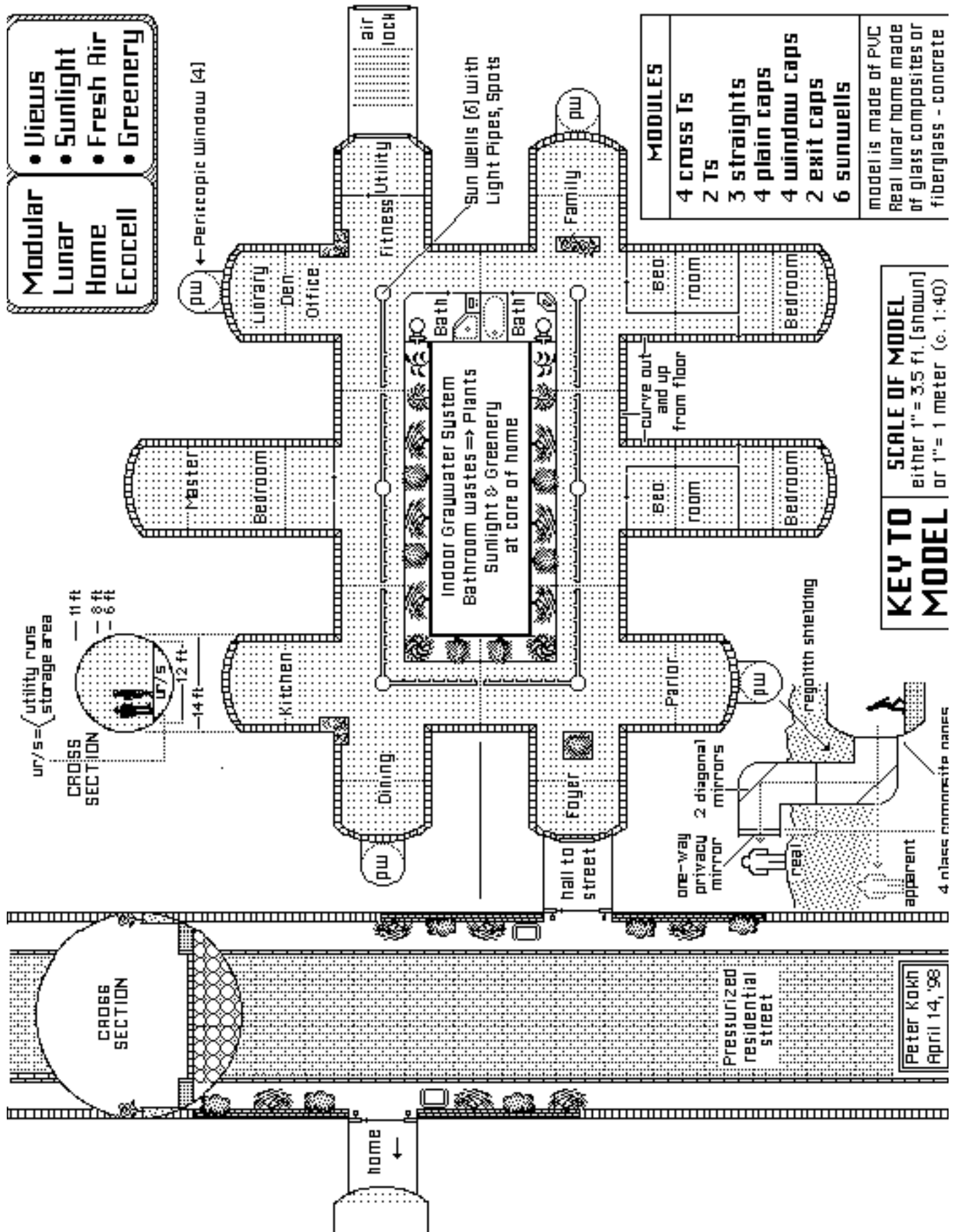
### The homestead gets across a lot of basic ideas:

- using regolith shielding for protection from temperature extremes, cosmic rays, solar flares, and micro-meteorites. The regolith blanket serves the same functions as does our blanket of atmosphere
- using modular construction of a small number of versatile components made locally on the Moon of concrete, steel, or glass composites
- visual access to the surface by periscopic picture windows
- flooding of the interior by sunlight through devices that follow the sun across the sky; and
- Wolverton's indoor graywater system which fills the sunlit core of the home with air and water refreshing greenery
- The homestead is built to be spacious, to let the family grow into it. So much for sardine-can living!
- Shirt sleeve no spacesuit-needed transit from homestead to settlement street to go shopping, to go to school, work, play, etc.
- pioneers would wear spacesuits just for decompression drills, much as our fire drills
- people could make themselves cozy and at home on the Moon using these simple principles
- From Earth would come pioneers, tools, seeds, and capital manufacturing equipment
- Most other needs would be met from local resources

That pioneers could make such a pleasant environment for themselves on the Moon using local materials is something most viewers thought "neat", "cool", "awesome", and "interesting". That they could apparently live so comfortably in an environment usually thought of as forbidding is enlightening. The exhibit, seen by thousands, has been a big hit!

<LRS>

Diagram of LRS' Lunar Homestead Table Top Model - 80" x 36" x 11" x 80 lbs.





*The Tortoise Plan:*

***Mobile Shelters for the Moon or Mars***

Many of us have had pet turtles when we were kids and take its strange architecture for granted. Along with its land based cousin, the tortoise, these ungainly shelter-needing creatures take their “homes” with them wherever they go.

Space engineers design rovers and other lunar or Martian surface transports with short-term use in mind. But someday there will be those who ply the surface regularly and must be protected from prolonged and accumulative radiation exposure. Their vehicles will need tortoise like sky ward armor of some sort. For more, see below.

*Scenic Cableways*



by Peter Kokh

On Earth, cable railroads and aerial gondolas have been used to transport people in hilly, mountainous country for two centuries, both for basic transportation, and for bird’s eye scenic viewing of spectacular and beautiful terrain. Various forms have been tried with great success from inclined planes, cog-railways, funiculars and aerial systems.

On the Moon, once there is a plurality of globally scattered settlements, *and* enough traffic, we are likely to see the emergence of some strangely familiar forms of mass transportation. Moon Miners’ Review # 13 AUG ‘93 pp. 10-14, reported the results of a group brainstorming effort on the prospects for “Railroads on the Moon.” From time to time we have mentioned in passing some other possibilities. In this article, we take an in depth look at one of them.

In this article, we propose a cable suspended boxed monorail design that would lend itself to long-distance travel over rugged terrain without necessitating extensive road grading, yet allow a heightened appreciation of the scenic moonscapes. The towers needed to suspend the system at regular intervals could be set in place by spider-legged walking vehicles, to minimize disruption of the surface below and keep the setting as pristine as possible.

**INTERMARIA PORTAGES & SHORTCUTS**

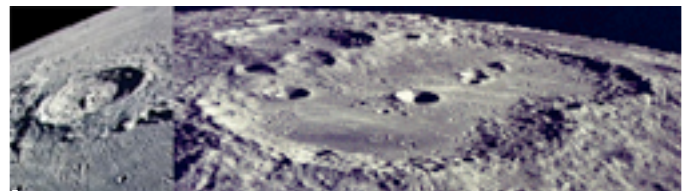
On the nearside of the Moon, perhaps the majority of good settlement and outpost sites are along “shores” or ‘coasts’ of the interconnected Nearside Chain of Maria. This allows easy “highway travel” in general. However, one of the most-often favored maria for settlement sites, Mare Crisium, the Sea of Clouds (the easiest feature on the Moon for the naked eye to pick out, a real media plus) is land or more accurately highland-locked. Surface travel between the Sea of Crises and the nearby seas of Tranquility (to the west) and Fertility (to the south) would require surveying logical low-grade routes through the crater-pocked highlands.

Even between contiguous maria, there are often sizable “promontories” or “headlands” to detour around. Such detours will add hours to the time needed. And even within a maria, inconveniently placed sinuous rilles (collapsed lava-tubes) will mean either hairpinning routes down one slope and up the other or a detour that could add hundreds of kilometers or miles to the trip, and many hours. Roads and even railroads will eventually find their way up and through and down low grade “valley routes” much as they do on Earth. Such obstacles will yield to them. Meanwhile, such obstacles present opportunities for scenic cableways portaging both passengers and freight - much as do waterborne ferries here on Earth - “to get to the other side” where freewheeling travel is again available.

On the much more rugged lunar Farside and through both polar regions and southern Nearside, cableways may be an early option of choice.

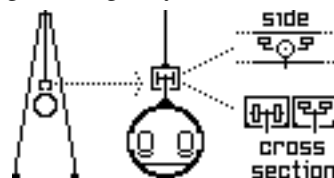
**SCENIC RIMWAYS**

Just as on Earth, recreational travel on the Moon will not necessarily be to a “destination”. We go on cruises to enjoy and relax, not to go somewhere. We can foresee scenic cableways along the rim ridges of the Lunar Apennines SE of Mare Imbrium, or along the shorecrest of Sinus Iridium in NW Mare Imbrium, or along the coastal ramparts of Mare Crisium, or along the rims of major craters like Copernicus. In fact such excursions, ending up where they started, are often cheaper than round-trip straightline travel to magnet destinations. Of course, such rim and crest following cableways will also work as practical ways to travel between various shoreline settlements.



Copernicus Rim ----- Van de Graaf Rim (Farside)

For tourists from Earth, such cableways will become a favorite, giving them a much better feel for the undisturbed rugged lunar terrain, as well as more sweeping views, than will graded highways with their cuts and fills, tunnels and bridges.



**Idea for Suspension Smooth Ride Monorail Cableway**



POINTS: Using the suspended monorail box beam, the ride will be much less up and down, smoother, with moderated changes in elevation and grade, allowing faster speeds. The box beam shades the “truck” that rides within it. There are spring loaded wheels that ride the inner sides of the beam and keep the truck centered so that the suspending bar or beam does not touch the sides of the box beam opening. The beam could be made of fiberglass reinforced lunar steam-crete<sup>1</sup> sections that would neither conduct dayspan heat or nightspan cold to the same degree nor expand and contract with dayspan/nightspan temperature changes as much as any beam made of available engineering metals: iron & steel, aluminum, magnesium, or titanium. <sup>1</sup> T.D. Lin of Construction Technologies Inc., who had first found a way using Apollo return samples to make lunar concrete, has now found a way to make it using the very minimum of water by steaming the mix. <MMM>



## ***Internal Combustion Engines for the Moon and Mars***

by Peter Kokh

**INTERNAL COMBUSTION:** an engine of one or more working cylinders in which fuel combustion occurs within the cylinders

This process relies on liquid fuels kept in tanks or compressed gasses kept in bottles. The oxidizer is air. And anyone will point out that you cannot have internal combustion engines on the Moon because the Moon has no air, or even on Mars because the air there is devoid of free oxygen.

### **BEYOND EARTH’S ATMOSPHERE**

BUT!!!! nowhere in the definition of the internal combustion engine, does it say that the oxygen has to be derived from an ambient atmosphere. Bottled oxygen, buffered with nitrogen if needed, can certainly be used. Thus there is no reason to exclude the use of internal combustion engines and vehicles built around them, on the Moon, Mars, or elsewhere beyond Earth’s friendly atmosphere.

There would seem to be no reason why a vehicle could not be developed to work not on bottled methane and bottled oxygen, buffered by nitrogen if necessary. All these ingredients can be processed rather easily from the Martian atmosphere so the development of “OOCH<sub>4</sub>IE” [Oxygen O<sub>2</sub>, Methane CH<sub>4</sub>] or “oochie” engines for Mars is a logical to priority.

### **GIFT OF MANY COMETS**

For the Moon, the challenge is twofold: source and recovery. With the discovery of lunar polar ice reserves, the source problem may be taken care of as it is to be expected that **carbon oxide ices will be part of the lunar polar endowment**, derived as it must be, from accumulated cometary volatiles.

The exhaust byproducts of oochie combustion will be water vapor and carbon dioxide. On Mars this is a happy result. oochie exhaust is indistinguishable from the Marts air from which the combustion fuel and oxidizer is derived. There is a logical recovery loop, an automatic recycling situation.

### **EXHAUST RECOVERY**

It would seem that on the Moon, the use of oochie vehicles would imply one-time unrecoverable use of these precious volatiles, as profligate as their use as cryogenic rocket fuels. It seems silly to build fleets of vehicles with a limited useful lifetime before they have to be scrapped because of fuel unavailability. It also seems a bad idea to be polluting the scientifically and industrially invaluable lunar vacuum with oochie exhaust gasses.

The use of oochie engines in small vehicles would seem to offer no salutary options. In larger vehicles, however, it should be possible to cool the exhaust to liquid form which can then be stored in pressure tanks. The process would have to work sequentially, first recovering the water vapor, then the carbon dioxide, as the requisite temperatures are quite different. Use of nitrogen as a buffer in the oxidizer would greatly complicate exhaust recovery, but not make it an impossible challenge. It might be well worth the work, however, to engineer an oochie engine that could handle pure oxygen oxidizer. In this respect, the threshold for the introduction of oochie engined vehicles on the Moon is quite a bit higher than on Mars.

### **GAS STATIONS FOR OOOCHIES**

Handy refueling stations are just as vital as a road and highway network which goes somewhere - and eventually, everywhere the driver might want to go. Road networks are a separate question altogether. Primary sources of oochie fuel and oxidizer on the Moon would be refineries at the lunar poles. On Mars they could be small atmosphere processing plants which could be mass-produced and set up anywhere traffic warrants. Where traffic is light, bottled fuel and oxidizer can be trucked in to refueling stations. Neither the primary processing stations nor secondary fuel stockpile stations would be involved in exhaust recovery and/or fuel reproduction.

On the Moon, however, local “gas stations” could be of two kinds. Primary stations would tap oochie gasses from the oxygen and methane pipeline network directly. Secondary stations, at a distance from the pipeline net, would store bottled products trucked in from primary stations. Both types of stations would take in bottled exhaust gasses or liquids to be returned to the original or, more likely, secondary refineries nearer major usage markets.

### **CAPTIVE MOBILE ONBOARD GAS STATIONS**

We talked of “larger vehicles”, i.e. large enough to sport the exhaust recovery systems that might be mandated on the Moon. “Large” is a question of degree. One can certainly imagine some *very large* lunar vehicles: the tractors of long “road trains”, mobile gas scavenging plants such as the monster Helium-3 harvester in the classic movie of pioneer lunar industrialization, “Plymouth” [ABC-Disney ‘91]; mare-plying wheeled “cruise ships”, etc.

For vehicles of this scale, another option emerges: storage of cooled exhaust products during nightspan, and then

reprocessing them into fuel and oxidizer in compact onboard solar-powered refineries during dayspan. This is a chemical engineering challenge, but one I predict is “doable”. The reward is considerable: a fleet of rather large vehicles which can operate on a continuous basis with only widely spaced “visits of opportunity” to fixed-site gas stations for “topping off” i.e. leakage loss make-up.

### OOCHIES & EVERWEST ITINERARIES

In a self-refueling oochie, tourist visitors from Earth could embark on circle the Moon tours, with generous stop-overs all over the place, leaving home port at dawn, and reaching the antipodes around “noon”, arriving back at dusk 44 days after first setting off, by traveling generally ever westward, staying always in the sun, enjoying a continuous dayspan. A more popular idea may be to start out in mid morning when the shadows are not too long, with the sun behind you, and to generally keep up with the sun’s progress, doing the entire itinerary in morning light conditions, arriving back at the departure point some 25-35 days later.

On the other hand, choosing to travel in an easterly general direction, thus fighting the sun’s progress across the sky, one would go through a pair of sunsets and sunrises during the same time period. Thus this is exclusively an “everwest” opportunity. But travelers would not have to head straight west. They can zig zag and meander all over the place so long as they keep progressing westward in longitude by an average of 10-15 degrees per 24-hr day. This is only the average progress that must be maintained. One could spend 12-18 hours traveling, progressing say 45 degrees westward, then stop off somewhere for a 2-3 day visit before resuming travel. Everwest options are very flexible and generous. One could not keep in the sunlight while traversing the lunar globe in an easterly direction *at any speed*.

On Mars, with a day night cycle is only 37 minutes longer than on Earth, this is not possible. Everwest “Long Morning” global tours are a consolation prize of the slow rotation period of the Moon.

Of course, one could always choose to travel westward around the Moon *through the night* in a similar fashion for whatever purpose. On the Moon there will be night people just as on Earth, only here, for truck drivers at least, they could live a life of *perpetual* nighttime. The self-refueling oochie would not support such an option, however, as solar power is needed to reconvert the exhaust gases back into oxygen and methane.

For the all nighttime travel option, there would have to be replacement fuel tanks already available at convenient regular intervals, in other words, a global network of oochie gas stations. Nocturnally inclined over-the-road drivers and vampire pretenders will have to wait some years for all this infrastructure to fall in place. Lunar global travel will be pioneered by daylight loving people as soon as reliable self-refueling oochies have been developed.

We do not have to wait until we are on the Moon to engineer and debug such vehicles. They will work on Earth. We could get them ready now.

### OOCHIE PROSPECTS

This seems an attractive scenario, flowing from the find of lunar polar cometary ices. The usual expectation is that the fuel options for lunar surface vehicles are limited: weak solar electric, heavy fuel cells, Pandoran nukes, beamed power, electrified rail or maglev. The concept of the oochie opens up whole new horizons for lunar settlement and development if the engineering challenges can be overcome.

Some will dismiss the prospect; we will dismiss them. Criticism in advance of experimentation, even “informed” criticism, is cheap. The challenges *are* many and the only acceptable attitude is that we *can find* a way to meet them, or if not, we’ll *make* one. Without this attitude, we’d still be living in the trees.

First is the dilemma of methane burning too hot in pure oxygen versus production of troublesome nitrogen oxides if it is burned in a buffered oxygen-nitrogen mix. We must make one horn or the other of the dilemma work. My money is on the first option.

Next, to recover the exhaust products for converting back into fuel, we need a highly engineered cooling and gas separation system. Power to run it can come from solar banks during dayspan, or from fuel-run refrigeration in nightspan.

