EXPANDING THE HUMAN ECONOMY THROUGH OFF-PLANET RESOURCES

MOON MINERS' MANIFESTO

MMM Classics
The First Ten Years

Year I: MMM #s 1-10
December 1986 - November 1987

ABOVE: *TerraLuxe* - a unique underground home in the Kettle Moraine Hills region 25 miles NW of Milwaukee, Wisconsin

A tour of this home in May 1985 sparked the "thinking outside the Molehill box" brainstorming that gave birth to MMM a year later.

Welcome to MMM Classics, Tome I

When one door closes, another opens. The Lunar Reclamation Society, publishers of Moon Miners' Manifesto, in an effort to control rising hardcopy printing and mailing costs, has decided to scrap its biannual Moon Miners' Review issues. But production and uploading of PDF files costs us, and our subscribers, and clients nothing. So *eureka! An opportunity!*

We have a limited number of back issue spare copies on hand, and these not for all issues. And there are still many issues not yet online in any form. Why not reedit & republish those articles that are not time-sensitive?

It seemed like a great idea. So here is the first "tome" with more to come every 6 months. Enjoy.

NOTE: We are using the *Andale Mono* font, closest to the original IBM Selectic *Elite*.

MMM Classic pdf files will be available online in two locations:

- www.lunar-reclamation.org/mmm/classics/
- www.moonsociety.org/members/mmm/

The latter location is only accessible by a current Moon Society member username and password. But the lunar-reclamation.org location is freely accessible by anyone.

For additional information about Moon Miners' Manifesto, please go to:

www.MoonMinersManifesto.org

You will need Adobe Acrobat Reader to read these files once you have downloaded them. This is a free download from www.adobe.com

Address all comments to the Editor, Peter Kokh, at kokhmmm@aol.com. Selected letters may be published in future tomes.

"M" IS FOR "MOLE"

by Peter Kokh < kokhmmm@aol.com >
MMM #1 - December, 1986

Forward: There follows the introductory and only essay article in the first issue of Moon Miners Manifesto, dated December 1986, shortly after the founding in Milwaukee of what was then the Milwaukee Lunar Reclamation Society L5, a chapter of the L5 Society advocating settlements in space after the inspiration of Gerard K. O'Neill.

This piece is about the historical roots of the inspiration behind MMM. Herein lies the personal "eureka" that gave birth to the brainstorming chain of thought that continues throughout many articles in MMM through the present. It explains the third "M", "the Manifesto". For while many readers refer to MMM simply as "Moon Miners", to Peter Kokh, the emphasis has always been on the third M. To Kokh, this newsletter has always been "The Manifesto".

"M" is for "mole", which is what many people, even some prominent space advocates, think settlers of the Moon are going to be. Yes, lunar habitats and facilities will be covered by some 2-4 meters (6-13 feet) of lunar soil or "regolith." But, while such a shielding overburden is necessary for long- term protection from cosmic rays, solar flare outbursts, and the sun's ultraviolet rays, this does not mean that we "moon miners" can't take the glory and warmth of sunshine down below with us!

A year ago this last Spring [May, 1985], in following up on an ad in *The Milwaukee Journal*'s Sunday Home Section, I went to see a marvelous place called "*TerraLuxe*" [“Earth Light”] in the Holy Hill area about twenty miles northwest of Milwaukee. Here, architect-builder Gerald Keller (appropriately, German for "cellar") had built a most unusual earth-sheltered or underground home.

Run-of-the-mill underground homes are covered by earth above and to the west, the north, and the east, while being open and exposed to the sun along the south through a long window wall. But Mr. Keller's large home (some 8,000 square feet) was totally underground except for the north-facing garage door. Yet the house was absolutely awash in sunlight, more so than any conventional above-ground house I had ever seen. Sunlight poured in through yard wide circular shafts spaced periodically through main room ceilings. These shafts were tiled with one inch wide mirror strips. Above on the surface, an angled cowl** [*see ** in Photo sidebox, next column*], also mirrored on the inside, followed the sun across the sky from sunup to sundown at the bidding of a computer program named "George" (undoubtedly of "let-George-do-it" fame).

And, even more amazingly, through an ingenious application of the periscope principle on the scale of picture windows, in every direction you could look straight ahead out onto the surrounding countryside, even though you were eight feet underground. I felt far less *shut in* than in my own Milwaukee bungalow.

TerraLuxe was built as an idea house and my tour cost $4. This home would make an ideal group field trip tour, but unfortunately, some visitor found it too irresistible, and it is now privately owned.

Of course, Mr. Keller's ingenious ideas to bring down below both sunshine and view, would have to be adapted to lunar building conditions. But I have no doubt that they could be. Mr. Keller told me that he had drawn up plans and blueprints for a whole city using his principles. Someday, I'd like to see them. If the streets and byways of his city were similarly built*** in a sun-drenched pressurized underground conduit, so one could leave one's lunar home and go anywhere throughout the settlement without putting on a spacesuit, why, it'd be better than living in the Milwaukee I love! - Peter Kokh, November, 1986. MMM

Photo of Exterior of *TerraLuxe*
[featured on the cover of this tome]

Photo taken the morning of October 15, 2002, more than 17 years later. Visible are the exterior panes of a trio of periscopic picture windows, and several modified skylights. The originals had mirrored cowls which followed the sun across the sky, resetting their position each night. More than eight feet of soil covers the home.

** There may have been subsequent problems with the "helostat" seals or the mechanical apparatus, or computer controls, as these sun-following mirrored hoods have long since been replaced by fixed bubble dome covers.

Location of TerraLuxe

MapQuest.com detail for 4631 Sonseeahray Drive, Hubertus (Washington County), WI puts the red star, indicating property location, towards the NW end of Sonseeahray Drive. It is actually located at the SE end of the drive, being the first property on the left as you enter off Hubertus Road.

*** table top model we produced for ISDC 1998

www.lunar-reclamation.org/page11.htm

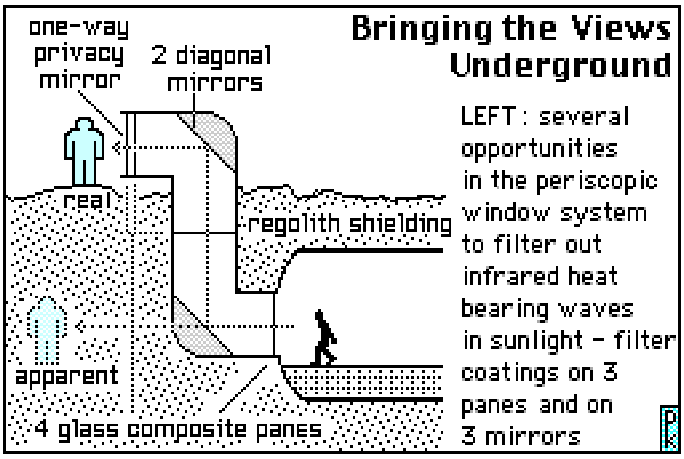
Diagram of model above at
www.lunar-reclamation.org/page11mm.htm

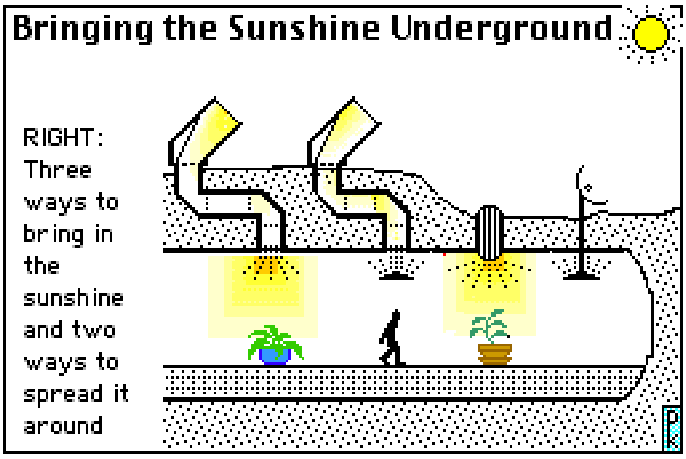
Moonbound: On March 11, 2004, "M" is for "Mole" wasw uploaded in pdf form to the TransOrbital ARCHIVE. If TrailBlazer 1 does fly, and eventually impacts the Moon, this archive is expected to survive.

For more information on TransOrbital, TrailBlazer 1, or the Archive project, visit:

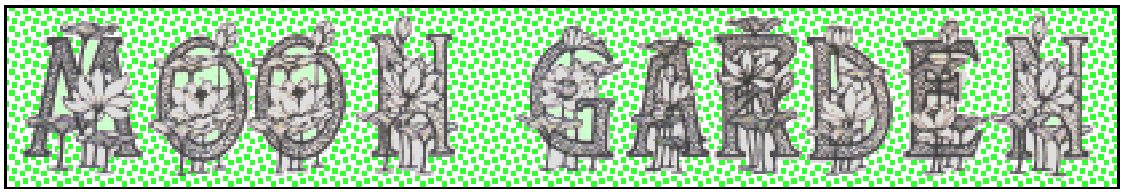
www.transorbital.net

This article is online at:
www.lunar-reclamation.org/mmm_1.htm





Moon Miners' Manifesto # 2 – February, 1987



MOON GARDEN

MMM #2 February 1987

[First of a series of articles on the need to predevelop the SOFTWARE of a Lunar Civilization]

by Peter Kokh < kokhmmm@aol.com >

Yes, the air and water of a Lunar settlement can be chemically recycled; and yes, the settlers can be fed synthetic foods so that it would not be strictly necessary to bring to the Moon any representatives of other living Earth species, plant or animal. However, most of us, I should hope, would hardly find this conducive to morale on a lifelong basis. And a settlement of colonists chosen for their indifference to the "real thing" could hardly be called a "human" one.