In the “everwest” [see the box at left] exclusively dayspan operation, solar may be enough, given that undiluted full-strength sunshine is available around the clock while the vehicle need only be driven a few hours a day on average to maintain its everwest pace. On the Moon, with no air resistance or drag to contend with, (much less any wind!) solar panels can be aimed in any direction necessary to catch the sun *full on*.

One can imagine that oochie-engined vehicles will become as much a part of Lunan culture, myth, and lore as the gasoline powered auto has in our own civilization. Add to that the subcultural influence of Lunan over-the-road rig owner-drivers, and that of everwest lunar “world cruises” and it may well be that the oochie engine, when perfected, will become one of the most distinctive ingredients in this newborn beyond-the-cradle civilization.

But more exciting than such idle daydreaming is the fact that the oochie is not a development that must wait upon the establishment of a permanent Moonbase. The engine itself, the exhaust cooling and recovery systems, and the reconversion of the stored exhaust products back into oxidizer and methane are items that can be thoroughly developed, tested, and debugged here on Earth so that they are all “off-the-shelf” prepaid technologies by the time we need them. By doing this work now, especially if we can pay for it from profits from any pre-identified terrestrial applications of the various parts of these technologies, we will have helped to “spin up” the road to a second, adopted, human homeworld.

For Mars, the oochie engine is even more ideal, as methane can be processed directly from the atmosphere. Mars fans should be especially interested in pursuing this option.

Contact: kokhmmm@aol.com - **MMM will keep track of those expressing interest and help put you in mutual email contact.** <MMM>

# Landcruising Gypsy House Boats

by Peter Kokh

## LIVING ON THE ROAD LIFESTYLES

What concern NASA has given to provision of **radiation protection** to its people on the Moon has been concentrated on methods of banking regolith soil around fixed habitats and shelters. This writer has never seen a NASA or contractor drawing or illustration of a lunar surface vehicle that paid any attention to the question. The assumption is that no one would be out on the surface long enough for it to matter, that surface sorties would be as relatively short and limited as the sight lines of those “in position” who talk about lunar bases.

But in any kind of longer term vision of what is likely to happen in lunar development and settle-ment such an assumption is patently absurd. Even an infant lunar global market is certain to sprout the following (and other) types of vehicles in which drivers and crews will be on board for very extended periods in which, without protection, they would accumulate potential lethal doses of radiation.

- fleet and owner-operated long distance truck rigs
- large gas/ice harvesters always in “the field”
- mobile markets, plying the settlement circuit, picking up special crafts and manufactures of one community to hawk in others at dockside markets [see MMM # 35 MAY '90, pp. 6-7. “Tea & Sugar” on the same lifestyle niche in the asteroid belt]

If lunar development goes anywhere at all, it will rather quickly move past the “tentative” stage in which personnel involved have come for short and temporary tours of duty, to then return to Earth to brag to their grandchildren how they where once on the Moon. If those “in position” dare not allow themselves the luxury of thinking in such “unsupported” terms, we, whose primary concern is to pave the way for just such long-term realizations must tackle the problems that will then arise.

One option, of course, is to limit accumulated exposure by making mobile assignments temporary, not allowing anything like lifetime careers “on the road”. But this is an unnatural choice. While living on the road is a lifestyle that does not appeal more than momentarily to most, it does suit the temperaments of a steady fraction of any population, who find themselves happiest in outdoor mobile occupations. Rather than limiting people, we should seek to turn them loose. People always do their best when they are following their own stars.

In any natural unfettered lunar society, there will be the long distance truck drivers, the traders, the road builders, the field prospectors, the out-vac sportsmen, whose spirits would suffocate within the confines of even the best designed settlement. How do we make a place for them, not just in society, but also out on the road and in the field, a place in which they are moderately safe from dangerous doses of cosmic radiation? [The solar flare question is another matter

altogether. See MMM # 37 JUL '90, pp. 4-5, “FLARE SHEDS: Butt-savers in the lunar out-vac”]

## TORTOISE SHELLS - THE CARAPACE

What seems to be needed in all the types of vehicles mentioned above, is some sort of overhead and side layer of sufficient thickness to harmlessly absorb incoming radiation. This cannot be conveniently minimized. Too thin a radiation barrier is worse than none at all because of the even more dangerous secondary radiation that occurs when cosmic rays hit layers between about 20 and 200 centimeters (8” and 2 yards). The first thing that comes to mind is to use garden variety regolith, pre-pulverized lunar soil, in bin rows to keep from shifting. Even in light lunar gravity (“sixthweight”), this would entail a loading of 180 lbs per square foot, nearly a ton per square meter. Talk about road-hugging vehicles! Obviously, such vehicles would have high centers of gravity and need to be very wide-tracked to compensate.

Can we find ways to lighten this burden? Like the tortoise and turtle, crews of constant use lunar vehicles will need to take their shelter with them. But doing so with “raw” and otherwise “useless” shielding threatens to bog them down in tonnage.

## LIGHTER WEIGHT SHIELDING MATERIALS

There are two reasons to avoid cheap raw regolith for this purpose. It is relatively heavy, 2.8 gm/c<sup>3</sup>, and loaded with middle weight atoms that increase the amount of secondary radiation. By weight, 76% of regolith is constituted by the lighter elements [with their atomic weights given]:

O oxygen [16]	Ma magnesium [24]
Al aluminum [27]	Si silicon [28]

Another 22% of regolith (abundance averages for highland and mare soil) consists of:

Ca calcium [40]	Ti titanium [48]
Fe iron [56]	

Highland soil has more light magnesium and aluminum but also more heavy calcium. Mare soil has more titanium and iron. In advance of the capacity to remove Ca, Fe, and Ti altogether, highland soil, free iron fines removed by a magnet, would be the better choice. This may be the practice for some time, and it will be quite feasible if early settlements are established, as we’ve recommended, along the shores of the various maria or lunar lava plains, i.e. in coastal mare/highland zones where access to both the most common types of lunar soil are readily available.

Once we can do extensive processing, the following options suggest themselves either singly or in any available easy to produce mixture [molecular weights, followed by **average atomic weights** given]:

Silica SiO <sub>2</sub> = 60/20	Magnesia MgO = 40/20
Alumina Al <sub>2</sub> O <sub>3</sub> = 102/20.4	Magnesium 24
Aluminum 27/27	

Foamed silica glass or hollow quartz Spherules would seem to be the most attractive possibilities, if they can be manufactured as a cheap byproduct of other priority materials. As quartz (pure silica glass) is transparent to solar ultraviolet, it is likely to be a high priority product of early lunar indus-

trialization, as waste water could be purified of bacteria and pathogens quite simply by exposure to the sun in pressurized quartz-paned tanks. But silica, magnesia, and alumina are also likely to be produced early on for various uses. And aluminum metal alloy could conceivably be foamed.

In similar situations on Mars, where both hydrogen and carbon are much more abundant, such passive shielding materials as C graphite [12] and simple solid or baffled liquid hydrocarbons [average atomic weights c. 4-5] would offer superior choices. On the Moon, even given the lunar polar hoards of cometary ices, such use of these elements would seem profligate [unless liquid propane becomes the fuel of choice instead of methane, in which case overhead and/or side-mounted fuel tanks could do double duty].

### SHIELDS OF CARGO, FUEL, SUPPLIES, BATTERIES

Above we called regolith and regolith derived shielding “otherwise useless”. Worse than useless, it will make for slower acceleration and braking. What about dual use materials and objects: items likely to be part of, or carried aboard which, if placed above and/or to the sides could do double duty as shielding, thus keeping total loaded weight (and fuel consumption) of the vehicle down? This is an area already much investigated in the design of deep space craft for human crews who need radiation protection but can ill afford the exorbitant fuel penalties of extra mass taken along for shielding purposes only.

Among such items are:

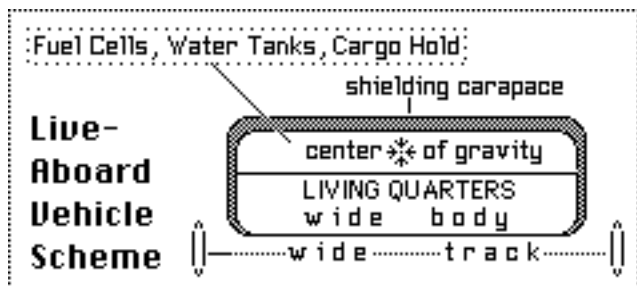
- banks of **fuel cells**, the bottled cryogenic hydrogen and oxygen that feed them and
- the tanks of water that they produce
- other **water** reserves and water in treatment
- **cargo** holds

With proper vehicle layout and design, such double duty shielding may be able to handle a large portion of the load, using the inert regolith-derived (atmosphere-derived in the case of Mars) materials for filling in and topping off. If cargo holds were counted on as part of the mix, vehicles would have to fill them with inert dunnage when no cargo was available for return trips.

But that very prospect may make some otherwise marginal products marketable as their shipping costs could largely be waived. For this purpose a market should arise for standard stackable containers; standard construction bricks could serve as salable dunnage in a pinch. Other creative and enterprising solutions will arise.

### DESIGN & ENGINEERING FEATURES

The discussions above would seem to suggest the following trial balloon general design:



### READER DESIGN INPUT WELCOME

The above sketch is meant only to spur the imagination. Our purpose here is to define the need. We invite the interested reader to suggest ways in which the design features can be realized. If you would like to play with some of the ideas discussed and suggest design options, contact the LRS/MMM define & design think tank:

kokhmmm@aol.com - or

Copernicus Construction Company  
1630 N. 32nd Street  
Milwaukee WI 53208-2040

When we have enough input, we will publish all promising design options and constructive criticisms in a follow up article.

### BASIC & SPECIAL ACCOMMODATIONS

**Design will follow function**, of course. And the function of such vehicles will differ according to the needs of their owners or users. Hired single drivers of cargo rigs will have simpler accommodation needs than owner operator couples, for example. Large crews of mining equipment, crawling gas harvestors, and road construction equipment will have need for even larger accommodations.

Then there are the special needs of whole families who use their vehicles like land-roving “house boats”, probably picking up trade goods in one port to market in the next, on regular circuits, or routes of opportunity. Some such families will be involved in trade only. Others may need shops and facilities aboard where they can give their own “value added” touch to special materials found or available only at certain “ports of call” - materials that lend themselves to crafting and art, productive pastimes that can fill the long hours spent on the road between settlement towns and outposts.

Others will trade in recyclables, and have time in transit for further sorting, disassembly of parts that need to be recycled separately, and even creation of art objects or decorative wares out of such materials, on route to towns with special wants.

Those engaged in such value added trade, may want to have the room to take on “apprentices” to earn further income from their instruction. Families in general will need convenient “growth room”.

Unused cabins will allow such vehicles to tap the “tramp steamer” market of travelers on standby for seats/berths of opportunity, whether to specific destinations or just simply anywhere that offers a desired change of scenery. The “wanderlust” market is likely to have negotiable ticket prices. Reporters, writers, people in search of themselves, and adventurous people in general would feed this market.

Vehicles plying trackless or less traveled routes may carry snail mail letters and packages to and from outposts off the beaten path.

And all such “gypsy traders” will need the built in capacity to display their wares attractively when they arrive at a settlement town or outpost. Display racks which compact to roll through docking ports for settlement interior dockside display would be rather handy, but display rooms onboard that can be visited conveniently through the docking port will also

work, especially where a few buyers are the targeted market, not the populace in general, as in wholesaling, or selling to businesses and factories as opposed to the anonymous town consumer.

Both cargo rig owner-operators and trading families may desire highly personalized exteriors for their live-aboard vehicles. Some will personalize their own wheels, but the special wants of others may give rise to a whole small but contributing entrepreneurial industry of customizers. This all helps the lunar economy grow. Ninety percent of any economy is domestic, and this activity will boost that. These same startup companies may cater to individual owners of spacecraft who want their craft easily identifiable, spacefaring statements of their personalities. And this would be an export side-market.

And then there will be lunar "RV"s available for lease or rent to vacationing families, with more generic, less personalized design features. And their will be the coaches that specialize in overland lunar excursions. Custom built vehicles of both classes may vie for best onboard entertainment facilities.

All such vehicles will need more than simple first aid kits, a cupboard dispensary that can take care of many simple emergencies. There will be stretches between towns and outposts that require several days travel to cover.

"First Aid" capacity, of course, is equally important for the vehicle itself. Onboard tools and equipment, including hoist and winch, to handle common roadside mechanical and electronic repair emergencies is a must.

#### SPECIAL DESIGN CONSIDERATIONS

This article does not touch on engine and fuel considerations. See the preceding article on Oochies for what may be a promising option. Nor are we concerned with navigation and communications, as important as all these things are.

As to environmental life support, it should be noted that the larger a live-aboard vehicle is, the greater the opportunity for a biological component for life support - salad gardens, herb and spice pocket gardens, and "house plants" in general. For rigs that are large enough, indoor graywater systems [MMM # 116, JUL '98, pp. 9-11 "A Modular Approach to Biospherics"] mating toilet facilities with air and water cleansing plants in a sunlit core of the living area, may be an attractive option. Greenery will do vital for the morale of those enjoying nomadic life-styles, the more so because, on the road, they will get little other opportunity to experience anything but the "magnificent desolation" of barren moonscapes.

Getting back to the live-aboard vehicle itself, we might predict such features as electronics-loaded bowsprits and eagle's nests to aid in negotiating rough terrain. Individually adjustable height wheel suspensions, individual wheel electric motors powered by a central plant (e.g. "oochie/electric"), and attitude stabilizers might all be valued options.

In general, there is little need for rights of way to be narrow on the Moon, as they are on Earth. Here the operatives are twofold, wind-resistance and high real-estate costs, neither operative on the Moon. Wide wheel tracks are the likely beneficiary. This will easily compensate for high centers of gravity. Considerations to the contrary may be narrow

mountain passes, narrow bridges over rilles and other chasms, and narrow berth/slip spaces in crowded "marinas" around bustling settlements.

Luxury items may include pentroof-shielded observation decks and other income splurges.

Those readers who want to exercise their design talents should feel free to address any of the special needs outlined above, or others that we have failed to mention. No one generic set of solutions will fit all cases, nor even most cases.

#### NOMADIC CULTURE & RHYTHMS

Just as specialty "truck stops" here cater to over-the-road drivers' every need and want, so too, a whole service sector will rise in settlement towns and outposts to mirror on-the-road nomadic culture. Quickie education and instruction courses for crews, even by crews if they have expertise uncommon in the settled populace. Service for onboard CELSS systems and other difficult repair problems. Tours of city sights. Bawdy spots to cater to starved "needs".

Live-aboard go-anywhere home-on-wheels vehicles will do their share to make life on the Moon more "world-like".  
Help make it happen!

<MMM>



#### Cruise "Ships" on the Moon's Lavasheet "Seas"

by Peter Kokh

✚ What is the essence of a cruise ship? May I suggest, dictionaries aside, this working definition:

an internally spacious and many-activity supporting means of transport that goes nowhere in particular over a non-distracting surface so that its passengers have nothing to do but relax, relax, relax.

The sea is essential only as a metaphor for a non-distracting motionscape. This can be a terrestrial ocean or sea\*, the surface of relatively featureless lunar or Martian lava plains, and above all empty stretches of interplanetary space itself.

\*There are places on Lakes Superior and Michigan and Huron, the Aral Sea and Africa's Lake Victoria, where ships lose sight of land for appreciable stretches.

Such plainscapes, watery or dusty, support vessels or craft that can be gargantuan in their dimensions. Bodies of water call for streamlined hulls because the craft in question must "part the waves" to make progress. But by using a double hull catamaran plan, ocean ships can be amazingly wide. Port congestion with close-spaced piers may introduce an artificial constriction not "of the essence".

✚ Why cruise "ships" on the Moon? Because they will provide the same welcome relaxation and escape from routine

as do their terrestrial counterparts. As here, the object will not be to go anywhere, even for an extended visit (e.g. Europe), though brief visits may be made to small ports with local color to spice up the vacation: San Juan, Nassau, Ochos Rio, Aldrin Vale, Alpine Valley Junction, Rover Crossing.

As with terrestrial “floating resort hotels”, over time a symbiotic relationship will develop between the ships and their ports of call. The quest of the passengers for variety will work to motivate local artists, craftsmen, and performers to produce unique items that give their “port” a special and hopefully memorable flavor. Produce or get dropped from the circuit. This motivation with both public and private support will be strong, even if service to the tourist trade is a secondary part of the local economy. Occasionally the “ships” will test visit new stops, on or off their accustomed circuit(s).

**Where on the Moon?** Many locations on the Moon are suitable for this kind of vacationing. Keep in mind that rilles are as much an obstacle, however, as craters of size. Treat them as barrier reefs and large islands respectively. Even so, most of the lunar maria have sizable continuous stretches that should be negotiable by large, seemingly “floating” structures. In each mare, proposed routes will have to be surveyed carefully for obstacles and alternates. The whole idea is not to have to “fix” the route by cutting or filling or bridging.

**Nearside “Seas”  
Farside “Seas”**

On the Nearside, since most of the large maria are interconnected in one great “Chain of Seas”, large scale cruising is a likely development. There is even one natural ready-made intermare canal, the Alpine Valley, that connects NE Mare Imbrium with S Mare Frigoris east of the conspicuous crater Plato.

While scenic shorelines and other natural features will give some potential routes a big boost, in the end it will take the efforts and energies and imaginations of individuals to make it real. And that is something that can never be taken for granted.

Cruises on any of the maria along the limb (N-S East Limb: M. Humboltianum, M. Marginis, M. Smythii, M. Australe; West Limb: M. Orientale. L. Veris) where the Earth appears to rise and set in the sky monthly due to an orbital eccentricity effect known as “libration”, could be popular. During stretches when the Earth is just below the horizon, especially during local nightspan, the Milky Way will dominate the skies in a way that no human has yet experienced.



Nightspan cruising will be more popular on Farside (M. Muscoviense, M. Ingenii, Tsiolkovsky, etc.) if powerful blacklight headlights in the absence of both sunlight and earthlight does indeed show the moonscapes in a magical guise. Experiments on Earth with Apollo Moon samples in a dark room should tell us whether that is something to pursue or not.

**The idea, we said, is not to have to “fix” a route** by one kind of civil engineering or another. That said, there is precedent for just that on Earth where channels have been dredged, rivers dammed, canals dug or blasted, and locks installed to allow navigation where it could not otherwise have been supported. Cheating? To purists perhaps, but few practical people would give it a second thought. Pragmatic acceptance of “helpful” engineering will be accepted on the Moon as it is here. In each case, the engineering feat will quickly fade into the background or asserts itself to provide special, even featured interest and enjoyment.

Overland cruising might even be supported along very carefully chosen highland routes through chained stretches of so-called “intercrater plains”. These favorable locations will be few and far between in the lunar highlands covering 70% of the surface. The corollary is that where they do exist in extent large enough to support such activity, this will be an economic incentive toward establishment of outposts in the area. In most cases this will be but one “plus” to be combined with other advantages outweighing any disadvantages before development will happen. Just one town at the “head” (i.e. nearest to a beaten path or intersettlement highway) of such a proposed circuit of smooth-going terrain may be enough to get the ball rolling, cruise excursions giving rise to other stops along the route - eventually.

We do not suggest that cruise activity be an important factor in the establishment of early era secondary settlements, for one simple reason. A Cruise industry presupposes a large established population in which at least some hundreds of people may be motivated to take the same kind of vacation at the same time. That won’t happen anytime soon.

Obviously, however, the way to start is small, e.g. with mare “yachts” and “schooners” that handle a few dozen to a hundred paying passengers plus crew. Indeed, mare cruising is likely to start with an upgrade of a live-aboard lunar “houseboat” of the type described in the last article. Design solutions must progress as well from smaller craft to larger ones. Of course, not everything can be scaled up or down. There are size thresholds above which things become possible for the first time and at which old tried solutions are no longer suitable. But one must never set the working threshold too high, lest one put it out of reach!

So in this article we are leapfrogging past the first decades of the frontier. But again our purpose is the same, to show that a surprising variety of activities we accept as commonplace on Earth (e.g. excursion cruises!) can be supported in some analogous way on the Moon. We want to expand the envelope of imagination and expectation which, if it were to rely only on the vision of NASA-contractor horseblinder minimalism is pretty skimpy. It need not be.

**✍️ We confine our scope to “defining” the functions of our topic - a lunar analog cruise ship resort hotel.** Once again we invite the reader to provide constructive criticism as well as to suggest design architecture, engineering, mechanical, power plant and fuel options that work with the basic concept to promote its eventual salinization. To contribute your ideas, concepts, problem identifications, etc. either by email or stamp mail, see the contact information on page 7, column 2 “Reader Design Input Welcome”.

**✍️ Here are some interior design considerations:**

- size and passenger capacity (50-2000?)
- adequate shielding carapace over top and sides
- side holds for supplies and equipment lockers
- adequate solar flare storm shelter as parking under a standard flare shed is out of the question
- substantial mini-biosphere and life support with allowable passenger tasks and involvement
- resort hotel accommodations and features
- solar atrium - thick layers of glass composites or honeycomb of bundled fiber optics cells
- decktop observatory
- mall offerings and features
- diversions and entertainment
- crew promoted networking and socializing
- other onboard services
- full spectrum communications and libraries
- luxury touches
- carry-aboard coaches to take passengers to nearby scenic overlooks etc. over terrain the cruise-ship cannot negotiate - these can double as “lifeboats”

**✍️ Here are some mechanical considerations:**

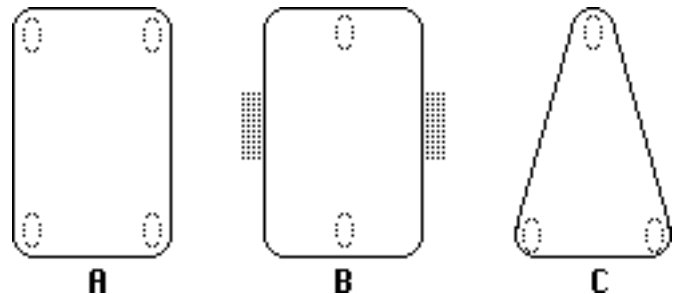
- oochie and nuclear power alternatives
- desired speed cruise 20 knots , flank 40
- use of “harbor tugs” for precision berthing
- very wide track to compensate for high center of gravity in a low gravity environment
- suspensions, track width, wheel radius, and clearance chosen for maximum stability, low sway ignoring small craterlets and boulders
- possible lowerable surface skimming observation platform for soft-suit moonscape observation in smooth terrain
- possible use of drag rakes to minimize wheel wakes in the dust, keeping the “sea” trackless

**✍️ Here are some legal issues:**

- Establishing cruise preserves to make as much as possible of the circuit corridor within flanking horizons (from the highest onboard perches) off limits to other surface vehicles to help preserve the trackless character of “open sea” (in concert with the drag rake feature mentioned above).
- Restriction of transecting corridors open to other surface vehicles in the vicinity of crossings with tunnel underpasses where possible
- Possible exemption from local government restrictions on gaming and gambling
- Traditional power of “ship” captains to conduct marriage legal ceremonies

**✍️** If ever the era of low-paced living and leisurely travel “to” destinations returns, **Ships that go somewhere and take people somewhere** as once great liners took people between New York and Le Havre or Southampton across the Atlantic, land-sailing liners may someday take people “somewhere” on the Moon. We do not foresee that. For now we are talking simply of “cruises to nowhere” in which the ship itself is the destination, a vacation site at which you can’t get into your car and hustle around just like you do at home during the work year. Cruising is meant to give a complete break to the pace of life. In this sense, “Love Boats” on the Moon are plausible.

**✍️ A trio of sketches to prime your imagination.** Feel free to start fresh and to look at other concepts.



Some Possible Chassis Plans for a Mare Cruise Ship

A Rectangular 4- wheeled design

B Rectangular whimsical “paddlewheel” design

C Delta 3-wheeled design

The paddle wheel design (at least the wheel placement) would allow greater maneuverability (“turning on a dime”) than a conventional 4-corners wheel arrangement. If you wanted to press the paddle wheel analogy and allusion, you could design it so that it would pick up regolith that would fall off the trailing edge like water. Romance should not be pursued at the expense of practicality, however.

A three wheel design might be the most stable, especially over moderately rolling terrain (“high seas”, if you will) although a conventional 4-wheeler would be fine in really flat areas. Of course, each wheel should be large enough to ignore pockmark craters, and have enough play in its independent suspension to handle those several yards (meters) wide without forcing a detour. A companion advantage of a delta design is that it would allow more passengers to have forward facing lounge seats.

**✍️** We’ve tried our crude hand at **some elaborative design options that seem promising.** But we’d like to see what our readers can come up with first before publishing any of these suggestions. While this brainstorming is perhaps a century ahead of its time, it is a horizon-stretching activity. More to the point, it is a mind-stretching exercise that will help in imagineering the near term lunar frontier as well.

So jot ideas down as they come to you, let them simmer, and once you sense you have the start of a “critical mass”, start putting them together and see what you come up with, keeping score of problems solved, problems remaining, and problems created. Take breaks as needed, and send MMM the results when you have taken them as far as you can.

If your brainstorming stalls, you might want to look at a CCC design study for an 80 passenger Earth-Moon Hotel Cruise Ship [Moon Miners' REVIEW # 12, January 1993, pp. 2-8,---- <http://www.lunar-reclamation.org/papers/transitel.htm>]. While this study is for a vessel that plies space, not the lunar surface, the features included in the hotel portion are things you might want to take into account in your own design. Some of the design solutions may find a parallel in a mare cruiser, others not. But features included are a minimum:

- lobby
- grand staircase and/or atrium
- purser's office
- gift shop
- hair salon
- dining room(s) and snack counters
- bar
- lecture rooms
- performance theater/stage
- cinema
- communications/computer room
- gym/exercise room
- library/quiet room
- chapel/meditation room
- dance floor/lounge
- hot tub/massage room
- observation areas
- three or more classes/sizes of staterooms

Some of these functions can be adequately combined in dual purpose rooms. You get the idea.

### "Cruising" on Mars

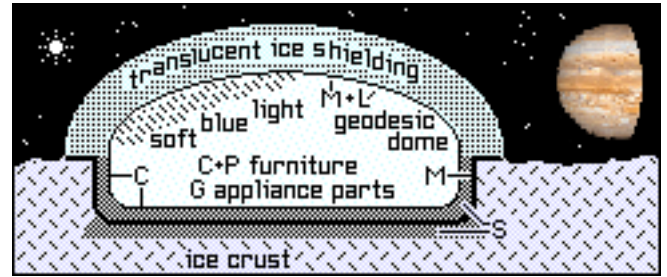
For those of you who want to translate the surface "cruise ship" concept to Mars, these differences in the conditions there may affect your design:

- Wind itself is not a problem
- dust storms sometimes last months
- best cruising areas:
  - northern plains (basin of ancient Boreal Ocean)
  - Hellas and Argyre impact basins to the south
  - Floor of Valles Marineris may be too rough
  - Rim of Valles Marineris may be too rough
  - Flanks of great volcanoes may be gentle enough
- ochie power plants (oxygen/methane) are ideal
- water vapor in exhaust through smoke stakes might produce a puffy cloud trail
- radiation protection is important on Mars to as the atmosphere is too thin to be of much help
- Earth-like day/night cycle applies
- Black light night cruises possible - no interfering Earthlight as on the Moon's nearside maria
- starting later, Mars population will eventually pass Moon's

As results come in to MMM, Copernicus Construction Company (presently down to the writer and Doug Armstrong) will see which ideas mesh and which don't. In brainstorming, one person's blind spot is frequently another person's bright zone. Do not be afraid to make whimsical allusion to pieces of the Earthside experience that would seem at first to have no lunar translation e.g. paddle wheel designs and smoke stacks, but do give them a real function!

And do write or email us about other glimpses of Old Earth for which you'd like to find a place on the brave new world of the Moon, or Mars, or elsewhere.

⚓ Keep in mind that **the ultimate sail is "to the Stars!"**  
Ad Astra! <MMM>



### European Pioneers "Living Off the Ice"? Why Not?

One of two "either/or" scenarios on Europa: (a) a robot probes find life in the ocean; (b) we do not find life. Either way we'll need a permanent outpost (a) to explore; or (b) to seed the ocean with Gaian stock. The recent discovery of salts on the ice gives us needed stuffs to support a "Live Off the Ice" effort. Sample habitat: Mg magnesium; L Lexan; G graphite; C nylon/resin composites; P plastics; S styrofoam. See below.

# EUROPA:

## "LIVING OFF THE ICE"

Galileo finds Brine Salts on Ice Surface  
Europa's Ocean Seems to be Carbonated

by Peter Kokh

We had previously suggested that Europa's ocean would be free of those salts common in Earth's oceans that derive from sedimentary erosion of the continents. We'd also predicted that carbon dioxide from ocean bottom volcanoes along with other soluble volcanic and hydrothermal vent exhalations would characterize the water. We even suggested (in an email letter) that CO<sub>2</sub> in excess of what could be dissolved would build up in pockets under the ice [cf. MMM # 110, NOV '97, pp. 1, 8-10] and could be the principal method of triggering fissures that would spew this special brine out onto the surface. Salts are left when the water evaporates.

### FIRST FINDINGS

In its extended Europa mission, Galileo, has now found two of these telltale salts on the ice crust with its Near Infrared Mapping Spectrometer (NIMS). Various compounds absorb and reflect sunlight differently, and thus leave distinctive signatures.

So far, the Galileo NIMS has detected the signatures of Natron [hydrous **sodium carbonate**] and Epsom salts [hydrated **magnesium sulfate**] traces in several dark line areas of Europa. Traces of these salts have been found at several dark line areas, indicating a global ocean that is fairly homogenized.

The hope that Europa's Ocean [we've suggested it be named "The Rhadamanthic" after Rhadamanthes, mythical son of Europa sired by Jupiter] might harbor life is stimulated by the relatively recent discovery of rich oases of ocean bottom life on Earth around the hydrothermal vents found along the ocean bottom volcanic ridges that cause ocean floor spreading



and continental drift. There has been no direct evidence of any kind that such theoretically possible vents are a feature of the sea bottom of the Rhadamanthic. But the presence of a saturation abundance of dissolved carbon dioxide (seltzer or soda water) makes this a very believable scenario, indeed hard to explain otherwise. And this makes the hope that we will find primeval life in the Rhadamanthic more realistic, less romantic. Detection of the signatures of nitrate and phosphates would turn this hope of finding life into a strong expectation.

The interaction of Jupiter's giant magnetic field with the deep salty global currents of the Rhadamanthic may also give rise to a magnetic field island around Europa that could moderate the harsh radioactive climate previously expected. It's strength is yet to be measured, and its existence confirmed.

### SEA SALT BONANZA?

Natron and Epsom Salts?!? Carbon, Sodium, Sulfur, Magnesium? What's that? This does not seem a lot upon which to base a "life-off-the-ice" effort at partial industrial self-sufficiency for a prospective human community engaged in continued exploration and research on this very fascinating world. Yet **these six elements** (not to forget hydrogen and oxygen in the water) form more of a "critical mass" of chemical feedstocks than one might suspect at first thought.

Moreover, these are just the first findings. Hopefully, we will find other elements present on Europa's surface in the form of evaporated sea salts.

### EARTH SEA SALT INGREDIENTS FOR COMPARISON

To whet our imaginations, here's the scoop on Terrestrial Seawater (based on salinity of 35g/kg):

Main Salts in Earth Seawater			
Cations	g/kg	Anions	g/kg
<b>Sodium</b>	10.76	Chloride	19.35
<b>Magnesium</b>	1.30	<b>Sulfate</b>	2.71
Calcium	0.41	<b>Carbonate</b>	0.14
Potassium	0.40	Bromide	0.07
Strontium	0.01	Boric acid	0.03
* <b>Bold</b> - also now found on Europa			

Some 3.5% of terrestrial seawater consists of dissolved substances in which 40 elements (other than hydrogen and oxygen) are represented. Of this, 82.86% is Sodium Chloride, NaCl, common table salt.

In the other 17.14% of seawater are sulfates, magnesium, bicarbonates (all detected on Europa), but also calcium, potassium, strontium, fluoride, boron, bromide, silicon, nitrogen and phosphorus. (underlined elements essential for life, along with many lesser micronutrients.)

We also find salts of the other engineering metals: iron, aluminum, titanium; these common alloy ingredients: zinc, copper, nickel, manganese, cobalt, vanadium, tin, chromium; these precious metals: gold, silver, lead; other halogens: iodine and barium; miscellaneous elements: mercury, bismuth, tungsten, antimony, thorium, beryllium, arsenic, uranium.

Can we expect to find all of these in European seawater? Hopefully some of them. Detection by Galileo or follow-on probes of the major nutrients vital for life as calcium, potassium, nitrogen, and phosphorus would be

encouraging. But on Earth, salts find their way into the ocean by two routes: erosion runoff from the continents, and submarine emissions from sea-bottom volcanoes and hydrothermal vents. Only the latter processes operate on Europa - *maybe*.

### PLANNING FUTURE EUROPA MISSIONS

Scientists are even now excitedly preoccupied brainstorming future missions to Europa that will:

- confirm the presence of a global ocean
- map the global topography of ice crust thickness
- penetrate the ice to sample the ocean directly
  - ocean currents
  - temperature gradients and flux
  - submarine hot spots and thermal plumes
  - salinity and chemical composition
  - signs of living organisms or building blocks

**We suggest prioritizing the orbital detection of evaporated brine salts** on Europa's ice surface - as this would give us three important things:

1. an earlier read on the likelihood of life in the ocean. *If we find nitrates and phosphates, the outlook for life will be greatly improved.*
2. a clear preview of the geological processes that have been operating on Europa's sea floor, like *volcanism and hydrothermal deep sea vents*, etc.
3. a more complete list, especially if we have some idea on relative abundances, of the *building blocks available for self-supporting industry* for a substantial human presence engaged in a much more thorough scientific exploration of European geology, oceanography, and biology.

It is a happy confluence that what those of us interested in expansion of the human envelope to Europa need to find to flesh out our brainstorm further, will also cast a brilliant first light on the questions most interesting to both the planetary geologists and the exo-biologists. A Europa Brine Salt Mapper (or mapping instrumentation on the first Europa orbiter) is a no-brainer win-win for all.

### GOING WITH WHAT WE KNOW NOW

What we have on the table already, thanks to Galileo's recent finds, gives us a situation similar to that awaiting those who would "Live Off The Clouds" in aerostats just below Venus' cloud deck. From the carbon dioxide (carbonates on Europa) we can make spun graphite products and, perhaps, Diamondite.

Add to the mix the hydrogen and oxygen from water (or water vapor) and sulfur, plus nitrogen, chlorine, and fluoroine (the last three, so far, only on Venus) and we have the building blocks for hydrocarbons and organic synthetics: **plastics (& fibers)**

- cellulose (rayon)
- polyester (and dacron)
- polypropylene (herculon, olefin fibers)
- polystyrene
- polysulfones
- urethanes and other urea (nitrate) derivatives
- polyamides (nylon and Kevlar™ fabrics)
- polycarbonate- Lexan™ windows, lenses
- resins for making nylon and olefin composites
- fuels like methane and propane
- solvents, and much more

And, on Venus at least, where we have found hydrochloric and hydrofluoric acid cloud droplets:

- vinyl, polyvinyl chloride (PVC pipe)
- Teflon™ abrasion/corrosion resistant coatings
- and more

Even if, on Europa, we do not find nitrates (that would kill the chances of finding life forms on Europa) or chlorine (despite the gigatonnage in our own oceans) or fluorine, that would still leaves a tidy repertoire of feedstocks for fuels and manufacturing plastics, fibers, resins and more.

If indeed the halide elements found in the Veneran clouds are not to be found in European brine salts, there is one big consolation. European pioneers will have a supply of at least one useful engineering metal: **magnesium**, and at least one potential ceramic: **magnesium oxide**. See the article below.

Get the chemical engineers busy and design minimal capital equipment (lowest shipping weight) factories to produce graphite, a variety of basic fuels, plastics, fibers, and resin-composites, as well as magnesium castings and sheet metal and magnesia ceramics. That would enable European pioneers to go a long way to meet their basic needs for shelter, furnishings, food production, transportation and recreation. *Sounds like a World Seed* to me.