Whether we think of it or not, human beings cannot be divorced from the rest of Earth life amongst which we have evolved not only biologically and physiologically but culturally as well. True, many persons live in homes and apartments that seem almost antiseptic, but Nature is just outdoors. On the Moon there is no world of living nature just outdoors, and the colonists will most certainly feel compelled to go overboard in compensating for the Lunar sterility and barrenness by living in homes (i.e. not mere modules) that are lush with greenery, vivid with floral color, and sonorous with bird song.

Now the Lunar dayspan-nightspan cycle is twenty-nine and a half times as long as our day-night cycle; and this presents a problem for Lunar gardening. True, a solar power satellite at L1 or some other amply sized power unit (e.g. nuclear) might allow the colonists to cycle light and darkness to their gardens on an artificial twenty-four hour schedule. True again, colonists themselves will live and work on such a schedule and illuminate their homes accordingly. But on the one hand, it is foolish to assume that energy available will always allow such lavishly inefficient usage; on the other hand, once the beachhead base and its modules are outgrown and the first genuine Lunar homes are built on-site from building components produced from the lunar regolith, it is likely that these homes will have some sort of atrium floor plan centered around a solarium-garden flooded with sunlight captured by a heliostat and channeled perhaps along an indirect shielded route. (Bear in mind that glass, though not quartz, filters out ultraviolet). In such a garden, probably a combination of decorative and fruit and vegetable varieties, natural lunar cycling will be the ideal -- efficiently using available energy, and avoiding excess heat buildup. We are not ready.

Should NASA spend precious dollars needed elsewhere to pay some mercenary to develop Moon-hardy floral and vegetable varieties? NO! It is rather up to those of us who would go there or prepare the way for others to someday acculturate themselves to satisfying lunar living, to experiment at our own expense to discover the hardiest varieties now around vis-à-vis length of the day-night cycle and keep breeding them until we have a Burpees/Luna

Catalogue full of Moon-hardy varieties to grace Lunar homes and provide Lunar settlers with the same feeling of being cradled by Mother Nature -- despite the stark and harsh Lunar "outlocks" -- that we at home have grown up with here on our bounteous Earth.

Now finding plants that will thrive on fourteen and three quarters dates of continuous sunshine will surely be a lot easier than finding those that can shutdown, if you will, for an equal period of darkness, with the least need for punctuation by sessions under grow lights. But the closer we approach the ideal of natural Lunar cycling, the more efficiently will the colony be able to use available energy, and the more autonomously would the gardens maintain themselves. All of this holds true of the Lunar farms that will raise the major crops and staples as well.

Ideal will be the crops that can germinate and sprout in the warm, moist darkness and then sprint to maturity during the two week period during which they will receive more than a month's worth of sunshine by Earth standards. Next in desirability will be crops that mature by the end of the second sun-flooded period.

On Earth, garden flowers fall into two broad categories: annuals which bloom all season but have to be replanted every year, and perennials which bloom briefly but come back of themselves year after year. On the moon, the breeding ideal will be the plant that blooms every sun period or perhaps every other, and coasts through the sunless period without dying back.

It will take years of breeding work by many experimenters to develop the kind of Moon-hardy plants we have briefly described. But it is a work that, at least in its beginning stages, can be done by knowledgeable laymen. Creation of artificial Lunar-like growing cycles indoors is a simple matter and does not require expensive high-tech methods. Time well spent is the key.

So you see, even if the Congress weretoday to provide NASA and Space Studies Insti-tute [SSI] chemists and engineers with all the funding they could possibly use so that hard-ware for a return to the Moon were ready in five years, the effort would be doomed to failure. For it will take a lot more than hardware and chemical engineering to make a Moon settlement a success. There is so much more to human civilization than that.

The work necessary to predevelop an ample repertoire of suitable plants will continue to be neglected unless it is done by such as us in the heretofore cheering section. We commoners must roll up our sleeves. If fans of the space movement remain just that, content to send in donations, write their congressmen, and make phone calls, nothing will be accomplished. We must not be lulled into believing that this is the most we can contribute to the realization of our dream of the extension of the the human realm beyond the traditional range of the Earth's surface.

Nor is this the only area in which there is a critical need to predevelop Lunar "software" -- where we cannot "wait until we get there." In future articles I will talk about other areas in which people outside NASA and the aerospace contractors can find ample room to contribute to the successful flourishing of a Lunar civilization.

Meanwhile those of you guys and gals who fancy yourselves possessing a green thumb, take this as a call to arms. If enough of us were to get off our duffs and do Lunar homework in this and other needed areas it might be possible to network our efforts through some such vehicle as "The Mother Moon News". Why not? TMMN

To learn more about the MiSST and LUNAX experimental lunar agriculture efforts that followed this call to arms in the early 1990s, go to

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

The above article is online at:

www.asi.org/adb/06/09/03/02/002/moongarden.html

Essays in "M":

Man in the Moon; Market; Metropolis

by Peter Kokh < kokhmmm@aol.com >

M IS FOR MAN-IN-THE-MOON:

Man-in-the-Moon my foot! Looks to me more like a fetus in the Moon, the fetus of the human civilization that could arise and flourish there, given the development and utilization of our present capacities and lots of dedicated non-mercenary hard work. Other-wise, the fetus-in-the-Moon will surely be stillborn, or worse, aborted. And then we will have the Ghost-in-the-Moon.

M IS FOR MARKET:

The customary "prospectus" for the Moon is that it will be a major, or the major, supplier of liquid oxygen to low Earth orbit depots and of raw ores to L5 colonies or "Space Settlements" where it will be turned into metal alloy components of more space colonies and solar power satellites, the slag left over being used for shielding. Really, this depends on where people actually choose to live, how big the lunar settlement becomes, and whether it chooses to deliver low value raw materials or higher price value-added processed materials and / or finished goods. The assumption that the great bulk of manufacturing will be done at L5 rather than on the Moon on the grounds that humans cannot tolerate 1/6th G for long is an untested, unproven, unwarranted, and gratuitous opinion. There is enough room, enough of a market, and enough volunteers for both kinds of settlements. The rivalry between L5 colonies and the Moon will be both healthy and productive.

LUNOX Corporation, selling liquid oxygen to the various low Earth orbit (LEO) space stations and staging depots, probably in exchange for equal volumes of liquid hydrogen (nitrogen, ammonia, methane will also be needed) may well be the Moon's first employer. But current writing shows lack of imagination. Raw materials from the Moon can be processed into many things that can be sold and delivered to LEO at great cost advantage, e.g. modules and trusses of the space station itself, windows

and glassware, ceramic table ware, fiberglass insulation and fabrics, tools and instruments, some furniture items, and so on. And all of these items will find a market in GEO (Earth synchronous orbit) and L5 as well. LUNOX will supply oxygen not only as fuel oxidizer but as the major component of water and the breathable component of air. Even food items grown on the Moon with "upported" hydrogen, carbon, and nitrogen are still about 50% lunar oxygen and can be delivered to LEO, GEO, and L5 more cheaply from the Moon than from the Earth.

Even the heavy parts of satellites might better be made on the Moon to be mated with the lighter "works" in an LEO or L1 station. The hulls for ships to take men to Mars might better be made on the Moon, and on and on and on. The day may come when competition from the Moon restricts Earth-bound aerospace giants to producing high value light weight components that require materials that are not abundant on the Moon, e.g. copper, gold, platinum, silver, tin, niobium, hydrocarbon plastics, etc.

Yes, the markets are there, and the Moon can pay its way!

M IS FOR METROPOLIS:

It has been estimated that it takes a community of about 250,000 minimum to provide all the various goods and services in a diversified economy to be substantially independent of imports. When anyone speaks of their belief that a Lunar or Martian settlement of a few hundred persons can be autonomous, they are either being naive or are defining autonomy loosely. Such a small settlement might achieve 50-60% self-sufficiency, but a metropolis of a quarter million could be 95% self-sufficient. No wooden nickels, please! Let's go for broke or quit kidding ourselves. MMM

The above essay is online at:

www.asi.org/adb/06/09/03/02/002/moonessay.html

Moon Miners' Manifesto # 3 – March, 1987

ESSAYS IN "M":

Mare, Maria; Multiple Sites; Mounds

by Peter Kokh < kokhmmm@aol.com >

M is for MARE , PL. MARIA (MAH-ray, MAH-ri-a)

The large dark areas on the Moon, the so-called Lunar Seas, formed three to four billion years ago when most of the large impact basis filled with layers of a very low viscosity lava and cooled. Some such basins on the Farside of the Moon did not fill with lava and are called "Thassaloids" (from the Greek word for sea).