If Galileo or follow up probes detect nitrogen, phosphorous, potassium, calcium, chlorine, fluorine - why then we can be really optimistic. Nor need we be rosy eyed to expect to find at least some of these.

#### ENTREPRENEURIAL “SPIN-UP” HOMEWORK

In the meantime, there is plenty of occasion and spin up entrepreneurial opportunity to experiment in stretching the applications of the above materials to cover uses ordinarily filled by other materials. On Earth we ordinarily concentrate on developing a new material just for those applications at which it will excel, or at least compete on price. Uses where a material will come in second best are rarely pursued. The result is that most materials are more versatile in potential application than we imagine. Has anyone experimented with fabricating items other than window panes and eye wear lenses out of Lexan™ polycarbonate? Has anyone tried to form curved shapes of the stuff by laminating thin flexible sheets? How far can graphite be pressed? When there are few metal alternatives, cost may not matter. The neglected homework list is long.

The essence of the frontier is a readiness to reinvent everything to meet an unfamiliar set of challenges with less than the usual list of resources - and finding a way to thrive anew - therein giving glory to whatever Creative Energies are responsible for our existence. Europa, and Venus are challenges we must accept, or we do ourselves and our creation less than full justice. It is a matter of being true to ourselves, hidden talents and all.

#### HOW DO WE DO WE HARVEST THIS BOUNTY?

Those elements we do find on the surface in the form of precipitated salts can be concentrated by bacterial cultures. “Bioprocessing” would use a number of bioengineered bacteria that concentrate available elements differentially grown in nutrient vat cultures, their bodies then harvested for a bene-

ficiated, concentrated product, or for life nutrients, added to the food supply in one form or another, either indirectly via hydroponic solutions, or directly as dietary supplements.

We are optimistic about detecting nitrate salt signatures, and guardedly so about phosphates, potassium salts, and calcium. We are even more guarded about chances of detecting dissolved silica, minute traces of which are efficiently absorbed by diatoms and sponges. Indeed, trying to grow such creatures may be the only way to both detect and harvest available silica. A source of Silica means true glass, concrete, ceramics, and more. Such early era experimental aquaculture will be a top priority in efforts at further industrial diversification.

To be kept in mind, of course, is that there is no providential logic that guarantees that elements will be available in abundances proportionate to the relative quantities *we would like to have*. That is why we have to go to the Moon for Helium-3, for example. It is why we have trade between nations and regions differently endowed. It is why those pioneers thrive who are resourceful enough to “make do” with what they find and who learn how to make happy substitutions, and why those pioneers fail who do not do so.

#### EUROPAN FRONTIER LIFESTYLES

Lets muse a bit about the lifestyles of the resourceful and industrious on Europa’s frontier.

##### More than a one town world!

- “New Woods Hole” in a thin but stable ice crust area at the site of the elevator exploration shaft to the ocean below - equipped with water-locks, of course
- “New Oceanside” station at the elevator terminus on the underside of the ice crust, possibly afloat in an honest-to-goodness-air-pressurized cave pocket excavated in the bottom of the ice crust handy to the shaft terminus.
- “Cornu Copia” situated in the midst of the richest brine salt evaporate fields in a dark line area, chief industrial settlement and population center
- “Europaport” at the most favorable site for arrivals and departures from Europa orbit and from elsewhere in the Jovian system and beyond
- “Jove View” Resort at a near limb Joveside local where Jupiter seems to hang just over the horizon
- “Funlands” Chaotic Terrain Excursion and entertainment escape area
- “Captain Nemo’s” submarine oceanographic exploration ship and forward base for teleoperated robotic deep submersibles.

##### Giving European landscapes the human touch:

Ice regeneration, melting rough ice and then allowing to refreeze flat and clear, perhaps under vapor escape retarding polyethylene film might be a useful side industry. One can imagine ice skating and ice dancing rinks, not just in the open vacuum but in pressurized shelters - or at least in man-made ice caves filled with diffracted blue light (those who have visited ice caves on Earth, such as the ones up Washington’s Mt. Ranier, will know what we mean!)

Man-made surface ice caves could also best house a growing ice sculpture collection. Since such sculptures would not melt, even were they to be exposed to full Europa-strength

sunlight, their production would invite more carefully cultivated skills and more serious talent, than that already respectable craft we see on display in our northern cities during winter festivals.

And why not European hockey? Again either in pressure suits under the stars or in bluelight ice caves, or indoors without air masks.

Regenerated snow could transform higher pressure ridges and ice fault scarps into ski hills, with magnesium ski jumps added for excitement.

Man-carved or molded ice “ramadas” would house tank farms for volatiles, warehouse various incoming goods awaiting delivery or manufactured items awaiting export, and in general for storage and routine “out-vac” tasks in a “lee” environment that shields from radiation and micrometeorite.

Ice tunnels could carry surface highways through pressure ridges. Roadway surfaces at the cryogenic temperatures out on Europa’s surface would not be as slippery, no thin layer of lubricating water molecules would develop. Just the reverse: the surface could be micro-ridged to improve traction.

Better yet, magnesium-rails could support hovering MagLev coaches also made of magnesium, whisking people and goods between settlements.

Someday, if abundance is no problem and public largess for the arts is high, we might even see man-sculpted magnesium “nunataks” (exposed mountain peaks) rising out of the ice sheet paralleling some tourist-trafficked MagLev route between major settlements. Those who have had the fortune to fly over southern Greenland will get the picture. These could be of thin sheet stock on this windless moon.

### **Pleasant cityscapes**

One can imagine Lexan™-thermopaned geodesic domes and vaults covering public spaces. Covered with transparent regenerated ice, they would offer radiation free softly blued sunlight - no need for sunglasses at this distance from the Sun where it shines with only a 25th the brilliance we are accustomed to in the Inner System “bright space” areas.

To avoid the china-syndrome-like problem of warm habitat structures inexorably melting their way into and through the ice crust, hard/soft styrofoam foundation sandwiches over smooth regenerated ice could provide an adequate thermal barrier. Whereon the Moon, regolith serves as both radiation and thermal shielding, on Europa this job might be left to ice and styrofoam or other foams respectively.

At least some waste heat from habitat space might be used to premelt brine crusted ice for use in the various processing industries

### **Change of scenery getaways**

The floating habitats in under-the-ice gas pockets that we first suggested in MMM #110, pp. 1 and 8-10, will be built as working outposts. But rooms and suites in a hotel module expansion unit would not likely go unrented. It would provide quite a change of scenery, even the chance to go outdoors with a medium weight jacket if the atmosphere pressurizing the pocket were a breathable oxygen/ nitrogen (or helium) mix. At such a complex, even swimming in the ocean itself would not be out of the question. But if you can’t swim, or tire easily, it will be a long way down to the ocean floor an estimated 100

km or 60 miles down!



As relatively smooth as Europa is - highest and lowest elevations do not differ by more than a thousand meters, 3,000 feet over the entire Africa-sized globe, there are areas where the ice is especially fractured and jumbled in a chaotic way. Such a terrain might not be the easiest place to put an amusement park - or an “Old Frontier” type movie set - but mix the possibilities with imagination and you get an explosive mix.

And somewhere, both on the Jove-facing side and the averted side will be places aplenty for private ice wilderness retreats, licensed retreat houses, even monasteries.

### **Fuels and Power for all this?**

As on Mars and Venus, the elements necessary to produce methane for combusting with bottled oxygen are there. This can take care of non-rail surface transport and other uses.

At Jupiter’s (i.e. Io’s, Europa’s, Ganymede’s, and Callisto’s) distance from the Sun solar power seems at first totally unrealistic. Some would tap the enormous power differentials in Jupiter’s radiation belts for power, but that seems a more far distant prospect than another more familiar energy scheme, which to my knowledge, been totally overlooked. It would not be without its engineering challenges.

We speak of OTEC (Ocean Thermal Energy Conversion), i.e. tapping the considerable heat differences between European surface industry waste-heated water reservoirs and cold ocean waters - through the ice - using magnesium heat exchanger pipes if necessary to dam the shaft to prevent catastrophic blowouts.

On Earth, at depths of approximately 1,000 m (3,300 ft) in certain areas of the ocean, such as the Gulf Stream, temperature differences of 15-22° C (27-40° F) exist. On Europa we are talking about a similar vertical distance scale and a similar, if not greater temperature range.

Warm surface water is drawn into an evaporator where, under low pressure, some of this water flashed into low-pressure steam and used in a steam turbine. Exhaust steam passes into a condenser, at a still lower pressure, and is condensed by cold water brought up from the ocean depths, producing power. Vast quantities of water must be handled, and the component parts of the plant must be very large. For a 100,000-kW plant, the pipe bringing up the cold water might have a diameter of 30 m (100 ft). Maintaining the structural integrity of such a large pipe against the ice pressures working to collapse it might be no small design challenge. It would help efficiency, at the expense of greater complexity of working parts, to use ammonia, isobutane, or propane as the working fluid to be boiled by the warm surface water in order to power the turbine.

We have yet to work the engineering bugs out of an

Earth-based OTEC system. Not a few have given up the challenge. But it will perhaps be the better part of a century before we are ready to add Europa to the list of human worlds. By then the economics of energy supply on Earth may have dictated that solutions to daunting engineering problems be found. The translation to a Europa system would then be easier.

Yet, while OTEC may be possible in theory, it would require a sizable installation that may be way too ambitious for a populace of a few thousands. Perhaps, even given the 25-fold diminution of the strength of sunshine at this distance out, solar power should not be dismissed. Everything else equal, that means that per design power output, a collector needs to be only five times larger side for side. Given improvements in efficiency and the use of concentrating mirrors, that should be no problem at all for surface based installations, as unworkable a solution it may be for weight-limited space craft in transit.

#### **Storing Day-generated power for nighttime usage**

Europa's day/night cycle is 3.55 standard Earth days (85.2 hours) long, the same as its orbital period around Jupiter with which it is rotationally locked (as are most natural satellites). This period is less than an eighth as long as the Moon's dayspan/nightspan cycle or sunth, and thus it will be that much easier to store up power for Europa's much briefer night period (42.6 hrs long). If fuel cells are used, it will be important to redesign them to use locally made components as much as possible.

#### **REALITY CHECKS**

Because the ions that are present in terrestrial seawater exist in minute amounts, more than 200 m (about 660 ft) of salt water must evaporate to precipitate mineral deposits 1 m (3 ft) thick. But on Earth the area of surface water available for evaporation has been relatively great. On Europa, such thick deposits are most unlikely as the total surface area of liquid water exposed to evaporation at one time on average has been comparatively minuscule.

Salt harvesting on Europa would entail mobile equipment roaming far afield from scattered primary processing stations. This should not discourage the scenario above. We are talking about some few thousands of pioneers at best, not hundreds of thousands as on the Moon, much less billions as on Earth

Just as important as industry will be food production and biosphere maintenance. Discovery of nitrate and phosphate salts will be encouraging. Not finding them will discourage any "Live Off the Ice" efforts. Calcium deposits on Earth are biogenic, that is derived from shells and bone of living creatures. If we find the signature of calcium that means it most likely that relatively advanced life forms evolved in the ocean. For industry, concrete could be possible *if* we find aluminosilicates too. Expect not!

Will we find meteorite strewn fields exposed on the glacial surface of Europa as we have in our own Antarctic? They could be a source of silicates and metals to round out local industry. Given the nature of the processes that have brought buried meteorites to the glacier surface and left them exposed on Earth, processes which certainly will have no counterpart on Europa, that is most unlikely. Most meteorites on Europa, if they migrate at all, are likely to work their way

through the ice to fall to the ocean floor.

Can the industries we outlined be realized on a scale small enough to serve that market? That is a question for the chemical engineers and low-capacity modular factory engineers to decide. What will it pay to produce on Europa from local chemical feedstocks given this small market? Could Europeans export any surplus products and value added manufactures to neighbor outposts on Ganymede and Callisto where such surface brine salts are much less likely? If so, the potential market becomes as large as the human population of the entire Jovian mini-system.

#### **"MUS/cle" FOR EUROPA & STOWAWAY IMPORTS**

Some parts of our scenario above will prove to be easier to implement than others. The nature of pioneering is learning to live with a different suite of resources than that to which one is accustomed.

On Earth we are used to having it all. On Europa, we will have to make do with a much smaller list. We will have had to do likewise on the Moon - only the lunar list and the European list are going to be quite radically different from one another. In both cases, the deficiencies will determine and color the local material culture, and set the stage for vigorous trade. Both the lunar and European frontiers will create demands that will inevitably open up new supply markets. Europa's needs will reinforce other reasons to establish human communities elsewhere in the Jovian system where needed materials are to be found. And where supply must be sought further afield, from the asteroids, from Mars, from the Moon, even from Earth itself, the economic equation will force three things:

1. special industrial design options to Earth-source only those components impossible to manufacture on Europa or on its sibling moons, designed to be easily mated to locally made components to make integral assembled items.
2. an interplanetary packaging materials industry that will make packaging containers, dividers, and fill out of scavengable elements scarce if not impossible to come by locally. Packaging for the Moon would be rich in simple hydrocarbon thermoplastics and/or press-aggregates of missing major and minor nutrients for food production. Packaging for Europa could include silicon, calcium, aluminum (glass, ceramics, concrete, alloys) as well as missing nutrients. Such carefully designed co-import packaging provides a relatively cheap "stow-away" option.
3. Filling missing needs creates entrepreneurial opportunities, increased life-style and career options, and keeps the Solarian human community in strong interactive contact

#### **CONCLUSION**

Here we sit on Earth, not yet returned to the Moon, farther than we'd like to be from launching the first human expedition to Mars. Yet we find ourselves talking about human futures on a much more distant if not less intriguing world - Europa. The ships that could take us there are not yet on the drawing boards - 3rd generation nuclear craft. We won't build the first generation prototype for some years to come. But dreams have power. After all, we are the "Ad Astra" people.

We dare dream of being star folk. And as Europa-like worlds may be far more common than Earth-like ones, learning what we can do on Europa is clearly on our critical path to the Stars!

We have sketched quite an ambitious picture of what it might be like to live on Europa someday, grounded on too small a number of chemical tidbits. It may read to some that we would attempt to make a meat and potatoes meal out of mere seasonings stuffs. But many a delicious meal has been conjured up by chefs of outcast populations from ingredients looked down upon as garbage by the have-it-alls. It is a matter of attitude. To adapt an old saying for inclusion in the Space Pioneer's Bible, "Attitude, if not everything, beats the hell out of whatever's second!"

Dream with us.

<MMM>

# MAGNESIUM - Mg<sup>+2</sup>

## WORKHORSE METAL FOR EUROPA

by Peter Kokh

### INTRODUCTION

Magnesium is the lightest of the engineering metals with a density of only 1.74 g/cm<sup>3</sup>. However, it is used as a structural metal in an alloyed form and most magnesium alloys have a density a bit higher.

Magnesium is a reactive metal and is usually found in nature as a carbonate or silicate oxide, often together with calcium. Because of its reactivity, production of the metal is very energy intensive.

World production of magnesium is small compared to the other structural metals such as steel and aluminium at only about 300,000 tons per year. Half of this is used directly in aluminium alloys to harden and strengthen them. [E.g. an aluminium can body has ~ 1.5% Mg, a cantop ~ 4.5% Mg.]

#### Properties of pure Mg (partial list)

Atomic number 12	Atomic weight 24.31
Color silvery gray	Density 1.74 g/cm
Melts at 650°C, 1202°F	Boils at 1103°C, 2017°F
Valence states Mg <sup>2+</sup>	

### ORES OF MAGNESIUM

Magnesium is the 6th most abundant element metal in Earth's crust, about 2.5% of its composition. However, its high chemical reactivity means that it is not found in the metallic state in nature.

Terrestrial sea water contains 0.13% Mg and some production facilities use this content for the production of the metal, after the precipitation of other sea salts to leave a magnesium-enriched brine. (Many known magnesium silicate minerals are pure enough to warrant processing to metallic magnesium.)

The annual tonnage of magnesium oxide or magnesia used to make refractory items far exceeds the annual production of magnesium metal.

### MAGNESIA & REFRACTORY PRODUCTS

Magnesia[MgO]-Carbon brick is resin-bonded with a high proportion of fused grain magnesite [MgCO<sub>3</sub>]. It is used as refractory brick [maintaining shape and composition at extreme high temperatures] in furnaces and in other hyperthermal situations. A range of qualities is available by varying proportions of fused grain magnesite.

On Europa, where other ceramic options may be unavailable, fused magnesia might "make do" "well enough" for many other construction and manufacturing uses. Magnesia could also be useful in making glass if we find silicon compounds anywhere on Europa (surface-accumulated meteorites?) But Europa-made polycarbonate (Lexan™) is a proven substitute for glass window panes and eye wear.

### SAND OR DIE CAST METAL COMPONENTS

This is the area of strongest demand growth for magnesium, particularly in automotive and aviation markets driven by the legislated need to meet fuel economy standards. The aluminum industry has been more successful at achieving this substitution, due in part both to the better corrosion resistance of aluminum and the wider familiarity with its use.

However, in recent years magnesium has been gaining popularity as the chemical purity of the alloys has been improved, resulting in a significant increase in corrosion resistance. The excellent castability of the common magnesium-aluminium alloys now sees use in large structural components such as seat frames, steering wheels, support brackets and instrument panels can now be successfully cast, often replacing complex multi-piece steel stampings.

If we cannot make such corrosion resistant alloys on Europa, magnesium products could be reserved for external use in unpressurized environments *or* in structural sandwiches, bonded between unreactive layers of magnesia ceramic or plastic.

Vapor deposition of magnesium (e.g. on surfaces of fused magnesia brick or ceramic) is one of the ways available magnesium on Europa could be stretched further in producing pressurized shelters.

### MAGNESIUM ALLOYS

Magnesium products are made of alloys. The addition of other elements can strengthen and harden the metal and/or alter its chemical reactivity.

The common magnesium alloys incorporate aluminum (3-9%), zinc (0.7-1%), and manganese (0.13-0.2%). Zirconium, silicon, and rare earth elements are also sometimes used. Of these, we might hold out the most hope for finding manganese in European sea water. Assuming that other common magnesium alloying ingredients are unavailable on Europa, more work needs to be done in magnesium metallurgy to come up with (a) serviceable alloy(s).

Magnesium alloy development is a strong area for research at this time, with a view to improving the corrosion resistance and high temperature creep resistance of castings. This ongoing R&D offers an ideal climate for exploration of other "make-do" uses of magnesium, to substitute "well-enough" if iron (steel) and aluminum prove unavailable on Europa.

The problem with increased use of magnesium on Earth is that demand for magnesium die cast components is

growing at about 15% per year and is scheduled to outstrip supply of available primary metal by the end of the decade. This keeps the price of magnesium metal high and is a disincentive for research and experimentation for additional uses.

**MAGNESIUM & FOOD PRODUCTION**

Magnesium is an important nutrient for living tissues. Now we have to hope we find phosphate and nitrate salts on Europa as well.

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# Europa: Facts of Interest

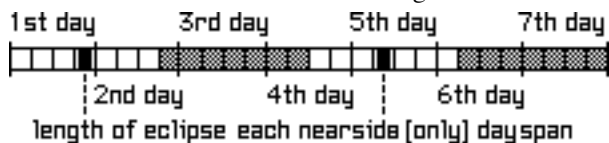
© and calculations by Peter Kokh, 1998

**SIZING UP EUROPA:** Europa is 3126 km (1942 mi) in diameter and its ice crust surface is 11.8 million square miles in area. That is some 81% of the Moon's surface, virtually the same area as Africa, and about 26% more surface than North America.

Europa contains lots of water and ice whereas the Moon is all rock and thus it is only 91% as dense as the Moon and has just 82% of the Moon's gravity level, or less than 1/7th (13.5%) the gravity of Earth. Anyone used to lunar gravity would be comfortable on Europa as well as on Io, Ganymede, Callisto, or Titan (111%, 87%, 75%, and 84% lunar gravity respectively) [\* To get the relative gravity, multiply the ratio in diameters by the ratio in densities].

**EUROPA WEATHER FORECAST:** Europa (& Jupiter) are on average 5.2 times Earth's distance from the Sun and so get only 1/27th as much light and heat from the Sun (inverse square of the distance). That's still more than 15,000 times as bright as the full moon on Earth - plenty of light to see what you are doing! The Sun would have an apparent diameter of only 6.1 minutes of arc compared to the 31.8 minute disk we see on Earth. The intensity of the light would be the same - there would be just less of it. Looking away from the Sun, you wouldn't need sunglasses. But helmet visors would still need to offer protection against glare. The surface temperature at noon is likely to be some 200° below zero Fahrenheit.

**EUROPA'S CALENDAR:** Europa orbits Jupiter once every 3.55 Earth days. By happy coincidence, two such periods are just over one week, 7.1 days or 7 d, 2 hr, 24 min. So if European pioneers wanted to keep the hour, minute, and second for the convenience of scientific calculation, they could use digital clocks which would reset after 24:20:34 h/m/s instead of 23:59:59. Each European clock day would be only 20 min. 34 sec. longer than the 24 hr standard we enjoy. The beauty of this is that no matter where one makes camp on Europa, every 7th clock day, the lighting phases repeat exactly (sunrise, noon, sunset, etc.). That'd make planning ahead a snap for the pioneers. To make this digital timing solution work, there'd be but one common time zone for the whole globe.



Typical weekly dayspan/nightspan lighting pattern. The day and night spans are each 42.6 hrs long.

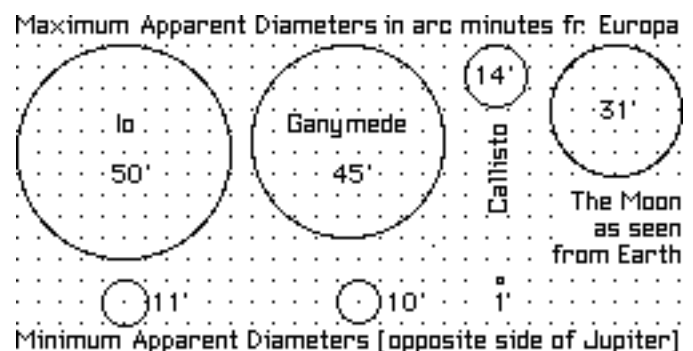
There would be 51.44 European Weeks (EW) to a standard Earth year, and 610 EW per Jovian year.

**EUROPA'S SKY SHOW:** The black airless skies of Europa host one of the most brilliant shows in the Solar System. But to take in the entire "Dance of the Worlds" one has to have a seat on the 50-yard line so to speak, i.e. along the Jovian nearside/farside limb. A polar perch (N or S) offers the best views, with all choreography at, and parallel to, the crisp horizon.

Europa orbits Jupiter at a distance of 671,000 km or 417,000 miles out (75% more than the Moon's average distance from Earth). But Jupiter is 11 times the diameter of Earth, so it will appear 6+ times as wide as Earth's 2° globe seen from the Moon. Jupiter will be a brilliant multihued ball in the sky some 12° across, filling 40 times as much sky as Full Earth from the Moon, 550 times as much sky as Full Moon from Earth. But at Europa's poles only its northern or southern hemisphere would be above the horizon.

For about 2 3/4 hours every 3.55 day orbit, Jupiter's bulk eclipses the Sun (as seen from Jovian nearside only) as Europa orbits swiftly through Jupiter's shadow cone at 30,750 mph (13.74 kps). The local dayspan time (morning, midday, afternoon, etc.) of the eclipses depends on the E-W longitude.

At their closest approach, Io (between Jupiter and Europa), Ganymede and Callisto (both to far side) present respectable disks with naked eye details.



While the Moon is always appears about the same size as seen from Earth, Europa's sibling moons revolve not about it, but about Jupiter, and that takes them to quite some distance when they are on the opposite side of Jupiter, as shown above. Of course, they will be eclipsed by Jupiter for short periods.

The best views of Jupiter and Io are 10° or more into the nearside from the limb and poles. And the best views of Ganymede and Callisto will be from at least a few degrees into farside. The limbs, and especially the poles, are the only and best points (respectively) to see them all, and the best points for a European Jovian System Observatory complex.

Closest approaches of Io to Europa occur every 3.53 days; of Ganymede to Europa every 7.04 days; of Callisto to Europa every 4.51 days. Their phases (new, crescent, half, full etc.) will vary. These "synodic periods" are the same as the intervals between launch/arrival windows to and from these sibling moons. The Jovian mini-system will be an interesting place to relocate!

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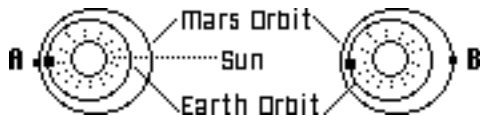
# Expanding the INTERNET to the Moon and Beyond

by Peter Kokh

Light travels at the speed of 186,292 mi/sec, or 300,000 km/sec. The Moon's distance from Earth varies between 221,456 and 252,711 miles. That means a 2.51 to 2.66 second time delay (not 3 secs) in electronic communications or teleoperation response. This lag is definitely noticeable for those engaged in radio conversation or at the end of a joystick controlling a surface rover, but with a little practice is easily tolerable. As this delay can be programmed into Earthside simulations, we can, and have been, experimenting with our proficiencies already, in anticipation of our return to the Moon.

This momentary delay would be even less noticeable for Moon-based personal browsing the Earth-based Internet, and would disappear altogether for fax and email transmissions, as for FTP requests and other postponable download - upload activities between Earth and Moon. For all practical electronic purposes, Earth and Moon are "the same location". It will be no problem all for lunar pioneers to participate on the Internet, i.e. for the Internet to expand to include servers and participants on the Moon.

## EARTH-MARS-EARTH & MARS-EARTH-MARS



A: 6+ minutes (375 sec.) at closest opposition or 145 times the average Earth-Moon delay (briefly every 17-18 years or so)

B: 44+ min. (2,667 sec.) at most distant conjunction or a 1000 times the average Earth-Moon delay

Mars may be as close as, or even closer than the Moon on the psychological threshold of pioneer dreams. Be that as it may, Mars is one "H" of a lot further away in light-time (and in travel time and rescue or resupply time) than the Moon. The latter is Earth's bonded "ribmate", traveling in orbit about the Sun with Earth. Mars is an "independent" planet with an orbit of its own that pays no particular homage to that of the Earth-Moon mini-system.

Live phone and radio and videophone communications between Earth and Mars would be awkward to the point of being intolerable and unworkable for even the most patient. While the Moon is "present" to Earth for conversational purposes, Mars is removed, absent, elsewhere and even "elsewhen", in its own "time well". The same will go for all other bodies in the Solar System, though a very few near Earth asteroids will come in close "conversational" range on very few rare and occasions for periods of a few days as much as a few decades apart.

All the same, there will be no problem for Earth <==> Mars email, faxes, and other one-way-at-a-time missives, including off-line download and FTP requests. A delay of a few minutes to less than an hour at worst in obtaining a non interactive reply will be quite acceptable. Indeed, much longer Earth <==> Europa and Earth < ==> Titan delays (62-103

minutes. and 133-175 minutes respectively) would be no problem either for these types of essentially one-way dispatches.

For unrestricted Internet access and World Wide Web browsing to work between Earth and Mars, embracing both, every domain server on Earth would have to have an updated echo on Mars, and vice versa. That is most unlikely to happen. At best, a "portfolio selection" of the most helpful, desirable, or most frequently requested terrestrial websites will be incorporated by echo into an essentially autonomous and insular Martian Internet. Various on-Mars servers could host and advertise different selections. Customers on Mars could request and lobby for additional echoes. Of course, a Martian pioneer could arrange *off-line* downloads from any Earth server without restriction. A Martian settler might well be online browsing through existing echo sites to hear a message "your download from Earth is completed".

Batch fetching requests could be arranged through commercial Mars servers. Special requests received could go then go into a public cache on a Public MarsWeb server to expand what is available online locally on Mars, the original requesters identity kept confidential.

## AT THE SACRIFICE OF PRIVACY?

Encryption notwithstanding, it'd seem that there'd be much more opportunity for eavesdropping and message interception by radio than by phone. But potentially more troublesome would be the opportunity for censorship that does not exist on Earth - as the online fare available on Mars will always be a "selection" of what is available on Earth-Moon. This virtual if unintended censorship would diminish in effect as the number of echo servers on Mars grows.

## STATIC, NOISE, GARBLED GRAPHICS & TEXT

Data sent over interplanetary distances is subject to electronic noise interference especially over years-long periods when the Sun is "active". Near-synchronous medley transmission repeats may eliminate most gaps. Total interruption during solar flare outposts is likely. Lack of an appreciable magnetosphere on Mars subjects all radio transmissions to interruptions and makes a hardened Mars global cable net an attractive enterprise priority.

In Contrast, echo servers will not be needed to spread the terrestrial Internet to the Moon. There will simply be one seamless Earth-Moon Internet. All that is needed is high speed, high volume lines via relay satellite available at low cost.

<MMM>

## Lighthouses & Beacons on the Moon and elsewhere in Space

by Peter Kokh

They can still be found here and there on Earth, old lighthouses, each distinctive, providing ships with navigational points of reference night and day, guarding harbor entrances and dangerous headlands along ocean and Great Lakes coastal regions. Fewer and fewer are in use these days, as reliance on GPS global positioning system units, becomes more and more

widespread and reliable for all aspects of maritime navigation. But lighthouses, each distinctive in their design, majestic and symbolic on their headlands or harbor jetties, have a romance and symbolism that persists and grabs at the onlooker.

### ASTEROID BEACONS & LIGHTHOUSES

In space, potentially troublesome pieces of solar flotsam, meandering astrobites, might be tagged with transponders, triggered by proximity sensors or upon being scanned (not gawking all the time when no traffic is around). Radio signals could be modulated to yield the identity of the body in barcode or some analogous fashion. If laser pulses are used, they might be in a color that stands out more easily from the starfield, like the red of the ruby laser.

One question is where to put them on a rotating body? Keep in mind, some of these astrochunks rotate or wobble on more than one axis! Convention might decree tagging the north pole of a body (the pole from which left gives the direction of rotation i.e. east). But that pole may be turned away from an approaching ship. An “equatorial” site, any one would do, would guarantee the signal would face anyone nearby at least half the time - these small bodies usually have short rotation periods of a few hours and one would be approaching them for days. To guarantee visibility/audibility at all times, more than one beacon would have to be used. This is a subject that deserves some discussion with the aim of coming up with the easiest, cheapest, most practical “tagging” method, and a solar-charged beacon that can be triggered when needed only. A few bodies might deserve permanent “always on” beacons.

### BEACONS & LIGHTHOUSES ON THE MOON & MARS

The surfaces of the Moon and Mars are very well known and detailed photographic atlases for both exist. No problem, it would seem. But remember that for nighttime approaches, these would be of little help. If there is going to be any steady and regular traffic to either body, Lunar and Martian Global Positioning Satellite networks would be a good idea. But why not a lighthouse or visual beacon to mark spaceport locations? Until the clusters of city lights that stud Earth’s planetary nightscapes have their counterpart on the Moon and Mars, such marker beacons would stand out quite clearly, and helpfully.

Sooner than some would think, on both worlds there will be a number of towns and outposts - not just one - and so there will be nighttime surface traffic. Rural areas in between will be extremely deserted, not like our own highways dotted with farm houses and gas stations and country stores and electrically lit billboards! We may see solar-charged mileage markers and junction signs. But why not a lighthouse on some elevated point along the approach to a Major (relatively speaking) settlement? Why not atop solitary mountain peaks or mountain crests when such spots are visible for many miles from all directions? Why not marking “straights” connecting the various lunar seas or maria, or the high flanks of passes through the highlands?

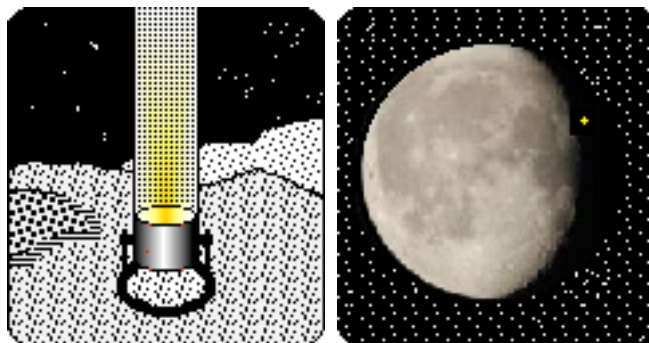
### THE LUNAR OVERTURE LIGHTHOUSE PROJECT

The role of the very first lighthouse on the Moon could be paramount. If it were established before humans returned to the Moon, on the fringe of the intended first Moonbase site, and easily visible to the naked eye of millions

on Earth, such a beacon would raise the “consciousness-level” about the pending integration of the Moon into the greater human world, like nothing else could. Hopefully it would increase expectation and garner political as well as monetary support.

Let’s say the Artemis Moonbase Project is finally about to in get off the drawing boards of dreamers. (That Congress would do a major policy turnaround and embrace a lunar beachhead initiative is the more science-fictiony of the two possibilities.) The Artemis folk are looking to the Mare Anguis site as a place to establish their first commercial Moonbase. (Mare Anguis is a small irregular shaped lunar maria off the NW coast of Mare Crisium, the Sea of Crises, and connected to it by an inlet - Artemis would rename the area “Angus Bay” to avoid the direct translation from the Latin, “Sea of Snakes” or “Serpents”.) A Lighthouse/Beacon at the entrance to Angus Bay off the Sea of Crises would be a publicity bonanza, stirring up anticipation and dollars in support of the bold project.

On page twelve, we play the gadfly and try to get such a project started. Brainstorming is fun, and cheap, and of the essence if anything is to become a reality. Those interested are welcome to participate with ideas and identification of challenges. <MMM>



## *The Angus Bay Lighthouse Steps in Making it a Reality*

by Peter Kokh

See the article “Lighthouses & Beacons” on page 11 of this issue. Putting such a Beacon on or near the proposed Artemis Moonbase site would be unbeatable publicity, make people aware that human return to the Moon is immanent, stir up the enthusiasm that will bring in money, resources, members, and talent, and create the ideal climate for Artemis Moonbase the Movie to be the box office success we need it to be. Here are some of the steps that will be needed to get such a project off the ground.

- An attitude that we *can* do it
- An email list-serve for those contributing ideas to the brainstorming of the project [ABLP]
- A web address where we can keep track of the Angus Bay Lighthouse Project as it takes shape.
- Determine how many lumens are needed (and the best color) to make the Beacon clearly visible to the naked eye

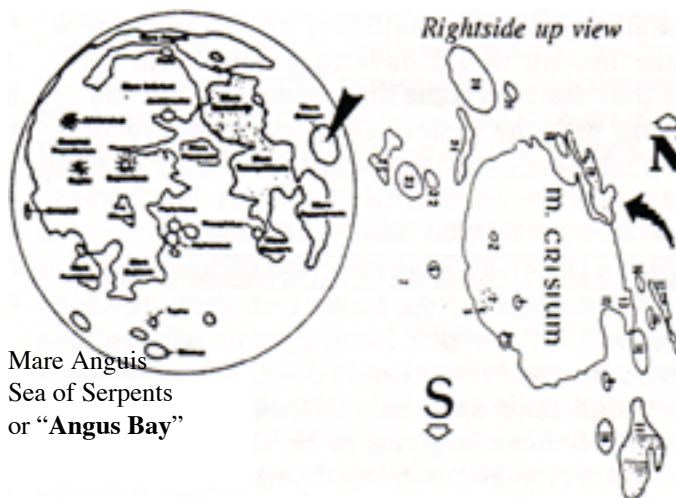


on Earth during local lunar night, as well as during total lunar eclipses.