While an initial Lunar Base might be built just about anywhere, once more extensive settlements are built, the maria are clearly preferable. The regolith, the loose surface material, composed of rock fragments and soil, which overlies consolidated bedrock, has a very variable thickness in the highlands, from zero to 30 meters. On the mare, however, the regolith has a more uniform depth of about 10 meters, which makes construction easier. While Lunar concrete relying on calcium rich highland soil and upported hydrogen will be a lot cheaper for initial base construction than prebuilt modules brought from Earth, once a lot of construction is planned, even that method will be too costly. The only way to go is site-extrusion, building the structures from the fused soil on the site itself. Mare soils melt 200C (360F) lower than highland soils and so will require significantly less energy either in fusing rammed soil or in making panels of cast basalt. The melt's lower viscosity will also help in some applications.

The levelness of the mare surface will also be an asset to laying out any extensive settlement. And importantly, the average atomic number and weight of mare soils, as compared to highland soils, makes them preferable for shielding against cosmic rays, etc.

But the best mare sites will be just "offshore" so to speak, so that highland soil, richer in aluminum and calcium, will also be available for manufacturing and processing. Finally, such a site will offer more scenic and recreational interest.

[Subsequent articles in later issues of MMM call for "coastal" sites, in the spirit of this last paragraph.]

M IS FOR MULTIPLE SITES:

One settlement a world does not make! Of course one must start with a single site, and it will be able to serve most of the initial needs. But no site has all the assets. Soils differ not only from highland (or terrae) to mare but also from mare to mare and even within a given mare. Different materials are available to the prospective processor or miner at such sites as crater and rille walls, the central peaks of some large craters, and the so-called dark mantle deposits.

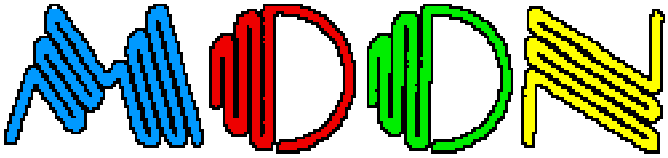
Some polar areas might have permashade fields of frozen volatiles like ice and carbon oxides. Some sites will be especially scenic. Locations along the limb between nearside and farside "librate": the Earth will alternately be just above and just below the horizon -- anyone want to build the first Lunar Honeymoon Resort? An observatory dedicated to the Great Andromeda Galaxy, M31, could be built in the north, while a similar installation in the south could concentrate on the Magellanic Clouds. Farside would be best for observation of the Milky Way and for giant radio telescopes and SETI searches, etc.

M IS FOR MOUNDS:

The first impression anyone will have of a Lunar Settlement will be that of a complex of mounds, the two-four meter (six-thirteen foot) overburden of Lunar soil used as thermal insulation and cosmic ray shielding. The downward

pressure of this much lunar soil per square inch is much less than the upward pressure of the air inside the habitat. So this blanket of soil does not present a stress upon the habitat(s). You can look at this blanket of dust as an analog of the blanket of air which protects us on Earth from the same hazards. In fact, if you could freeze out Earth's atmosphere, it would provide a light snowy blanket about 15 feet thick. MMM.

The above essay is online at:
www.asi.org/adb/06/09/03/02/003/mare-essay.html



Moon Mall

[The second in a series of articles on the need to predevelop the SOFTWARE for a Lunar Civilization]

by Peter Kokh < kokhmmm@aol.com >

I remember as a young man too many years ago [1955] my first time in Hudson Bay Company (yes, the original Canadian Trading Co.) department store in Calgary Alberta. How impressed I was by the great variety of goods imported from all over the British Commonwealth -- an abundance of choices unsuspected by the shopper in Milwaukee's Gimbel's or Schuster's of that era. Things are different now. Today's shopper in any mall in America is confronted with a bewildering variety of offerings from all over the world. No one is limited to the goods and services made in his own city or town. Indeed, to be so limited, even in a great world class city like Chicago, New York, or Montreal, would be quite a come down.

How will it be for the shopper in a lunar or Martian mall the first few decades? The settlements will be small, though growing, and "upports" from Earth's gravity well will be prohibitively expensive. Almost certainly and without exception, they will be restricted to items, and even to mere components of items, that are both indispensable on the new worlds and as yet impossible to manufacture locally. For everything else, the settlers must be willing to make do with local resources and materials as best they can. No one ever said pioneering would be easy. The frontier may be exciting, but like frontiers from time immemorial, it will of necessity have its rough edges.

Will this mean one style, one color only of dishes, for example? One model, one color only for radios, stereos, and television sets? Only one style and color of sofa or chair or dresser? Uniform-like sameness in clothing? Unless we do some resourceful and ingenious planning now the answer might well be yes; and the consumers' paradise of Earth will have no counterpart in the consumers' pits on the Moon and Mars. There will simply be too few people to make more than the simplest variety of goods with no supplemental selection available through the Sears or any other mail order catalog.

Two approaches to this problem suggest themselves: one high tech, one low. For a small factory, changing styles, colors, shapes, etc. of whatever it makes in order to satisfy a variety of tastes usually involves expensive dies, molds, etc., and extensive down-time for setup changes. The challenge here is to design production equipment which is set-up friendly so that limited runs can be made on a dial-a-style or insert-a-card basis with little loss in efficiency. Some modern production facilities on Earth are already being designed in the fashion. I am not privileged to work at one. In this way, just as one can dial a pretty pattern by the turn of a kaleidoscope, a consumer could order a unique set of dishes, for example, or a unique bolt of fabric. At the least, small production runs in each of many styles could be made without extra expense. Without this commitment to design Lunar or Martian factories to produce such kaleidoscopic product lines, life on the new worlds will be very drab.

[In the decade since this was written, computer aided manufacturing techniques have indeed made all this possible.]

Remember, the people back on Earth won't care, and governments will give it bottommost priority. It's up to us to see that such possibilities come to realization.

The second approach which might work well on some lines of goods or be available as an alternative choice to the Lunar or Martian consumer is for the factory to produce (either exclusively or in addition to a regular line) a line of unfinished goods -- ready for the consumer or venturesome craftsman to custom finish for him/herself or for resale. Some examples might be ready-to-glaze ceramic ware, ready-to-upholster furniture frames, and electronics chases sold without cabinets or with unfinished cabinetry, ready to dye, print, or otherwise embellish plain fabric bolts. Such secondary or co-manufacturing or custom craft finishing will likely become an important part of the frontier economy. And the person with crafting skills who can take a common ho-hum product and give it a unique and interesting touch might well enjoy the highest local prestige and social status. Those who do not have -- or refuse to develop -- the talent to custom finish purchased raw goods or who lack the income to pay someone else to put such touches on what they buy, might well be condemned to a home filled with the dull, boring, and commonplace.

Lunar and Martian society will greatly reflect this totally new set of rules in the consumer sport of acquiring a satisfying and personality- expressing collection of goods. On the Moon and Mars will dawn the new golden age of the artisan and craftsman. A "designer" item on these new worlds will mean something quite different from on Earth, for it will signify not a mass produced edition of a product designed by a famous name with high snob appeal, but rather a line of unfinished goods which have been designed to be easily, satisfyingly, interestingly, and kaleidoscopically finishable. And so there will be designer mediums, designer palettes, and designer frames and chases, etc. The designer who leaves the most scope for unique finish-ability will have the most honor.

Prospective settlers may be screened and accepted or rejected not only on the basis of their primary skill and occupation or profession but also on the basis of what they can contribute by their secondary talents, skills, hobbies, and avocations. If the new settlements are to avoid terminal blahs, the population will have to have a very high talent density in comparison with Earth.

We have already pointed out what we must seek to guarantee in the design of production equipment shipped to the Moon or Mars. We must also seek to guarantee a high priority for artistic and craft talent amongst the selection criteria for prospective settlers.

But we can make their lot far easier by doing some experimenting beforehand to develop new means of artistic expression limited to the materials and elements commonplace to the new worlds. Lead, gold, silver, copper, etc., are vanishingly present on the Moon, for example. Thus ceramics cannot use glazes based on the lead oxides; certain kinds of stained glass will not be producible; new forms of jewelry will have to be developed; new stains, and paints, and enamels formulated. Pre-clayed soils will be unavailable for ceramics and water will have to be worked into utterly dry Lunar soils to make fireable clay, etc. If those of use who are into arts and crafts here on Earth take Lunar restrictions as a starting point and through lots of work develop workable new crafts, that will give the colonists a head start. Without such SOFTWARE predevelopment, any Lunar civilization founded on hardware alone will surely suffer a fatal morale collapse. Can you help? MMM.

The above essay is online at:

www.asi.org/adb/06/09/03/02/003/moonmall.html

MOON MUSIC

Moon Music

by Peter Kokh < kokhmmm@aol.com >

A few weeks ago I took in an unusual concert: the Northern Illinois University (De Kalb) Steel Drum Band, largest and oldest in the country, was playing at the UWM Union (University of Wisconsin - Milwaukee). I went to get a fore taste of "Moon Music".

Humor me a bit with these assumptions. Musical instruments will not be "upported" ("up" the gravity well) from Earth to the Moon base or settlement -- too expensive. Yet the personnel or settlers will surely want to enliven their "evenings" with more than prerecorded music. This means fashioning musical instruments out of lunar materials in the base or colony shops.