- How close can we come to that candlepower with off-the-shelf commercially available equipment with minimum weight and low cost?
- Capacity to televise beacon installation in color
- Capacity to photograph moonscapes and take temperatures during eclipses for science.
- What else do we need that is off-the shelf?
- What is available as “military surplus”?
- Design a solar-power charging system for ABL
- What else needs to be designed, fabricated etc. from scratch?
- How much can we get donated “in-kind”?
- Possible piggyback moneymakers, their cost and weight penalties
  - Vanity electronic bulletin board on the Moon
  - Vanity phone relay
  - Morse code beacon advertising/messages
  - Various entertainment products
  - Beacon base to house memorial ashes
  - Beacon base to preserve signatures of donors
- Find cheapest way LEO to Angus Bay touchdown
- Look for possible piggyback ride to LEO
- Project Manager, local subassembly assistants
- Inauguration during a lunar eclipse visible from most of North America for maximum publicity

IF our collective brainstorming turns up no show-stoppers (other than money), then we propose this as a project by the Society. True, ASI does not *have* the funds for such a project, but just undertaking it will flush money out of the woodwork and out from under the mattresses. Diffidence squeaks, enthusiasm rolls in dough. Positive thinking can, negative thinking can't. Attitude is the most priceless commodity in the universe.

- Send early feedback to KokhMMM@aol.com



Mare Anguis  
Sea of Serpents  
or “Angus Bay”

**If you think you can't, you're right**  
**+ If you think you can, you're right**  
**=“attitude!, attitude!, attitude!”**

# LAKE VOSTOK

## Antarctic Europa Mission Training Camp

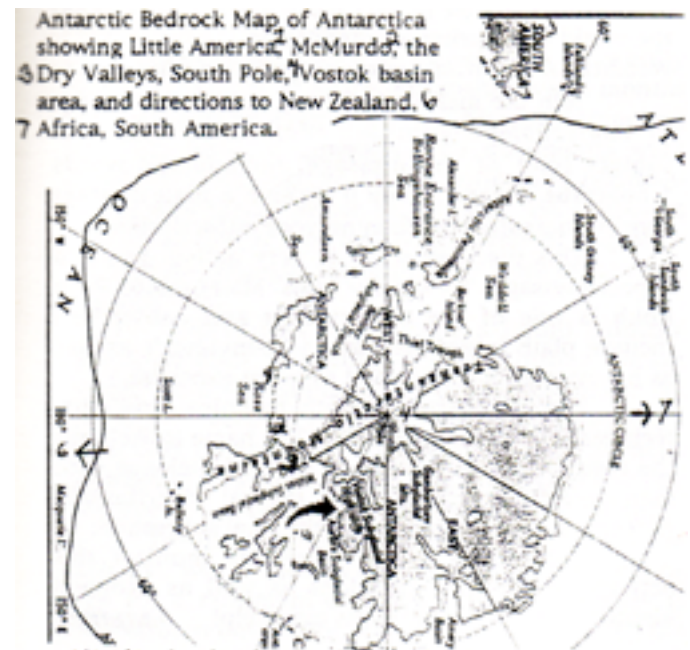
by Peter Kokh, from various sources

**Vostok Antarctic Station** (Russian), early 1996, at 78° S, 107° E [below Singapore], about 800 miles N of the South Pole and a similar distance W of McMurdo.

A three-nation team had been drilling into the ice here for ice-core samples when echo-sounders located a lake of liquid water another 300 meters [620 ft.] further down. The drill was stopped. At that point, they were 3,350 meters [11,040 ft.] down, and had retrieved ice cores 420,000 years old looking for data on the climate record of that time.

The lake's discovery came just in time to prevent possible catastrophic damage, giving an international scientific team time to work out how to examine the water without polluting it. The existence of the lake was confirmed in reports to the 20th Antarctic Treaty meeting in Utrecht in May '96.

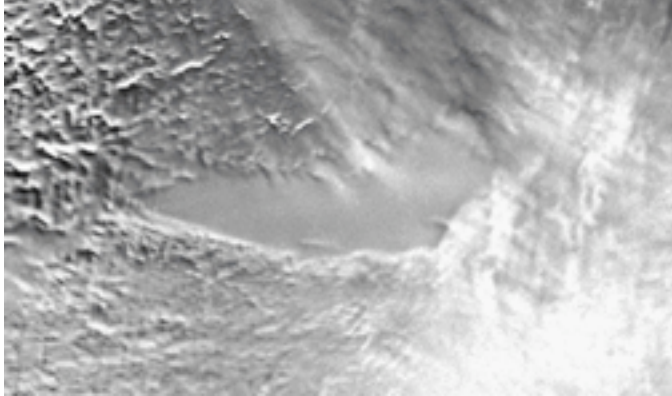
Called "Lake Vostok, the sub-glacial lake is covered by 3,700 meters [11,500 feet or 2.1 miles] of ice at the coldest spot on Earth, nearby the South Magnetic Pole, deep in the interior of Antarctica. It lies in a basin area 230 kilometers by 50 kilometers [143 mi. x 31 mi., *the size of Lake Ontario* ], averages 400 feet deep, with no air space between it and the ice above. It is the largest under-ice lake so far discovered. It may have lain undisturbed for at least 500,000 years. During all that time, any microbes and simple plants living in it would have been isolated from external biological and environmental contact. This is of considerable international interest.



It is not yet known how the water could lie unfrozen beneath such an ice mass. It may have been warmed by geothermal heat from below, or perhaps the ice pressure had formed the water.

Scientists have to figure out how to sample Lake

Vostok without contaminating it. Russia warned that random unprepared penetration of the lake could be catastrophic. Two scenarios to be avoided are (a) a blow-back that might send the pressurized water up the drill shaft like an oil strike, and (b) man-made materials, e.g. drilling fluid, spoiling the sampling of the lake. Fortunately, there are a several smaller sub-glacial lakes to experiment upon, so that scientists can be confident they know what they are doing when they penetrate into the biggest, and probably the oldest such lake.



The flat space in the ice betrays the shape of the lake deep below

Back to the present: an unprecedented expedition to search for ancient life in a lake deep beneath the ice sheet near Russia's Vostok research station, is being planned. A sterile probe ["cryobot"] will penetrate the more than two miles of ice that has sealed Lake Vostok since early in the era of hominid evolution. American, British, and Russian scientists will take extreme precautions to ensure that the drill doesn't contaminate the lake's pristine waters. Recent satellite data has helped to assess Lake Vostok's boundaries and chemical composition.

The drilling should be completed in about two years. Then a NASA-designed probe, the Hydrobot, released by the Cryobot drilling probe upon reaching the open water, will search the lake bed for any forms of life that may still survive in this dark, hostile environment. The pressure of the ice, and/or subterranean vents, may produce very warm conditions at that depth.

Scientists drilling deep under the oceans have discovered microbes that live off underground mineral deposits. And investigations of subterranean caves have found thriving communities of creatures that have survived thousands of years in isolation.

NASA hopes this activity will serve as a training ground for similar drilling experiments through the ice of Jupiter's moon Europa. A mission with a similar hydrobot could be undertaken within the next few decades to search for life beyond Earth.

That we should find the ideal place to simulant future missions to Europa in Antarctica should come as no surprise. Antarctica's unique Dry Valleys in Victoria Land, not far from the principal U.S. Antarctic complex at McMurdo Sound, offers the best available verisimilitude of conditions on Mars (extreme dry cold) for testing equipment and procedures for future robotic or manned missions to Mars. Without such ideally suited, and relatively handy, "Spring Training Camps", we would not be able to develop real confidence for future missions.

<M/M/M>

## Europa Orbiter Mission

As part of NASA's Outer Planets/Solar Probe Project, preliminary development has begun on a mission to send a spacecraft to Europa to measure the thickness of the surface ice and to detect an underlying liquid ocean if it exists. Using an instrument called a *radar sounder* to bounce radio waves through the ice, the Europa Orbiter sciencecraft would be able to detect an ice-water interface, perhaps as little as 1 km below the surface.

Other instruments would reveal details of the surface and interior processes. This mission would be a precursor mission to sending "hydrobots" or remote controlled submarines that could melt through the ice and explore the undersea realm.

Category 1A objectives are the minimum set of science investigations that would support an exploration mission. These objectives are determined by the international science community in the early planning stages of a mission. The Europa Orbiter Science Definition Team was formed in '98 to select Category 1A objectives. They are:

- Determine presence/absence of subsurface ocean.
- Characterize the three-dimensional distribution of subsurface liquid water and its overlying ice layers.
- Understand the formation of surface features, including sites of recent or current activity, and identify candidate landing sites for future lander missions.

## Europa Ocean Observer

### Science Objectives

- Verify presence of liquid layer
- Measure ice thickness and interior properties
- Image surface features

### Mission Description

- Delta II Launch
- Direct to Jupiter in 2.5 yr
- 10 Europa fly-bys in 1.0 year
- Possibly combined with Ganymede/Callisto fly-by S/C or Io Orbiter

### Measurement Strategy

- Radar sounding for ice thickness
- Tracking for gravity field
- Spectral imaging, angular resolution for global and local features
- Scatterometer by telecom for surface roughness

### Technologies

- Low Mass Propulsion
- Radiation tolerant components
- Efficient, lightweight solar power generation at Jupiter distance

# Europa Lander Network

## Technology

- High performance, low mass propulsion
- Radiation tolerant components
- Efficient, lightweight solar power generation at Jupiter distance
- Filtered seismometer for low S/N
- Miniature in-situ instruments

## Science Objectives

- Measure ice thickness
- Tomography of layers
- Chemical analysis of surface

## Mission Description

- Minimum of 3 landers through precursor mission could use just 1 for seismicity measurements
- Semi-hard landing with caging
- Some penetration of ice surface (for rad protection and seismic improvement)
- Precursor mission

## Measurement Strategy

- Seismic vibration from natural / induced collision
- Analysis of organics on surface (GCMS)

## Icepic: Europa Ocean Explorer



Icepic: the Europa Ocean Explorer Project is an effort to generate a design for a future mission to Europa. The probe's mission would explore the liquid water ocean that surface evidence suggests exists beneath Europa's surface. Larry Klaes' article in the April '98 issue of SpaceViews kicked off this effort.

The Europa Ice Penetrator Internet Committee (IcePIC), is organizing the project on a Web site and has a mailing list. These collaborative tools bring together project participants from around the world in a variety of disciplines.

Web: <http://occult.mit.edu/europa/team.html>

Join the mailing list: Send an e-mail message to [majordomo@occult.mit.edu](mailto:majordomo@occult.mit.edu). In the body (not subject line) of the message, include the words "**subscribe europa**". You'll receive a mail message shortly thereafter confirming your subscription.

This discussion list is very active. You can expect messages on a daily basis. MMM editor Peter Kokh is one of the participants and subscribers include plain interested wannabe-involveds as well as heavyweights with varied relevant expertise.

Discussion covers both technical and nontechnical questions and issues. The name IcePic was the result of about a week of spirited dialogue with many great suggestions from several contributors. Agreement was unanimous on the final suggestion. People at JPL and elsewhere monitor this activity for good suggestions as well as problem identification. Your two cents may help!

<MMM>

MMM #119 - OCT 1998

# BRAVING JUPITER'S RADIATION BELTS

## Callisto's Place in the Sun

by Peter Kokh

There would seem to be a major problem with the idea of planning human expeditions to Europa and the establishment of outposts there. Of the four great Galilean moons, only more distant Callisto lies safely beyond the reach of Jupiter's deadly radiation belts. This has led several writers to predict that humans would be able to land on Callisto alone, and not on Ganymede, Europa, or Io, all further in. The amount of protection we would need would be quite a bit greater than that routinely needed against cosmic rays and random solar flares in general. Extra shielding in the traditional form of water, cargo, lead or other mass would entail an unwelcome fuel penalty just to take it along for use inwards of Callisto. Electromagnetic shielding is an alternative that seems to us a long ways from coming off the drawing boards. Further, the apparatus to generate the needed field might be no less massive.

## CALLISTO JUNCTION

Here's our trial balloon work-around. Ships from Earth, Moon, Mars, or Ceres could pull into orbit around Callisto first, there to be "jacketed" with "extra" water derived from Callisto's surface. Thus the first Jovian System installations would have to be established on **Callisto** and in Callisto orbit. Let's call them **Callisto Springs** and **Callisto Junction** respectively. From Callisto orbit, radiation super-hardened ships would then proceed to any of the inner moons. They would need extra fuel for lugging around this extra shielding weight only for this last 3-6 day\* leg of the long journey from Earth, and for this they could also be refueled with liquid hydrogen and liquid oxygen produced from Callistan ice.

- \* 5.80 days Callisto to Ganymede
- 4.66 days Callisto to Europa
- 3.77 days Callisto to Io

[Trip times reflect not distance, but needed DeltaV]

The "jacket" to be filled with Callistan water could be an integral part of the ship, brought along from Earth empty i.e. uninflated - e.g. a Kevlar bag cradling the crew compartment and any sensitive cargo. Eventually, such jackets could be manufactured on Callisto itself, using local hydrogen, carbon, oxygen, and nitrogen to produce the Kevlar fabric.

Prior to this, it is conceivable that the position of getting Callistan water into Callisto orbit to a waiting transfer tank could be managed entirely by robotic means. This would make sense at the outset when traffic is just beginning and crewed ships from Earth are few and far between. The first crewed ship wouldn't leave the Inner System for Callisto Junction until a first precursor robotic mission had succeeded

in storing water there.

As usual, solve one problem and you create another. Getting to a parking orbit around Callisto without plunging into the radiation belt area to shed momentum via a close Jupiter flyby (recall the "ballute" used in skimming the upper reaches of Jupiter's atmosphere in Arthur C. Clarke's movie 2010) will be tricky. We welcome your suggestions.

### CALLISTO-EUROPA TRADE INTERDEPENDENCE

Callisto, too, has an ice crust, much thicker than Europa's and much dirtier with rocky material which means alumino-silicates, calcium, iron. Those things which a Europa colony (colony used here as a global complex of pioneer settlements) cannot produce for itself from the brine salts evaporated on its surface, a Callisto industry should be able to supply. Sourcing as much as possible within the Jovian system will be top priority, with all Jovian outposts striving for integral interdependence. The logistics of supply from Earth is simply too strained.

In exchange, Europa can supply Callisto with plastics, fibers, graphite items, magnesium products, Lexan, and fiber/resin composites, thus easing the burden on the Callistan settlements and allowing them to concentrate on glass, ceramics, alloys, etc.

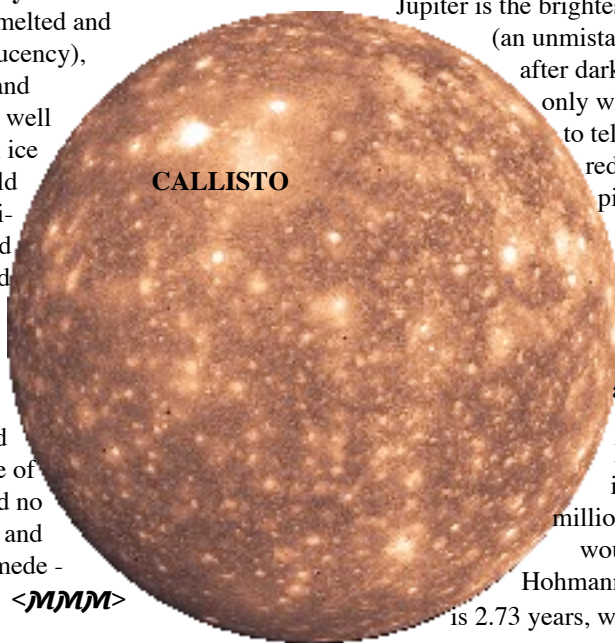
#### The dope on CALLISTO

Diameter: 4820 km (2996 mi., cf. Mercury, 3031 mi.)  
 Surface Area: 28,862,000 sq. mi. (cf. Africa + Asia)  
 (cf. twice Moon's surface of 14,657,000 sq. mi.)  
 Gravity: 12.3% of Earth's; 84% of Moon's  
 Distance from Jupiter: 1,884,000 km; 1,171,000 mi.  
 Jupiter's Apparent Diameter 2° (cf. Earth from Moon)  
 Orbital Period (Dayspan/Nightspan) 16.68 days  
 = 8.34 days of daylight, night each  
 Calendar Option: Weeks 8.34 d long divided into 8  
 calendar or clock days of 25 hrs. 1.2 min each  
 using digital watches that reset after 25:01:12  
 44 weeks or 22 periods = 367 day "Versaries"

### Meanwhile, on EUROPA's "hot" icy surface

Ice, probably regenerated (melted and then refrozen for fracture-free translucency), can be used to "canopy" highways and Maglev lines, providing shielding as well as the soft ambient blue light seen in ice caves on Earth. Regenerated ice could also be used to carapace surface vehicles individually. The clear ice would be used to shield geodesic domes and vaults made of Lexan thermopanels set in magnesium framing, to shield and brighten habitat spaces. No problem! Anything is threatening until dealing with it becomes second nature. That has been the experience of pioneers from time immemorial. And no doubt, we will find both the motives and the means to deal with life on Ganymede - and even sulfurous Io - as well.

<MMM>



# Backyard & Armchair Teletouring of the Jovian System

by Peter Kokh

[\* Moon Icon by Simon Rowland, ASI #286]

[Jupiter and satellite orbits to same scale]

### SEEING JUPITER'S GREAT MOONS FOR YOURSELF

To see **Io**, **Europa**, **Ganymede**, and **Callisto** with your very own eyes, all you need is a pair of good binoculars or a small telescope. They are easy to pick out - Galileo saw them right away when he aimed the first crude telescope at Jupiter in 1610, and the big four have been part of the "known universe" for 388 years now. Of course they look just like bright stars, too far away and too small to show "disks".

The current copy of either Sky & Telescope or Astronomy Magazines (at your library) will have the night by night positions relative to Jupiter of all 4 Galilean Satellite for the next month. (1= Io, 2= Europa, 3 = Ganymede, 4 = Callisto, J or O = Jupiter) e.g. 43210, 32014, 41032, 20143, lined up in a row with Jupiter's equatorial cloud belt (easy to see).

No scope? Visit your local astronomy club on its monthly public viewing night for a preview. This first sight of the Galilean moons may satisfy you. If not, join the club and use some of their instruments regular. Club members will be happy to help you decide what kind of first telescope to buy for using in your own backyard on your own schedule.