What can they do without wood, without drum skins, without brass (which is a copper alloy: the Apollos' limited prospecting would indicate copper is no more than a trace element on the Moon)? Not being a fashioner of musical instruments by trade or hobby, I honestly don't know. But definitely, one option is the West Indies' steel drum, a cut-off 55 gallon drum whose bottom is then beat with a set of sledge hammers into a complex concave shape capable of sounding from 3 to 36 full, round, vibrant notes. Certainly assorted bells and cymbals, "saws", xylophones, and even marimbas with metal, glass, or ceramic resonator tubes will work. Music has been played on a keyed set of drinking glasses. And to be sure the electric guitar with a ceramic, composite or metal body.

But stringed instruments with wooden sound boxes or brass wind instruments? No way! Can something passable or even special in the way of stringed sound boxes and wind instruments or horns be made from such lunar materials as glass, glass composite, ceramics, steel, aluminum, etc.? Why don't you musically gifted tinkerers out there see what you can come up with. But indeed just the instruments above will make a great orchestra!

The NIU band includes an ensemble of thirty steel drums -- each tuned differently to complement each other in orchestral fashion. No amplification needed! While the band's repertoire includes the usual calypso, pan, and reggae tunes, it amply demonstrated the great versatility of these instruments by such numbers as Cool and the Gang's "*Cherish*", Dionne Warwick's "*That's what friends are for*", Bizet's "*Carmen Overture*", and the opening movement of Bach's "*3rd Brandenburg Concerto*". Unbelievable and very moving. The steel drum shows all the dominant lead power of the piano and yet can be as soft and delicate as the violin.

I doubt Moon settlers will ever miss Earth's traditional orchestral instruments. They will do quite well with what they can make from Lunar resources. The results will help contribute to a unique Lunar culture with a flavor all its own. Recordings of lunar renditions and original Lunar compositions will take their place on the shelves of Earth's music stores. Some Earth FM stations may even feature lunar music just as others feature soul, rock, jazz, classical, pop, and country. Some Earth groups may even catch the fever and "downport" instruments made on the Moon.

Wouldn't it be fun for our chapter to have a small "Lunar Ensemble" to play at our various public events? A steel drum or two, a xylophone, a marimba, some bells, cymbals, and castanets? Perhaps you know someone who isn't all that interested in man's future in space but would find it fun to be associated with us in this way. Working with associated groups like this would be one way for us to extend our influence beyond our core of dedicated activists. Sleep on it. MMM

The above essay is online at:
www.asi.org/adb/06/09/03/02/003/moonmusic.html

Making Concrete on the Moon & Building a Concrete Outpost

Peter Kokh reports on a visit by Dr. T. D. Lin

Dr. T. D. Lin, a native of Taiwan, is now living and working in this country for Construction Technology Laboratories in Skokie, Illinois wants to build a lunar base out of concrete. He appears to have done his homework. In connection with the Portland Cement Association, Lin approached NASA and received a small amount of Apollo sample return moon dust for an experiment in making concrete using lunar materials.

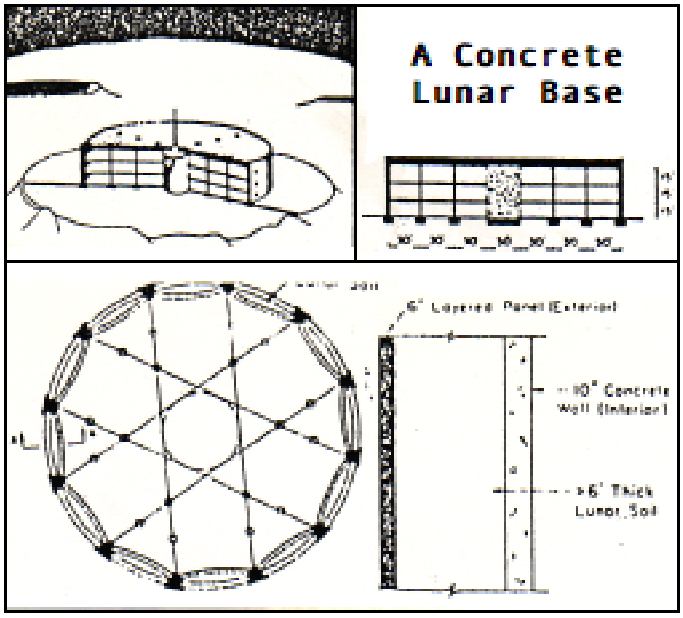
Since the sample was too small for more than one test, Lin experimented with lunar highlands soil simulant, rich in aluminum and calcium, to prepare his "cement" and using raw simulated regolith in place of sand and aggregate to mix in to make his batch of concrete. It worked fine.

Once he had the experiment down pat, he tried it using the real thing. Combining water, cement, and 1.4 ounces of moon dust he produced a one inch cube of concrete that proved to be considerably stronger than our garden variety terrestrial concrete.

"We measured its compressed strength at 10,971 psi, compared to 7,900 psi for a comparative sample of conventional concrete. Since the minimum standard for a reinforced concrete slab is 4000 psi, the results were very encouraging." Lin believes the angular shape of most particles that make up the lunar regolith -- they have never been exposed to weathering by wind or water -- help create the stronger bond.

Now on the steering committee of the Lunar Development Council (LDC), whose logo is a crescent moon with a steam shovel poised on the bottom cusp, Lin has designed a large concrete lunar base. At 210 feet in diameter the three floor round concrete structure would provide 90,000 square feet with all of the materials coming from the Moon, except for 55 tons of hydrogen which would come from Earth. In addition to the cement to be processed from highland regolith, raw local regolith would be used for shielding as well as for aggregate.

The walls of each floor would consist of 12 convex sections tied together by a criss-cross maze of cables under tension. As concrete is stronger under compression than it is under tension, the 10"thick convex panels work, in combination with the cable stays. An outer wall of 6" thick concrete, not under pressure would provide a surrounding bay to be filled with a minimum of 6' of regolith shielding, more piled on the roof. iron extracted from the soil would be processed not only into the tension cables but into H-shaped connectors joining the convex panels forming the inner pressure wall and the concave outer panels holding in the regolith shielding.



So instead of taking to the Moon a collection of Earth-made modules to assemble into a prefab ready-to-do-nothing outpost, with good intentions of someday working towards some early industrial projects, Lin's group would start with lunar industry, enough of it to process cement, his steel cables and panel connectors, his concrete wall, floor and roof panels, etc. The outpost itself would be the first project

This is a radically opposite approach from all others we have come across. The LDC base, once finished would be just the beginning as everything would be in place to make additional pressurized structures. You have to wonder if Lin's approach isn't the better one, that everyone else has the cart and the horse mixed up. This approach seems tailor made for a turn-key approach. LDC would build the Moonbase and then turn it over to NASA or a comparable operator who could then concentrate on operations: prospecting, exploring, and science experiments..

At 90,000 square feet, equivalent to a

square one floor structure 300” on a side, this one structure would provide plenty of space for early expansion, far more room than any other proposal for a starter outpost. Lin has also expressed a desire to repeat his experiments with simulated Mars soil. And he thinks he can cut down the amount of water (i.e. of imported hydrogen) needed if planned experiments to create concrete by steaming the ingredients instead of soaking them work as he expects.

Should some future Lunar Polar Orbiter detect hydrogen (probably meaning water-ice) in permanently shaded polar craters, Lin’s concrete moonbase plan would become even more attractive, if it proved feasible to access that polar ice. The discouraging thing, of course, remains the contrary political climate and the general government disinterest in any manned activity beyond low Earth orbit. TMMM

Moon Miners’ Manifesto # 4 – April, 1987

WHAT THE LUNAR COLONY WILL NEED MOST URGENTLY: A LEO-TO-LUNA FERRY THAT RUNS ON 100% LUNAR FUEL

by Peter Kokh < kokhmmm@aol.com >

J. Alex Gimarc in his 1 Dec 1985 dated report (to SSI) on Space Shuttle External Tank Applications, section IV-A, discusses orbital disassembly of the ET and melting and powdering of the aluminum for use as a fuel to burn with cryogenics (LH2/LO2) scavenged from the ETs in a hydrogen / oxygen / aluminum based rocket engine in a 1:3:4 mix with a specific impulse Isp) of over 400 seconds. Despite the high costs of engine development and the orbital melting/powdering facility, the economics of so much ET alum-inum available already in orbit are such that this technology would greatly enhance the possible scope of orbital transfer operations

But why do space enthusiasts continue to espouse and settle for developments which are NOT ON THE ROAD to ultimate goals? If all that is wanted is a token science base on the Moon and perhaps a robotics-operated mining facility / mass-driver launch system, okay; but then the hypocrisy about favoring settlement of the Inner Solar System should stop. Such an engine, discussed by A. H. Cutler (in *Aluminum Fueled Space Engines to Enhance Space Transportation System Effectiveness, Spring-board to the 21st Century,* NASA / ASEE Summer Study, 1984, by A. H. Cutler) and alluded to by Gimarc will not serve as the bootstrap rocket needed by a Lunar Colony to support itself without wholesale handouts from Earth.

Getting to the Moon only counts if we do so in a manner which allows us to stay there and thrive no matter what non-supportive political-economic decisions are made on Earth. To this end only an engine that burns Moon-sourced fuels exclusively will do. With such an engine, the Earth to Moon freight bill would reduce itself (so far as bottom-line balance of payments are concerned) to no more than the Earth to LEO (low Earth orbit) cost. The Moon could pick up cargo and settlers in LEO and transport them the rest of the way essentially free.