Jupiter is the brightest planet in the night sky after Venus (an unmistakably bright beacon visible only just after dark/just before dawn) & Mars (brighter only when near opposition and always easy to tell apart from Jupiter by its distinctive reddish orange color). Jupiter is easy to pick out from the field of stars as with its unblinking yellow-white light, it is far brighter than the brightest of them. (Note: It is also fairly easy to pick out Saturn with the naked eye, and its major moon Titan through a small scope.) Jupiter and its moons are 5.2 times as far from the Sun as Earth. Their closest distance from us is 366 million miles, the greatest 552 million. The lag in electronic conversation would vary between 33 and 49 minutes. Hohmann transfer orbit transit time to Jupiter is 2.73 years, with windows every 13.1 months. ###

## GOING BEYOND THE TELESCOPE & THE TABLES

To imagine yourself in your own personal rocket ship flitting to and fro between the Galilean moons, use these simple formula to determine launch window frequency, total transit times etc.

- **Surface Area** =  $4p(D/2)^2$  (square miles or km)
- **Gravity:** relative gravity = the ratio in diameters times the ratio in densities
- **Launch Window Frequency** (this is the same as the **Synodic Period**, the length of time it takes an inner body to lap or overtake an outer one):

in days =  $360/[360/PdI - 360/PdO]$

PdI is the orbital Period in days of the Inner body

PdO is the orbital Period in days of the Outer body

### Hohmann Transfer Orbit Trip Times:

Add the distances of the two bodies from Jupiter and divide by two = dh (distance [semi major axis] hohmann orbit). Plug this into the formula "distance ratio cubed = period ratio squared" [ $d^3 = p^2$ ]. In our example, add 671,000 km and 1,071,000 km = 1,742,000 km, and divide by 2 = 871,000 km, the semi major axis of the Hohmann transfer orbit between Ganymede and Europa. This is 1.298 times the distance from Jupiter of Europa. Cube that (=2.187) and take the square root (=1.479) to get the ratio of the Hohmann orbit period to Europa's period (3.55 days) = 5.25 days and take half of that because you are getting off when you get to your destination and not making a return trip or full orbit). The result, 2.625 days, is the hohmann transfer time between Ganymede and Europa. (cf. fast crude estimate of 2.8 days).

### BASIC TABLES FOR THE GALILEAN MOONS

KEY: Io = **I**, Europa = **II**, Ganymede = **III**, Callisto = **IV**  
**D** = diameter km [mi]; **d** = density (spec. grav. H<sub>2</sub>O = 1)  
**md** = mean distance fr. Jupiter 1,000 km [1,000 miles] {in terms of Jupiter radii}; **p** = orbital period in days; **E\*** = escape velocity km/sec; **O\*** = orbital velocity km/sec

	I	II	III	IV
D	3630	3126	5276	4820
[D]	2255	1942	3278	2996
d	3.55	3.04	1.95	1.8
md	422	671	1,071	1,884
[md]	262	417	675	1,171
{md}	5.914	9.404	15.01	26.05
p	1.77	3.55	7.16	16.68
E*	2.4	2.02	2.8	2.4
O*	1.69	1.46	1.98	1.63

### INTER-MOON SURFACE TO SURFACE DELTA V \*

km/sec	I	II	III	IV
I		5.7	8.1	9.4
II	5.7		5.7	6.8
III	8.1	5.7		5.7
IV	9.4	6.8	5.7	

[\*Pournelle]

# The "Maculas" of Europa

by Peter Kokh

A small number of "large round dark spots", including three larger than 20 km or 12 miles in diameter, show up on Voyager II and Galileo photos of Europa. Given their distinctiveness in admittedly exaggerated false color photo-maps, we've begun to name them, as is only natural, e.g. Tyre Macula, Thrace Macula, and Thera Macula.

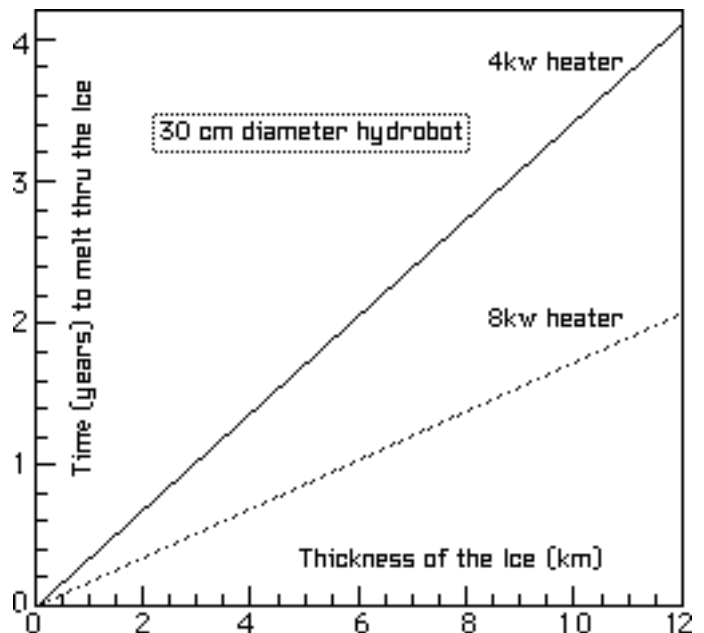
Our guess is that these features are relic impact points of sizable asteroids that have crashed through the ice crust, the dark deposits representing evaporated sea brine salts.

(1) these "Maculas" may be the richest "salt mining" or "brine harvesting" regions on Europa, with the thickest deposits. Promising sites for industry.

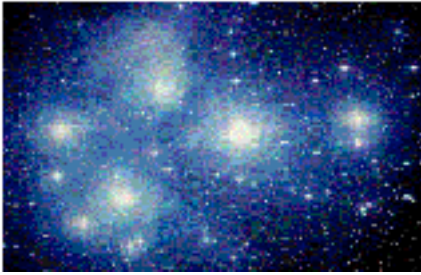
(2) if the impacting asteroids were rubble piles, they may have reassembled in rubble heaps on the ocean floor. But if impacting asteroids had sufficient integrity, their speed may have been slowed in the ocean enough for them to "sink" intact to the ocean bottom an estimated 100 km or 60 miles below. The angle of the asteroid impact would make little difference as the resistance of the ocean water would soon neutralize any residual lateral motion. The impact relics should be recognizable on the ocean floor directly below the Macula. Depending upon the makeup of the impacting body, they may constitute a future mineral resource

<MMM>

## How Long Will it Take to Melt Thru Europa's Ice Crust into its Ocean?



<http://www.phys.cmu.edu/~clark/icepic.html>  
 clark@ernest.phys.cmu.edu - Russel Clark



***The Pleiades:  
a nearby young  
star cluster.***

***Is the Sun  
a "Single Child"?  
Or does Earth  
have "Cousins?"***

SETI is the methodical search, generally of incoming radio noise, for signs of intelligent life - *anywhere out there!* This is one response to the question: "Are we alone?" But assuming that there *are* other "Earthlike" worlds and that technology-using intelligence *has* arisen elsewhere, there remains the question of affinities. Was our Sun born as the single child of a star-birthing nebula, or was/is it a part of some galactic cluster like the familiar 100 million year old Pleiades Cluster shown at right, some 415 light years away? See below.

### ***In Focus: Essence of the Frontier: "Readiness to Reinvent Everything"***

Commentary by Peter Kokh

Throughout human history, whenever groups of people endeavored to pioneer new territory, unoccupied or not, they have had to adjust to different conditions than those they were familiar with in their traditional homeland. When there was a choice of prospective new territories, they would, of course, naturally select those that seemed most similar to the one left behind, at least in those respects that mattered most. Steppe peoples favored other steps. River delta people, other river deltas. They would have to make some adjustments, but hopefully not wholesale ones. But nowhere could they expect to find a new home just like the old one in every way. Whether the stress was on finding a new life setting, or on getting out of the old one, except in the case of unwilling refugees, the movers were a group self-selected according to their willingness to start over, their acceptance of the need to "reinvent" many of the givens of daily life to fit the character and available assets of the new home.

Mineral resources, wildlife, vegetation, and climate all affect what the pioneers can make and the methods they might use. On hand manufacturing and craft stuffs will affect home and building styles and construction methods, furnishings, clothing. Sports, games and amusements, even cuisine, will show major or minor adjustment to the new realities.

Those who liked their lives as they were and were willing to change little, stayed behind. Those who left would naturally change as little as possible, but *were* willing to change and adapt and make do whenever, wherever necessary.

As we move into space locations, we are very unlikely to find any places reminiscent of Earth except in trivial ways (the Arizonesque scenery and similar day/night cycle of Mars). Those not ready to make major and wholesale adaptations will chicken out once they take off their rose-colored glasses. Sure,

we've all seen the very Earthlike concave landscapes painted by artist dreamers trying to sell the L5 vision. But if ever such places are built, it may be long after the youngest of us is dead that the extremely high economic thresholds involved are reached. Nearer term, whether on or under the lunar or Martian surface, or in the primitive shielded construction shack space settlements that we might be able to build in coming generations, the frontier's most Earthlike aspect will be ourselves, the plants and animals we bring along, and our characteristic "we can do it" attitude.

Those who find they have to leave behind too many "favorite things" and lack confidence that they can find/make satisfying substitute "favorite things" will choose to remain behind. Never has there been a frontier, or set of them, so challenging, so demanding of our readiness to reinvent everything. It is a task that daunts us, whether we'd go to the Moon, to Mars, to the asteroids, or pioneer the first crude space settlements. There will be a premium on adaptability and attitude. The tasks involved should frighten anyone taking a real look.

Yet there *are* ways to adapt, to do without, to make happy substitutions. There are ways to hone the rough edges off the early frontier. Taking a look at them, one by one, is just what MMM is all about. That is what the third "M" is all about. A brash, brazen **MANIFESTO** that shouts: "look, we *can* do it, and *these are some* of the things we might try to make ourselves 'at home' in our new setting."

If we remain displaced Earthers, we will have failed. We will need to redefine ourselves as fully settled-in Lunans, Martians, L5ers, asteroid 'Belters' and so on. We can only do this if we leave Earth behind in our psychological rear view mirrors, and forge unreserved new attachments to our new homes. We need a no-holds-barred readiness to reinvent everything. Sure, some material, cultural, and social aspects of our lives will translate readily enough. But others will require major changes, reinvention, replacement, or sublimation.

If the Frontier is a place where we are forced to start anew, it is also a place where we will have a chance to get in on the ground floor, a greater chance to play a significant life role, where we can leave behind the baggage of examples, customs, habits, and strictures accumulated on Earth. The space frontier will be a rugged place where the status quo, the way we do things, is *not* a given, but something to be created afresh with our input. And all this is a plus. It is this gain in the potential value and significance of our individual struggles that will make all the sacrifices worth while. It is this promise, the chance to start over when the old life has been found wanting or become unbearable, that has been the beacon, the siren, the beatific vision pulling many a person and family to pioneer in the past.

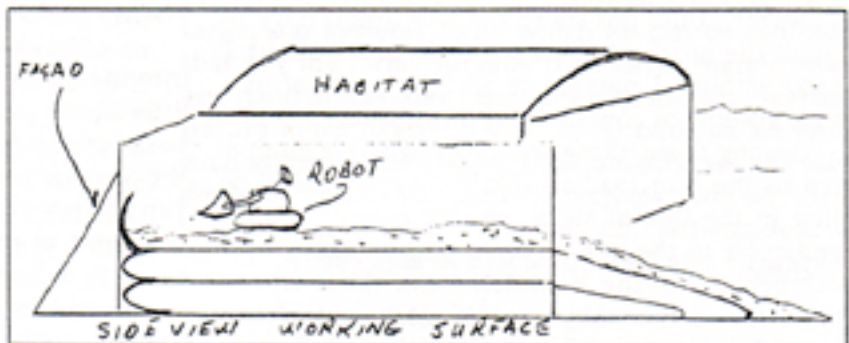
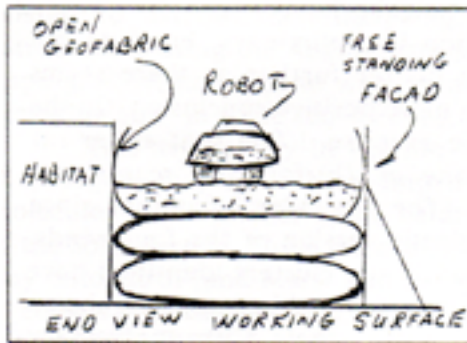
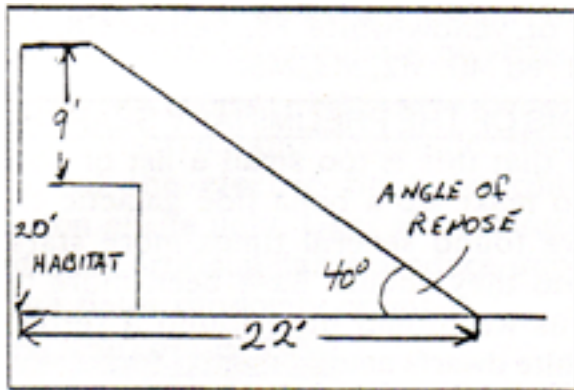
The deep logistical mutual quarantine of the various space frontier sites will offer unparalleled opportunity for social, political, cultural and religious experimentation without attrition to, and erosion by, a dominant and overwhelming mainstream culture. It is not only political, cultural and economic anarchists and utopians that will be drawn outwards, but many individuals with more concrete, more personal problems with their current life situations. The frontier will be an unparalleled scene of renaissance, creativity, fulfillment. **PK**

# CONSTRUCTING A VERTICAL SHIELD WALL

Ken Skinner, NSS member, <kmskinne@bechtel.com>

It is generally accepted that lunar regolith will be used to cover surface habitats and structures in order to provide shielding from solar radiation and ionized particles. As lunar development progresses, habitats may be built underground or in natural caverns such as lava tubes or covered rilles. Early habitats, however, will most probably be built on the surface until heavy construction and excavation equipment becomes available for more elaborate construction.

Simply covering surface structures with unconsolidated regolith has several disadvantages. To cover a structure 8 ft. high with three to four feet of regolith requires the toe of the regolith slope to start 13-14 feet from the side of the structure. This assumes an angle of repose of the regolith at approximately 40° (reference: *Lunar Sourcebook*). To cover a structure with a full 10 feet of regolith pushes the toe of the regolith cover away from the structure by another 8 feet. Working at angles of 40° is also problematic even in low gravity, so even lower constructed angles may need to be used extending the side slopes even further. This wide side slope of unconsolidated regolith cover is loose and therefore somewhat unstable (can not be walked on) and is a limiting factor on how close together separate structures can be erected, assuming that everything is not built all at once and then covered by a huge mound of regolith.



It has been proposed that sand bags be filled with regolith and then stacked to construct vertical walls. This can be done; however, there are several disadvantages to this approach. While teleoperated construction robots could be designed to fill sand bags, stacking them in a stable manner above about a meter is a more difficult task. Humans could perform the construction if the sand bags were filled and ready for use but this seems like a rather wasteful activity for very expensive manpower and may result in excessive exposure time to complete the task.

A construction method that has been used in the environmental business in landfill and road embankment construction could be employed to build vertical walls for habitat shielding. This method uses interleaved geofabric and unconsolidated soil (read regolith here) to break the angle of internal friction into thin lifts [steps] encased in the geofabric. The construction method is rather simple; a sheet of fabric is placed on the ground, a lift of regolith 1-1.5 feet thick is placed on the fabric, the fabric is then folded over the lift of regolith and heat welded or hot glued closed, sort of like wrapping a burrito.

Successive lifts are constructed in the same manner resulting in stacked pillows of fabric encasing the unconsolidated regolith. This method works because the fabric breaks the internal angle of friction into several small angles in each lift. The fabric must be only strong enough to hold the regolith in place for each successive lift.

On Earth large sheets of fabric generally 40-60 mil HDPE (high density polyethylene) are used and workers fold the fabric into place and heat weld the seams. A decorative façade is often placed along the vertical face for aesthetic value. In a teleconstruction mode, it may be beneficial to use a free standing façade and small sheets of fabric to wrap the individual lifts of regolith. The sides of the habitat and the free standing façade would hold the sheets upward while the regolith was placed, the fabric could then be folded down across the lift and welded or glued. An access ramp at one end of the wall could be extended as lifts were added and later cut-off and finished or extended as new habitats were constructed. Walls 5-10 m high and 3 m wide could easily be constructed using this method.

<KS>

*Always listen to experts.  
they'll tell you what can't be done and why.  
Then go do it.*

- Robert. A. Heinlein

*To remain relevant,  
any organization  
must keep reinventing itself.*

## The Sun may not have litter-mates

by Peter Kokh

In a previous article [MMM # 61, DEC '92, p. 7, "The Lost HELIADES Cluster: Does the sun have lost siblings? If so, does Earth-Gaia have Cousins?"] we discussed at length (full page) the likelihood that the Sun formed as part of a star cluster of sibling suns out of a common nebula. We dubbed this cluster the "Heliades" after "Helios", Greek for "the Sun".

We had suggested that since that time the Sun has made an estimated 18-23 trips around the core of the galaxy, so there was plenty of time for various members of the cluster to wander off to considerable distances. But dispersal may not be the typical case.

I have learned two very ancient galactic clusters, both billions of years older than the Sun (one is M67 in Cancer) that remain closely together in relatively compact neighborhoods. Rather, the problem is this: The bright stars that call our attention to such clusters in the sky are the hotter burning stars more massive than the Sun with relatively short lifetimes on the "main sequence" before burning up all their hydrogen to end up as inconspicuous white dwarfs (or neutron stars or black holes, if their residual mass is above a certain limit.)

If the Sun did indeed begin life 4.6 billion years ago as part of a new galactic cluster, only a few of the cluster's stars brighter and hotter than the Sun would still be around. B stars (very hot super-giants like Rigel), A type stars (like Vega or Sirius), and perhaps most of the "early" F spectrum stars would all have burned themselves out. All that would be left to shine with their adult brightness are mid to late F type yellow-white suns like Procyon, yellow G type suns like our own, Alpha Centauri A (Ixion), and Tau Ceti, cooler orange suns like Epsilon Eridani and Alpha Centauri B (Nephthele), and small cool red stars like Proxima Centauri and Wolf 359.

We are not saying that any of these familiar nearby stars belongs to our birth cluster, but name them only as examples of types of cluster stars that might still be around. All the brighter sibling stars would now be white dwarfs. What'd be left (visibly) of the cluster would not stand out. We would have to look at all the nearby known stars, there are about a thousand within 15 parsecs or 50 light years of us - an ample volume to contain a lurking cluster.

Among these, those showing negligible motion relative to the Sun (radial velocity approaching or receding in the line of sight, and/or proper motion perpendicular to the line of sight) will be candidates for membership in the Heliades. Next, those whose spectrum shows that they are definitely older than the Sun (like the Alpha Centauri pair) or definitely younger, would be excluded.

We personally do not have the means to look for relative age. But we do have the 1969 W. Gliese catalog of Nearby Stars which lists 915 stars with information on several characteristics including spectrum, radial velocity, and proper motion.

Radial velocities run from (near) 0 - 100 kps. Even at

1 kps, 1/300,000th of the speed of light, a star could wander 1 light year relative to the Sun in 300,000 years. That's 15,000 light years plus in the 4.6 eons since the Sun's birth. So we looked through the list for stars whose radial velocity was given as zero. We did not find many, just nineteen to be exact, within 50 plus light years, and none of these were white dwarfs. (Small clusters can have a hundred members, bigger ones a thousand.) Of the nineteen, a further examination will certainly exclude some (too high a proper motion, clearly too young or old, etc.)

To satisfy your curiosity, only ten of these have "names", the rest have just alphanumeric catalog designations (e.g. DM-46 5923; AC+31 70565 etc.).

### names, distance, and spectrum (hot to cool) are:

<i>Iota Centauri</i>	64 LY	white	A2 (too young)
Sigma Bootes	57	yl/wh	F2 (age limit?)
Beta Triangulum Aust	39	yl/wh	F2 (age limit?)
Eta Bootes	32	yellow	GO (like Sun)
Iota Bootes	39	yellow	G2 (like Sun)
36 Ophiuchi	18*	orange	K1
Delta Capricornis	38	red	M0
Beta Andromedae	72	red	M0
Wolf 1130	55	red	M3
Ross 555	37.0	red	M4

None are from the "familiar" litany of interesting solar neighbors. Only one\* is even fairly "close".

The remaining nine range from 11.5 - 80 L.Y., from the Sun, and have spectra (again, from hottest to coolest) of yellow-white F8, yellow G8, orange K0, K0, and red M0, M2, M3, M5.

### CONCLUSIONS OF THE PRELIMINARY SEARCH

I feel that this is too small a list of potential candidates to make up a bona fide galactic cluster. I should have found several times more stars at a minimum, and they should have been more tightly clustered. Plus we should have found a respectable number of white dwarfs among them (I found none, all the white dwarfs in the catalog list being temporary visitors to the Sun's neighborhood.

My conclusion is preliminary, but I do not intend to take the matter further as there seems little likelihood of a more positive conclusion. On the basis of this simple exercise, I feel that either (a) the Sun formed alone, or, (b) for some reason, the Sun's birth cluster (The "Heliades") has long since scattered to the galactic version of the four winds. Yet it is natural that all the clusters identified have remained intact. That proves nothing, anymore than a list of couples celebrating their 50th anniversary need include all those who married 50 years ago.

### WHY THIS SUDDENLY SEEMS IMPORTANT

In our earlier article, I had argued that even if, as I then felt likely, we have a number of "cousin" worlds out there, born of the same cluster, of the same age, and, some of them, also favorably sized and placed to host life, that:

this says *nothing* for the similarity or dissimilarity of any life forms that may have arisen out there to the kind of life forms we find on Earth - unless, of course, and this seemed to me unlikely, these cousin worlds were all "seeded" from some common source (if "seeded" at all).



Now, nearly six years after I wrote this, some have suggested that this is indeed “likely” to have occurred. The Sun’s birth cluster may have shared a condition that resulted in the seeding of all of its collapsing proto-solar system clouds together with one of two set-choices of life-precursor products.

We have known for 150 years that all life on Earth shares what would seem to be an arbitrary set of building blocks of proteins and nucleic acids: *left-handed amino acids and right-handed sugars* -- a mystery\* that has been without clues -- until now.

\* In 1848, Louis Pasteur discovered that some molecules can exist in two mirror image forms, right-handed or left handed. In living organisms, molecules tend to be all one form, not a mixture of both. Amino acids, the building blocks of protein, are always left-handed, sugars (including deoxy-ribose, an important component of DNA) always right-handed. But when synthesized in a laboratory, equal numbers of right and left are formed.

In 1930, scientists did discover a way to destroy molecules of one-handedness by using circularly polarized light. But when life began on Earth, there was no source of circularly polarized light.

Light is an electromagnetic wave consisting of oscillating electric and magnetic fields. The direction of the electric field determines the polarization of the light. Light sources such as the Sun and most artificial lights produce unpolarized light, with fields randomly oriented.

#### A SUDDEN BREAKTHROUGH

In a report “A Clue to the Origin of Life” posted to astro@lists.mindspring.com 7/31/98, astronomers using the Anglo-Australian Telescope in Epping, NSW, have found what would seem to be a “smoking gun” in some star-forming nebulas.

This asymmetry in the life building blocks, they argue, may have been imprinted in organic molecules in interstellar space before the formation of the Solar System. These molecules then found their way onto Earth (and Mars? and Europa?) via impacts of comets and meteorites to provide starting material for the origin of life.

Writing in Science, Dr Jeremy Bailey and his colleagues report that last year, scientists at Arizona State University discovered an excess of left-handed amino acids in the Murchison meteorite (which fell in 1969 near Murchison in Victoria, Australia and has since been found to contain an extraordinary variety of organic molecules.) This showed that the asymmetry already existed before life began on Earth, and must have been present in the material from which the Solar System formed.

Using the telescope at Siding Spring Mountain near Coonabarabran, New South Wales. Baily’s team detected circularly polarized light in a region of the Great Nebula in Orion called Orion Molecular Cloud 1 (OMC-1). It is known that new stars are being formed here, and that organic molecules are present. The region may be similar to that in which our own system formed. Circularly polarized light in such a region could imprint a preferred handedness on any organic molecules in a cloud beginning to collapse to form a

star with a retinue of planets.

Unfortunately thick dust clouds prohibit observations at the wavelengths of *ultraviolet* circularly polarized light. But Baily’s team made their observations at *infrared* wavelengths. The key is that their calculations showed that circular polarization must be present at all wavelengths, from infrared to ultraviolet.

#### SIGNIFICANCE

There may be two mirror image types of life forms in the universe, mutually indigestible. We are likely to find life forms out there certain to be of our own “orientation” or “persuasion”, *if we can detect* long lost sibling suns of the scattered *Heliades*. As to worlds around other stars, not Sun siblings, the odds of mutual digestibility are 50-50. Not of course, that we are interested in *us eating them*, but, ...

However, if the Sun has siblings, it is likely to be just a few, not a clusterfull. My scan of the data known about nearby stars would indicate that.

In some as yet unforeseeable future, we will hopefully have advanced far enough to begin the interstellar phase of the out-migration whose baby steps we are even now brainstorming. We will be far advanced beyond initial beachheads on the Moon, Mars, the asteroids, and space settlement oases. But even then, we are unlikely to have a handy list of target star systems about which we can be confident that any life forms sunning themselves therein share our handedness and (mutual!) digestibility. Instead, we are more likely to face 50-50 odds as we enter each system to be visited. Undoubtedly, we will have devised “protocols” and “directives” for all three possible situations: right-handed, left-handed, or devoid of life (thus available for seeding).

<MMM>

Further information:

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phone 61 2 9372 4823 - email: jab@aaoepp.aao.gov.au

## ABOUT GALACTIC CLUSTERS

by Peter Kokh [from several sources]

Galactic Clusters are younger (close to 10 billion years for the oldest, but most are *much* younger) than globular clusters. They are made up of stars built from material enriched in heavy elements transmuted by generations of stellar evolution, spewed into space in the debris of nova and supernova explosions. They contain up to **100 times the amount of heavy elements** found in globular clusters, and are thus said to be “metal-rich”.

[“Metal” in “metal-rich” in this astrophysical context refers to any element heavier than helium, including carbon, oxygen, and nitrogen and other elements *not chemically considered* metals. How metal-rich a star is can be detected in its spectrum. Stars less metal rich than the Sun are assumed to be older, and to have formed when the concentration of higher elements in the star-forming nebulas was lower. Older stars are likely to have planetary systems with less total iron and silicates. But that does not mean that they do not, or cannot, have terrestrial type planets at all.]

Galactic clusters are small, averaging only 15 light-years in radius. Most have *between 100 and 1,000 stellar members*. They're found principally close to the equatorial plane of the galaxy.

Familiar examples, all "young", between a few million to less than a billion years old, are:

- The **Hyades** with 200 stars 160 LY away
- The **Pleiades** or Seven Sisters has between 250 and 500 stars and is 490 light years from us
- The **Praesepe** or Beehive or M44 cluster
- The spectacular Double Cluster, **H & X** [Greek Chi] **Persei**
- Most of the **Big Dipper** stars belong to the closest such cluster yet identified with 80 members.



Even in a small telescope, these clusters are riveting sights never to be forgotten. **H & X Persei** tantalizes with its fantasy "a thousand points of light." [ ... and now you know the rest of the story!]

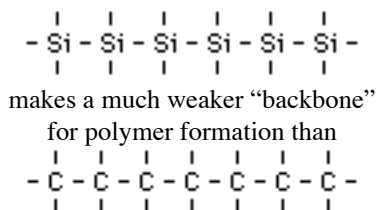
Most clusters have densities of several stars per cubic parsec (35 cu. LY). [A parsec is 3.26 light years and a convenient way to measure stellar distances determined by parallax angles.] In contrast, the solar neighborhood averages but one star per two cubic parsecs [our calculations]. Having a star like Alpha Centauri only 4.3 light years away is by that reckoning a bit of good luck.

The author is the proud owner of a beautiful painting by Illinois artist Ed Reck depicting an unusually close and rich star cluster rising over some planet's horizon, entitled "Skies of Another Religion", inspired by my remark to him that had we such skies on Earth, our nature religions would surely be warped by the seasonal sight. <MMM>

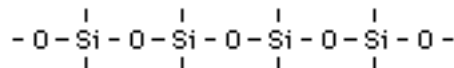
## ON LIFE "AS WE DON'T KNOW IT": AGAINST "SILICON-BASED LIFE FORMS"

[Cf. MMM # 65 MAY '93, p 4 "Silicone Alchemy" republished in MMMC #7]]

The hydrides of Silicon behave more like those of boron (with a +3 valence) than those of carbon. The two (Si, B) are similarly very reactive to oxygen, water, and halogens (chlorine, fluorine, etc.) Even in compounds where they each (Si, C) form only single bonds there is this significant difference: *silicon bonds poorly to itself as a basis for polymer building.*



On the other hand, deriving the "organic" backbone from silica sand instead of just silicon yields a backbone which is very durable under many conditions.



This is called the "Siloxane Bridge" and is the basis of the misnamed "silicone" chemistry ["siloxane" chemistry would have been more apt.]

The combined result of carbon's peerless ability to form double and triple bonds, and the need of silicon to incorporate oxygen into its polymer backbones is that truly parallel chemistries are not possible. Where we find analogous molecules with a Si for C substitution, they do not behave analogously.

*Now maybe in another unconnected universe* that may be real unto itself in its own time and space, nowhere and never with respect to our own, in which universe the mass ratio of the Proton and Electron is not what it is here, the resulting "siliconoid" in that universe may behave chemically like carbon does in our own, and it will be the "carbonoid" in that universe which comes up short. One can speculate freely, but without hope of empirical verification. It remains unlikely that any form of silicon-based life in our own universe, even computer chips, can ever give rise to as rich a variety of life forms and life processes as we see with carbon-based life all around us.

It is all right to admit our ignorance and to very humbling limits to our combined wisdom. Yet we should not sell short *what we have indeed found out* in physics and biophysics, chemistry and biochemistry. <MMM>

## Angus Bay Beacon Reader Feedback to Proposal

How dim can a light projected from Moon to Earth be & still be visible?

From Bill Bogen, Ann Arbor, MI  
<WBOGEN@EB-AA.MHS.compuserve.com>

From "The Physics of the Human Body": 1) The easiest light to see is green and has a wavelength of 510nm. 2) A flash duration of 0.1 sec or less is all the same to the eye, longer flashes need more total photons. 3) 90 photons will be seen 60% of the time.

Let us assume 1,000 photons entering a person's eyes will always be seen. Assume the flash is distributed over the entire hemisphere of the Earth facing the Moon at that instant. The area of the projected flash therefore =  $\pi \cdot (6,372 \text{ km})^2 = 1.28\text{E}14 \text{ m}^2$ . The area of the viewer's pupils (dark adjusted) =  $2 \cdot \pi \cdot (0.01\text{m})^2 = 6.3\text{E}-4\text{m}^2$  so the fraction of the photons entering his eyes =  $5\text{E}-18$ . To see 1,000 photons means the flash must contain  $2\text{E}20$  photons.

How much energy does it take to produce this much light? The energy of a photon ( $E$ ) =  $h \cdot f$ , where  $h$  = Planck's constant,  $6.6262\text{E}-34 \text{ J} \cdot \text{sec}$ , and  $f$  = frequency =  $c/\text{wavelength} = 3\text{E}8 \text{ m/sec} / 510\text{E}-9\text{m} = 5.9\text{E}14/\text{sec}$ . So each photon contains  $3.9\text{E}-19 \text{ Joules}$ , the entire flash of light carries 78 Joules of energy.





Just wanted to get a little note in here to say that I am continually amazed at the prolific and meaningful composition and editing that you do each month for us in the Moon Miners' Manifesto. I scarce can praise you enough for your conscientious work in that realm. I feel almost guilty to say please keep it up! I cannot imagine anyone else doing so well.

Anyway, I just wanted to offer a suggestion for future occasions when the issue of "outposts," whether permanent (per the NSS Mars Policy Statement of MMM #113 (p. 5, MAR 98) or otherwise. How about referring to all extraterrestrial locations of habitation (by two or more people?) as settlements? That conveys not only a sense of permanence but of expected growth and development. And that way you, too, can avoid the trap using the term "outpost" (ref. MMM Mars Policy Statement, "Continued work on a Rationale for a Positive Trade Balance . . . .", p. 5, MAR '98).

Yours truly,

**Curtis M. Wise**

#### EDITOR:

Thank you for your personal encouragement. MMM is both a labor of love and an extensive and structured monthly task that has given welcome rhythm to my life for eleven and a half years. I would be a lost drifter without it. I am only too aware of my limitations, and there may be many times where my speculations are way off the mark. However, if in saying something preposterous, I will have stimulated someone else to come closer to the truth or to find a more practical approach, my stumblings will have served a purpose.

I am very loathe to call something a settlement if it does not deserve the term. I *do* want settlements. But I think it is very important to call a "wooden nickel" a "wooden nickel". Lots of people will settle for human presences that are not genuine human communities.

In its startup phase, a future genuine human community will be, at minimum,

*a beachhead poised to grow, with the facilities to experiment and process and fabricate with on site materials, at which people are free to stay indefinitely, and at which personnel are allowed to establish relationships, at which pregnancies are allowed to happen, etc.*

To call something a settlement when it is only a scientific garrison would be to deliberately deceive ourselves and others. To call anything "permanent" but a settlement committed to permanence, no matter what is decided in board rooms, or cabinet rooms on Earth, is also self-deceiving hype. No matter what our intentions, until we have a genuine community determined to adopt the new turf as its "home" and stay, *come what may*, we do not have permanence. What we have is something that *can, and probably will be canceled or unfunded*, sooner or later. We don't need to be in the business

of establishing future ruins and ghost towns.

At [www.asi.org/mmm](http://www.asi.org/mmm) some back issues are archived. In MMM # 88 SEP '95 pp. 3-4, "Bursting Apollo's Envelope", I discussed these terms: base, camp, fort, habitat, hostel, outpost, station. I pointed out that what we needed was *none of the above*.

Instead I brought into consideration some new terms not usually used in such discussions: *beachhead, incubator, and interface*. I concluded that

*what we needed to concern ourselves with establishing can be described as "beachhead interfaces" places at which we can only scientifically explore a new world, but come to grips with how to live there on "its" terms,*

or "settlement incubators" = i.e. even if we start with a few people, *we go with the right tools and agenda to eventually metamorphose into the real thing.*

If we go to Mars on another "flags and footprints scientific picnic", then lie to ourselves and the public that we have opened Mars to settlement, we serve no purpose, and will deserve the post-Apollo repeat letdown that surely follow. "Those who do not learn from history, are condemned to repeat it."

We *must* open the Moon and Mars to settlement, thus it is crucial to make the *right* beginnings.

**Peter Kokh**

#### [Curtis Wise' response]

*While I'm inclined to agree that the right beginnings are important, I've also learned (or at least been told by people who know better than myself) that if you wait until everything is done to one's satisfaction (i.e., "done right"), then either it might never get done or no one will see the fruits of your labor and be able to build upon them.*

*(My own practical case had to do with the preparation of some significant updates to a project's documentation --- there was always some improvement that I felt could be made.)*

*Well, anyway, the point here is that maybe it wouldn't be so bad to take a chance on establishing a ghost town or two. I'm not advocating recklessness or inadequate planning, but we can't wait until ALL contingencies are anticipated. First off, we don't know which settlement/"beachhead interface" will fail, and even those that do can provide "lessons learned" and encouragement to others (meaning both people and other settlements) if those others are willing to pay attention and to learn. That's the way we (well, those of us who embrace living) survive and grow in the face of any adversity.*

EDITOR: As you point out, perfectionism is a vice, not a virtue. On the other hand,

*if you leave it all up to the bean counters,*

*I hope you understand that any mission will be sterile.*

There is an old maxim "aim high and hit the mark." Aim at the "satisfactory" and you guarantee that you will *not* be satisfied. Again, too many progress-starved space fans will eagerly settle for "anything that looks like progress". - PK.