BOOTSTRAP ROCKETS!

[The above was written more than a decade before Lunar Prospector's confirmation of substantial water-ice reserves at both lunar poles. Since that discovery, many have called for using this resource to produce liquid hydrogen and liquid oxygen rocket fuels. This would constitute a one time unrecyclable squandering of a limited resource that took hundreds of millions of years to be deposited. The "rocket jocks" who couldn't care less about lunar settlement and only want to jet set around the solar system on voyages of discovery, can scratch their itch elsewhere. The writer stands adamantly opposed to the production of rocket fuels from lunar polar ices when they are not necessary. Once we are this far out on the shoulder of Earth's gravity well, hydrogen-free fuel combinations with a lower Isp produced locally on the Moon will do quite well. -- PK.]

The aluminum rocket IS the answer, of course, but without the costly Isp enhancing hydrogen purchased from Earth sources. Burning powdered Lunar aluminum with liquid Lunar oxygen, O2 (possibly enriched with ozone, O3), in a hybrid engine will not have the high Isp performance we have grown used to, but it will be superior to the CO/O2 fuel system now being favorably considered for Mars based operations.

[Other metallic fuels worth investigating are iron, especially as powdered unoxidized iron is abundant in the surface regolith and needs only a magnet to harvest. - PK]

Whatever problems there are in development of a working Al/O2 engine pale into insignificance in comparison to the rewards. Those with the right stuff or can-do mind-set will not be discouraged by apparent "obstacles."

Meanwhile, the H2/Al/O2 rocket is but an expensive distraction that wins the battle of orbital transfer operations but loses the war of space settlement. It must be resisted. TMMM

The above article is online at:
www.asi.org/adb/06/09/03/02/004/bootstrap.html

Essays in "M":

Marshall MacLuhan: "Medium is the Message"

by Peter Kokh < kokhmmm@aol.com >

M is for Marshall MacLuhan, Canadian communications theorist and for his well known dictum: "The Medium is the Message." Translated from communications-speak into rocket-jargon, this comes out as

"The Vehicle *is* the Payload"

if you are at all honest about efficiency!

Space enthusiasts are known to cry in their bear about the low payload to fuel ratio of the rocket and/or shuttle system. But it is low because

1) we throw a good deal of the vehicle=payload away, i.e. the External Tank (ET) and

2) we return to Earth more than is necessary (engines and cabin) i.e. the shuttle hold or payload bay. Both ET and hold could be redesigned to do double duty as payload and then, presto, instant heavy lift vehicle.

NASA is charged by the government (with our acquiescence) with short range goals and thus does not look past the objectives of the mission at hand, or missions in the planning stages. "Obstacles" are seen as things to be avoided, not as "challenges" to be embraced. But many of us have learned one of life's most valuable lessons: every "obstacle" is a golden opportunity in disguise. It's a "right stuff" mind-set for successful living.

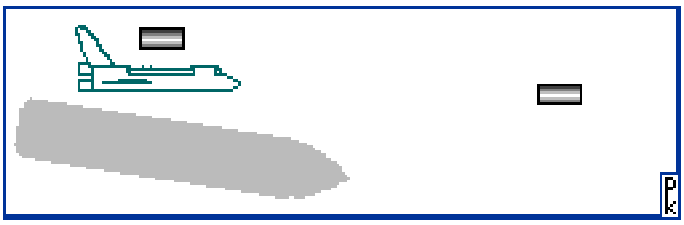
Yes, the ET's orbit, as delivered, would not be stable - we need to experiment ASAP with the rotating tether simultaneous boost of the ET into higher storage/parking orbits and fuel-saving de-orbit of the shuttle orbiter.

Yes, the ET is "wet": the remaining cryogenic fuels are a source of water and electrical power (both via fuel cell) and can be used as station-keeping fuel and for orbital maintenance.

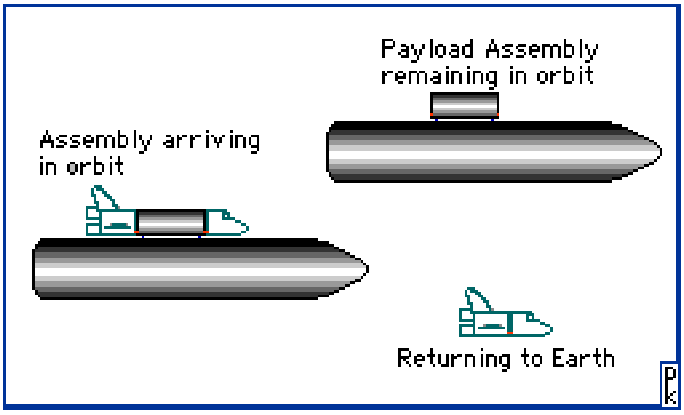
Yes, it would take too many man-hours to retrofit the ET as a Lab. But where the ET's spaciousness is needed is not in the labs/work environments but in the habitat/off-hours environment for which far simpler and lower tech outfitting is required.

It is not enough for the newly formed External Tank Company (ETCO) to ask to take delivery in orbit of spent ET's for commercial marketing. As a precondition, ETCO should be required to buy an unused ET, for use in ground-based practice in retrofitting. ETCO could also save itself time and trouble in orbital retrofitting by developing such thins as a non-degassing SOFI (spray on foam insulation) which NASA would then be required to use.

Along with the ET + Habitat payload, a Shuttle II could be designed in modular fashion with engines and reduced wings/tail in rear, cabin in front, and a larger lab module being the entire mid-section (not just within a hold, and conveniently pre-attached to the ET/Habitat-to-be, passageways and all.) The lab module would have a spinal cord which plugs into both the engine/wings module and the cabin module through male/female connection so that both ends, after release of the habitat/lab complex can reconfigure and deorbit together.



in the current STS configuration, only the contents of the Shuttle Payload Bay are "payload" - a very small percentage of the original Launch Vehicle assembly. The intact cargo carrier orbiter returns to Earth and the External Tank is scuttled just before it would have entered orbit. The package "delivered" to space is just a small fraction of what it could be.



In the radically reinvented space transportation system, the return "orbiter-tug" is much smaller than today's shuttle (smaller wings & tail and no payload bay. All these weight savings are reinvested in a larger payload structure that remains attached to the External Tank which is taken all the way to orbit, for minimal extra fuel.

The smaller return vehicle (less entire mid-section + payload) needs smaller wings and tail. Weight savings here can be reinvested with the ET in the form of a micrometeorite shield. The major weight savings formerly invested in payload bay hold and doors can be reinvested in an Aft Cargo Compartment (long studied and planned for) for the ET to carry retrofitting supplies, and/or in pre-filling the empty volume of the ET's InterTank with the habitat's life support system, and/or a more massive lab module.

Why cry in our beer when by tossing out the baggage of a totally inappropriate mind-set we can thus vastly improve payload to fuel ratio by a couple of hundred percent?

"Your first assignment is to list all the reasons why this idea simply can't and won't work."

"For your next assignment, brainstorm just how we are going to make it work anyway!" - *unknown*

MMM

PAPER CHASE

Paper Chase II

[Third in a series of articles on the need to pre-develop the SOFTWARE of a Lunar Civilization]

by Peter Kokh < kokhmmm@aol.com >

On Earth with its vast atmosphere, oceans, and still extensive forests, we can arguably afford to withdraw such organic ingredients as hydrogen and carbon from the environmental cycle in the form of paper, plastics, etc. After all, Nature has been doing the same thing, "banking" these elements for geologically long times as coal, oil, and gas.

On the Moon the situation is quite different. Hydrogen and carbon do exist in amounts worth scavenging in the upper layers of Lunar soil, put there by the incessant solar wind. From Apollo samples we might expect every thousand tons of soil processed to yield (besides over 400 tons of oxygen) one ton of hydrogen, 230 lbs. of carbon, and even 164 lbs. of nitrogen (source: Stuart Ross Taylor. *Planetary Science: A Lunar Perspective.* Lunar and Planetary Institute, 1992, p 159). This is hardly abundance. Polar permashade fields certainly must be searched, but this scenario requires that the Moon's axis will not have shifted more than a degree or so in the past 3.5 billion years: a tall order. If any ices of water or carbon oxides are found there, they will certainly be needed to expand the biomass of the colony. Withdrawal and banking will still be quite out of the question. Hydrogen and carbon for non-biological uses will still be priced as "import elements."

[The above was written in 1987, eleven years before Lunar Prospector confirmed the existence of ice deposits at both poles. Yet the caution remains. Even billions of tons of hydrogen, carbon, and nitrogen (presuming that the ice contains carbon and nitrogen oxide ices as well, which one might expect if the source is comet impacts) -- even so much is not enough to support (a) lunar biosphere(s) if the population on the Moon grows to a considerable size. A conservative approach is still the best strategy, if we are not to stunt the growth of lunar development. -- Ed.]

Paper is basically cellulose, a carbohydrate, half hydrogen & carbon, half oxygen. Its production in modern forms is very taxing on environmental air and water. While this may be a justifiable tradeoff on the bounteous Earth, the toxic burden of its production would soon overwhelm the very limited environments of Lunar (or in-space) settlements even if "waste papers" were recycled 100% (which would necessitate brainwashing all would-be settlers.) Luna City (ans "New Tucson" at L5 as well) must be a paperless society. Throw-away addicts will argue this, of course, but then addiction has always been resistant to treatment.

What will this mean in practical terms? First let's set everyone's mind (some double entendre here) at ease. With so many of the engineering problems of human outmigration already solved, it would be ironic if having to apply fiberglass to one's exit zone proved to be the show stopper. Fortunately toilet tissue that is 100% biodegradable and environment friendly is already being made and sold on the mass market. This is also a fast cycling usage, the hydrogen and carbon involved not long withdrawn from circulation. "But ye who enter here," (the gates of the Moon settlements) "forever give up all hope" of paper plates, cups, towels, napkins, and junk mail.

Now a paper-less society, Lunar or L5, is an enormous challenge and we had better begin preparing for it. A whole spectrum of alternatives must be developed and ready-to-go to address the diversified applications of paper in our civilization that have so insinuated themselves into our way of life as to almost define it.

Books, magazines, newspapers: electronics to the rescue, you say. Well only if there are some quantum leap improvements over what is available today. Cathode ray tube (CRT) eye strain is a common enough complaint to show that the final format of electronic reading media is not yet on the scene. The Lunar "EZ-Read" must not only be eye-friendly, it must be lightweight, even pocket-able. Rainbow-color capacity should not be a luxury.

Electronic books, magazines, and newspapers, etc. to be inserted into the reader must be quite compact especially if hydrocarbon plastics are involved so that the weight ratio to paper replaced is as high as possible. All metal alloy and / or silicon would be the best.

Downloading from central library / databases may well fill much of the need. But if this is all that is available, the right to freedom of information will be imaginary. The Lunar Bill of Rights (even the American one) should include the right to own individual books in whatever applicable format. The desire to own one's own core library should be unrootable in anyone who fancies him/herself more than a cog.

However much progress is made on the electronic front, a kosher all-Lunar substitute for organic fiber paper would be most desirable. 100% fiberglass papers have been successfully produced, but so far as I have been able to determine, these are used primarily as filter papers. If an all fiberglass paper with a suitable texture or "hand" can be developed, then a method of printing it without organic based inks and toners (using metals and their oxides, for example) must be found. Perhaps some of the research done on the various forms of xerography might indicate directions for further experimentation?

Whatever the eventual repertoire of

Lunar print media, one thing is sure. Printed materials will not be physically imported from Earth. Rather whole libraries will be electronically transmitted to Lunar receiving stations to be re-materialized in the new media and formats. And this presents a unique, once-in-history opportunity. The use of appropriate interfaces on the Lunar side of this information stream would allow for spelling reform, modest or drastic (even a whole new alphabet would be possible) of the English language. The merits of pursuing this option are beyond the scope of this article.

[In 1987, when the above was written, the Internet was still very much in the future!]

Checks, invoices, statements, bills, inventories, etc. The coming "smart card" may point the way to handling these needs. But a whole family of "smart cards" will be needed to handle the full variety of personal, in-house, and commercial transactions.

Cereal boxes and all other food item packaging: There can be no exception to the use of glass, fiberglass, metal, and foil. Plastic is just as taboo as paper. Food will probably be available only in bulk, and one would purchase the desired container type and size separately, a strong motive for reuse. The same goes for most other normally convenience packaged items.

Labels, tags, and stickers: Fiberglass papers and foils with not-yet-developed kosher ways of imprinting or perhaps embossing them seem the only way. Some mechanical way of affixing them must be worked out as hydrocarbon and other organic adhesives are likely to be unavailable.

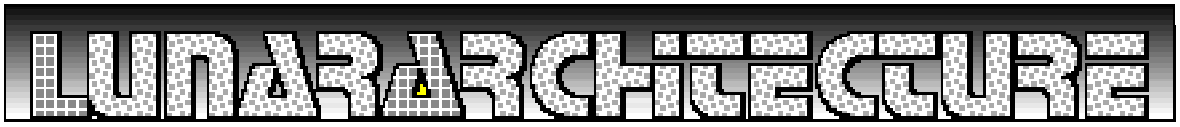
Paper bags, gift wrap, cardboard boxes, and dividers: Ingenuity must be applied to such kosher materials as metal and fiberglass fabrics and netting and reinforced foil (how about a vacuum laminated foil / fiberglass gauze / foil sandwich?)

Greeting cards and love notes: One can foresee a non-commercial and unpoliceable use of homemade art papers (such as are now well represented in art fairs) and vegetable inks for this purpose. Maybe the contradiction of personal mass produced greeting cards will at last give way to something that really does show individual effort. A possible black market item.

I am sure I have not covered it all, but I hope the idea is clear. Lunar culture in full bloom will be quite different from ours. But one can be assured that given preparation NOW, these differences will not be impoverishing. On the contrary, they should be refreshing and enriching. Certainly there will be lessons learned that may help Earth bound culture find its way to a somewhat less disharmonious relationship with our own host world. MMM

The above article is online at:
www.asi.org/adb/06/09/03/02/004/paperchase2.html

Moon Miners' Manifesto # 5 — May, 1987



LUNAR ARCHITECTURE

[Fourth in a series of articles on the need to pre-develop the "Software" for a Lunar Civilization]

by Peter Kokh < kokhmmm@aOL.COM >

Through the years, a variety of suggestions have been made for the erection of the First Lunar Base. Most common is to make use of fully prefabricated shelters (such as space station modules or re-outfitted space shuttle external tank) imported from Earth and / or a low-Earth orbit (LEO) space station and burying these in the Lunar soil. A less expensive method of erecting a base of similar limited scope is Dr. Lowell Wood's plan (of Project Columbus) to use inflatable kevlar (carbon fabric) bags (air pressure would be more than enough both to inflate them and to support the overburden of protective soil).

Construction techniques may seem to be a HARDWARE question. But what is built on the Moon will depend _entirely_ on the philosophy behind our presence there. Without the right SOFTWARE of purpose, nothing significant will happen.

The stated purpose of most lunar base proposals seems shortsighted: to serve as a base for doing Lunar Science (Selenology, but the lazier term Lunar Geology is in vogue) and for mining engineers tending a largely automated operation. A word about Lunar Science. Few laymen perhaps have as high a "selenology curiosity quotient" as the writer, but science is properly the function of a living community already in place. Many would-be Lunar Scientists want only to titillate their own curiosity and then go home. But our purpose has to be different: to make the Moon a second human world. Science in the long run -- much, much more of it -- will follow naturally, science done not by visitors from Earth but by people who have adopted the Moon as their new home.

The type of small prefabricated initial base described above makes better sense as a construction shack for a much larger facility to be built with as high a percentage of native Lunar materials as is initially possible. T. D. Lin's proposed 90,000 square ft, three level, 210 ft diameter concrete structure might be ideal (see the sketches on the last page of MMM #3) in which 55 tons of terrestrial hydrogen is

called for in comparison to 250 tons of Lunar steel, 1500 tons of Lunar highland cement, over 10,000 tons of Lunar soil used as aggregate, and over a million tons of soil used as shielding. [see illustration on page 8]]

If expansion is to be an afterthought, it will end up being a forgotten dream. uch a truly Lunar base might be large enough to support open-ended goals of developing non-token Lunar agriculture, pilot materials processing industries, and production-scale 100% Lunar sourced building materials and construction / erection equipment and methods. If (expansion is to be an afterthought, it will end up being a forgotten dream (and you can carve that quote in marble). The only base it is worth building on the Moon is one whose function it is to prepare the methods and tools needed to expand into a full blown settlement.

Only if we make it possible for several thousands (not dozens) of people to live on the Moon from generation to generation (not just through short tours of dut) can we:

(1) develop a Lunar economy that is truly full and autonomous

(2) develop a genuinely Lunar human culture and civilization to express and unfold potentialities hidden in humanity since the dawn of time ("Be all that you can be")

(3) say truly, that the human presence on the Moon is more than that caricature we find in Antarctica and that we have securely established humanity beyond Earth. Only then will we begin to cut the umbilical cord that ties us to the womb world.

So Lunar Architecture, or “LunArchitecture”, must be a charter function of a *bona fide* base. Considerations flowing from the goal make several things clear.

1. Speed of “labor-light” construction is essential.

To begin with, "Lunarchitects" must develop a system that can provide shelter at a pace sufficient to house settlers as fast as the growing Lunar market / trade / economy can absorb them. This means that not even lip service can be given to the time-honored slow, *labor intensive* housing construction methods. What is important is to build secure shelter as simply and quickly as possible -- let us be so bold as to aim at one per day per crew!

There is a place for labor-intensive, artful, craft-rich, proud work, and that is in the leisurely discretionary finishing of interiors. This can be do-it-yourself or contracted on a pay-as-you-go basis, etc. and can be stretched out over years or even generations. We'll thus employ the analogs of brickmasons and carpenters for interiors, but they have no place in erecting the pressure shells of Lunar indoor / middoor spaces.

2. The “Dirt Cheap” Goal

The pressure shells of buildings must be literally dirt-cheap. One cannot "live off the land" nor "sleep under the stars" on the Moon. The place for flaunting affluence is in interior finishing. To keep the basic construction "regolith-cheap" two things are necessary: extrusion of the shelter from the site itself and the use of the least amount of construction energy necessary to do the job well.

3. The Concept of the Lunar "Great Home"

The "right to ample living space" ought to be “religiously” pursued, unammendably, unpostponably. Add-on space will be difficult, risky, and expensive. All the pressurized shell-volume that even an extended family might want should be provided at the outset. Young families might make a "cozy place" in only a part of this and slowly grow into the rest. Included should be solarium and garden space large enough to provide a respectable fraction of their food needs and to help to keep their air fresh as well as provide an oasis of serenity and delight. Another bonus of this "right to ample space" approach would be the availability of in-home areas for starting entrepreneurial cottage industries.

It is necessary then to purge the mind of the facile but inappropriate examples of the prefabricated space station habitat module. Even if manufactured on the Moon, they would be more energy intensive in their construction and almost guarantee a stiflingly stingy allotment of sardine space in turn for the ever unfulfilled promise of more spacious quarters "when the settlement can afford it."

A limited amount of technological homework has already been done along lines that would enable the realization of the goals just outlined. We already know that the Lunar soil can be compacted and then sinter-fused with a mobile magnetron, a high-power microwave generator (the idea of Tom Meeks of the University of Tennessee). This would be ideal for road surfaces, floors, and exterior walls set into excavations in the soil. We know that the soil can be melted into cast-basalt slabs ideal for interior partitions and roof segments, with the balance of the excavated soil being replaced on top as shielding while the interior is being pressurized. We know how to build safe periscopic Lunar picture windows (see MMM #1) and heliostats to flood the interior with sunshine.

But much work needs to be done. Using imported epoxy resins as sealers would be prohibitive. At the least, the natural glass-like glazing of the cast and sintered surfaces may well reduce the need for sealant to joints. In the temperature stable Lunar underground environment with no vibration to worry about from wind or occasional mini moonquakes, and no water-table-induced settling to worry about, this sealant may not need to be as flexible as one might think. Perhaps glaze patching would do the job. On site experiments will be needed to prove out these ideas and build production-capacity equipment.

The scandal of totally unnecessary cost multipliers built into the present establishment approach has discouraged many, leading them to settle for the little dream, the token base, in the false hope that it is a foot in the door. We must not be sheepish about insisting on the Big Dream, our only chance! MMM

MOON WEATHER

WEATHER ON THE MOON

by Peter Kokh < kokhmmm@aol.com >

On Earth, the weather forecast often plays a major role in our decisions. Can we go golfing? Fishing? Swimming? Can we go on a picnic or hang out the wash to dry? Do we need an umbrella? Or a shovel? Will it be a good day to paint the house or wash the car? Or are indoor activities in order?

Beyond this, we anxiously watch storm paths. Will the latest hurricane threaten the area where we live? Is there a danger for blizzard, ice-storms, tornados, brushfires, etc?

Finally, without the fickle weather, how would one ever find anything to say to a stranger or acquaintance? On the weatherless Moon, will we be at a loss for words, passing one another on the street with eyes averted? Will sports be more closely watched, not because we really enjoy them, but because we need something innocuously trivial to talk about as a social lubricant?

Well, the Lunar environment isn't quite all that cut and dried. First, believe it or not, there will be a slight seasonal difference in the seemingly steady-state indoor Lunar temperature. (Six feet down, insulated from the heat of the sun and the cold of the night, the Lunar soil is a steady -20° C or -4° F, very manageable for the buried habitats and factories and connecting walks, streets, and plazas. Just the heat of life and industrial processes will make up most of the heating needed to provide livability.) There is a difference nonetheless of about 3° F between March and September. This seasonality comes not from polar tilt (only 1.5 degrees) but from the Moon and Earth being 4 million miles closer to the Sun on January 1 than on July 1 with a couple of months lag time in consequent build up and loss of extra heat.

Then there are solar flares. Flare seasons are long and in sync with times of active Sun with a period of about eleven years from peak to peak and quiet flare-free times in between. But in flare season, warnings of particular storms will be on very short notice. Flare storms will not affect indoor or "middoor" (see this month's "Essay on 'M'", below) activities but will affect those who have business on the surface. A network of permanent flare shelters, e.g. at intervals along highways, etc. will probably be built. There will probably be portable or mobile shielding canopies at construction and mining sites. These will probably be in common use anyway, as working under them will require lighter suits that need pressurization but not cooling or as high a degree of micro meteorite protection. Such suits will be more comfortable, more supple, and allow many more accumulative hours of surface activity at reduced cosmic ray exposure.

But there will always be some work done outside the easy range of such protection. For these workers and for travelers, warning times must be maximized. One way to do this would be a set of six solar synchronous satellites. Here I do not mean synchronously interposed between Earth-Moon and Sun, but in an orbit, well within Mercury's, where they each remain in step with the rotating Sun. The Sun's "day" is slightly variable, but an orbit about 16 or 17 million miles out would allow the "Vulcansats" to keep track of potential flare-producing sunspots for the duration of their lifetimes, each satellite watching its own 60 degree wide sector.

Moonquakes are below the threshold of concern and would be felt only by instruments. But meteor showers, especially the predictable ones, will stir protective measures. On Earth, these bits of comet debris burn up in the atmosphere and are harmless beauties. On the Moon they zoom in without visible indication. They just hit, now and then with damage. But what is life, if there is no risk at all? MMM.

ESSAYS IN "M": Middoors; Matchport

by Peter Kokh < kokhmmm@aol.com >

FOREWARD: On the Moon, exiting an airlock in a space suit is something that architecture and engineering will both seek to make as unnecessary as possible. This for two reasons. First the high Lunar vacuum (10E-12 torr daytime facing the solar wind, 10E-14 torr nighttime sheltered from the solar wind) is a precious industrial and scientific resource especially in combination with the Moon's substantial gravity. Opening airlocks for exit or entry and purging atmosphere into the vacuum, if done frequently enough, will degrade the vacuum to a point that the solar wind can't restore through its flushing action. Second, the nitrogen used as a buffer gas and biogenic ingredient in the colony's atmospherule must be imported and therefore must be conserved. Making up for preventable losses could well tax the colony's capacity for growth.

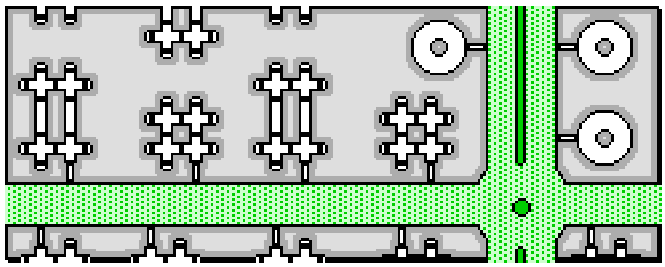
M IS FOR MIDDOORS:

On Earth we have been familiar with the distinction between indoors and outdoors for many thousands of years. In the last two decades or so, a new environment, the middoors, has become familiar to most of us in the form of the enclosed, climate-controlled streets and plazas of many a shopping mall. The "landscaped", sunlit central atrium in some new hotel and office buildings offers another kind of model.

In Lunar cities, except to enter and exit those (e.g. industrial) facilities which for safety's sake must keep their air unmixed with that of the city at large, it will be possible to go most anywhere without donning a space suit. Homes, schools, offices, farms, factories, and stores will exit, not to the airless, radiation-swept surface, but to a pressurized, soil-shielded, indirectly sunlit

grid of walkways, residential streets, avenues, and parkways, parks, squares, and playgrounds.

While the temperature of traditionally indoor places could easily be maintained at "room comfort" levels, that of the interconnecting middoors of the city could be allowed, through proper design, to register enough solar gain during the course of the long Lunar day (dayspan), and enough radiative loss during the long nocturnal period (nightspan) to fluctuate 10 degrees F on either side, for example from 55-85 degrees F during the course of the month. "The Great Middoors" could be landscaped with plants thriving on this predictable variation. This would be both invigorating and healthy for people, plants, and animals alike, providing a psychologically beneficial monthly rhythm of tempered mini-seasons. Of course the middoors could also be designed to keep a steady temperature. But oh how boring that would be!



Section of a neighborhood: individual homes open onto pressurized "middoor" streets hosting the bulk of the settlement's modular biosphere.

M IS FOR MATCHPORT:

To go from one Lunar city to another, or from the city to the space port or other outlying installations, or to transfer from one vehicle to another, all vehicles and city docks or marinas will be equipped with standardized matchports or interlocks. These will probably be of unisex design rather than male-female, and with either able to do the necessary aligning for safety's sake (although there will undoubtedly be protocols). When the two matchports are aligned and locked (vehicle-vehicle or vehicle-city), the narrow -- hopefully less than 1 cm -- vacuum gap will be slightly overpressurized allowing port doors to unseal and open easily inward (into vehicle, into city).

Prior to disengagement, the port doors closed, the narrow inter-door gap would first be flushed with pure oxygen and then this would be pumped out (into vehicle, into city) to provide a low grade vacuum which would seal both port doors by internal pressure (vehicle, city) allowing the vehicle to pull back its matchport and depart, with the escape to the outdoors of only a minuscule amount of cheap oxygen -- no precious nitrogen would escape.

There would probably be three common matchport sizes: for personal surface vehicles, for public surface transports, and for cargo rigs. Outside of safety drills held periodically, perhaps most Lunans will live and travel widely about the Moon without ever putting on a spacesuit. It won't be necessary. MMM

The above article is online at:
www.asi.org/adb/06/09/03/02/005/airlockessay.html

Lean & Tall

by Peter Kokh < kokhmmm@aol.com >

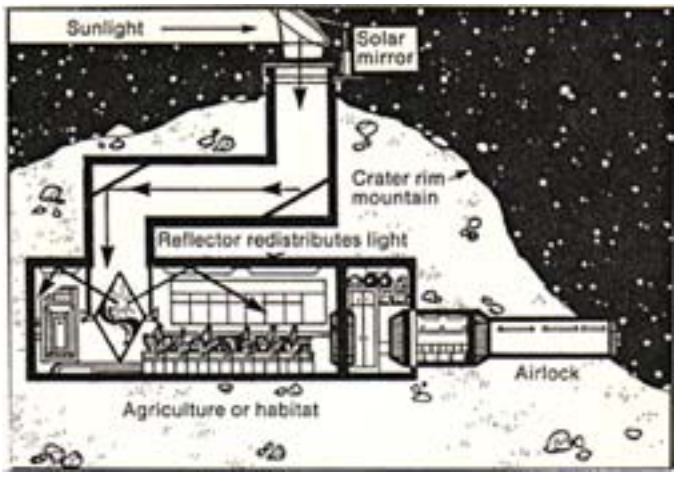
• Will men and women born native to the Moon grow up to be lean and tall in lunar "sixthweight?" We may never get the chance to find out.

One of the more expensive aspects of most lunar development scenarios is the assumed need to rotate personnel.This timid, Moon-shy approach, of which many space settlement fans are just as guilty as the public policy makers, is indefensible.

There are enough people on Earth with "the right stuff," willing to volunteer for one- way journeys ready to commit themselves to making the Moon a hew human frontier, that this costly and uncommitted approach to lunar "occupancy" needn't be considered, except in the early outpost establishment phase.

If the government cannot gamble on success, how can it be the right bus for us to be aboard? Only we can answer that. Do we really want the Big Dream to come True? Or are wistful might-have-beens and Little Dreams what we will sell out for, betraying all who have gone before? It will take courage: We can't let the faint-hearted, the risk-averse, and the seleno-phobes prevail.

We will only know for sure how humans born on the Moon will develop, and how healthy future generations will be, if we allow them to be born there in the first place. That means allowing volunteers to commit to settlement, allowing them to establish families. Not taking this plunge in a timely fashion, will both stretch out the timetable of settlement dramatically, and increase the total cost manifold. MMM



UNDERGROUND POLAR HABITAT: Sunlight piped in from heliostat. L. Ortiz/NASA. *As drawn, this would work if the Moon's axial tilt were zero. In fact it is 1.5° and to be able to catch the sun's rays at all times of the month, the heli-ostat would have to be on a tower at least 2,000 ft. above all surrounding terrain. If the habitat were not at the exact pole, the tower would have to be even higher. So much for a nice idea.*

ESSAYS IN "M"

by Peter Kokh <kokhmmm@aol.com >

M IS FOR MISSING VOLATILES: The Moon, as compared to our bountiful Earth, is very poor in elements with low boiling points, especially hydrogen (and thus water), nitrogen, and carbon (which is volatile in its usual form as carbon monoxide and/or carbon dioxide.) Other relatively volatile elements, like sodium and phosphorus, for examples, while present in usable and probably sufficient quantities, are less abundant than on Earth. This volatile depletion is one of the tests to which any theory of the Moon's origin must be put.

More importantly, this depletion sets constraints on what is economically possible on the Moon.

1. Any Lunar civilization must import the bulk of the hydrogen (barring polar permashade ice fields*), carbon, and nitrogen it needs for biomass and life-support.
2. Such a civilization must seek to find inorganic substitutes for non-life related uses to which these elements are put on Earth: wood, paper, plastics, coatings, adhesives, oil, and grease, etc.

[This was written eleven years before the exciting confirmation by the *Lunar Prospector* orbiting geo-chemical mapper, that such polar ice reserves do, in fact, exist. But even at "billions of tons" this is a very limited resource which must be used wisely only for recyclable purposes. - Ed.]

M IS FOR METHANE & 'MMONIA: (*poetic license*) The easiest way to ship the missing volatiles is to combine them as methane (CH4) and ammonia (NH3) which are easier to liquefy and handle than liquid hydrogen, especially. But any excess needed hydrogen* would have to be imported in the pure form. (Some hydrochloric acid and hydrofluoric acid might be shipped to co-import any needed chlorine -- to combine with Lunar sodium to make salt -- and fluorine. Both may be needed to endow recycling ore extraction processes.)

To increase import efficiency to 100%, containers can be used which are made exclusively of elements the Moon needs to import. Such usable "tare" could be of metal, like copper, or of easily reduced solid hydrocarbons like polypropylene, (-CH(CH3)CH2-)^n.

* [Actually, of H, C, and N, it is Nitrogen which will probably be in shortest supply in comparison to the amounts we will need, solely as a buffer gas used with oxygen for breathable "air". Nitrogen can be conserved by reducing the interior air pressure to half sea-level normal, but with the same amount or partial pressure of oxygen, reduced nitrogen accounting for all of the reduced air pressure. If indeed this shortage does turn out to be critical, it will be a strong incentive to keep ceilings low, thus reducing the cubic volume of air needed per square foot of inhabited space. Goodbye visions of high-domed megastructures for the time being! - Editor.]

M IS FOR MINIMIZATION OF THE COST OF IMPORTING METHANE, AMMONIA, HYDROGEN, ETC: The Moon's top priority in its program to minimize the cost of its import burden will be to learn to replace (with native elements) or do without non-life-related usages of missing elements. Next in priority will be to develop sources of its import staples (hydrogen, methane, ammonia) that are less costly than upporting them from Earth. Any infant Lunar civilization MUST (or die!) open up other parts of the solar system as part and parcel of an integral and viable NTM economy (NTM = non-terrestrial materials). Mars is so close to having everything that is needed that may be a tendency of Martian Pioneers to be isolationist, not caring to open other space markets. If you want to guarantee widespread Solar System development, best to put your eggs in a basket that is strategically deficient! To have an interesting system-wide economy and commerce you need a system-wide community of interdependent places. Any extra-terrestrial game in which the name of the start square is not "LUNA" will be a dud. To those who say the Moon lacks the resources to support a civilization, we have a one word answer: Japan.

M IS FOR MANNED MISSIONS TO MARS AND ITS MOONS FROM THE MOON: If you want a mission which is not going to be an Apollo-type dead end, or so weight-restricted as to be a token effort you can do two things:

1. Source as much of your throw weight as possible from the Moon. The spacecraft can be made largely from Lunar materials with their bootstrapping 20:1 advantage.
2. Depart, fuel tanks topped off (at least Liquid Oxygen), from high on the shoulder of Earth's gravity well, for example from the L1 Lagrangian point about 40,000 Miles in from the Moon towards Earth. While this would restrict departure to the period of the full moon to head you in the right direction with maximum velocity, the advantage will be so great that you could launch from L1 at several successive full moons on either side of the every-780-days window for the same energy cost as departure from LEO -- low Earth orbit -- at the the heart of the "window."

Looking down the road, manufacturing the building, construction, and mining equipment for use on Mars, Phobos, and Deimos will be a growth industry for the young Lunar settlements. Earth could not compete! [That, in many respects, mining and processing "regolith" on Phobos and Deimos will be very similar to operations on the Moon, makes such synergy all the more sensible. MMM

MARS PHOBOS DEIMOS

by Peter Kokh < kokhmmm@aol.com >

Some several millions of years from now, Phobos is expected to spiral in towards Mars' equator, probably disintegrating under tidal stress to form a dark ring around the ocher planet. But for the near term, spirals with one end on Phobos or Deimos will be of freight outward to the Moon & LEO, and of freight and hopeful settlers inward to a sandy Martian destiny.

Compared to Earth's Moon, of course, Phobos (12.4x14.3x17.4 miles) and Deimos (6x7.4x10 miles) are small "potatoes." Yet this works out to a surface area of 1,800 square miles for Phobos, 500 square miles for Deimos. [Compare with Rhode Island at 1212 sq. miles.] It has long been theorized that these moonlets are captured asteroids and indeed their reflectance spectra resemble that of carbonaceous chondrites, one of the major asteroid/ meteorite classes. This is what leads us to expect that they are rich in hydrogen, carbon, and nitrogen in one form or another as well as silicates and other oxides. The upcoming* Soviet PHOBOS mission will hopefully confirm this and set the stage for some very serious planning. *[this mission ended in failure]

While it requires less energy for a round trip from LEO to the PhD twins than from LEO to the Moon, it is discreditingly ridiculous to suggest that LEO stations and depots get their liquid oxygen from the Martian moons rather than from the Moon. The Moon is handy all the time via a two or three day trip. The Martian moons are available only every twenty-five or so months and only via journeys from 6 months to two years long. Liquid hydrogen is quite another matter as the Moon cannot provide it (barring rich polar deposits**) and will need it even more than LEO. Hydrogen, methane, and ammonia can be processed on Deimos or Phobos and shipped to the Moon for perhaps a third of the cost of transporting them up the steep well from Earth -- that is, discounting initial capital investment.

**[*Lunar Prospector* did discover ice reserves on the Moon at both poles in 1998. But this is a limited resource that, in our opinion, should be reserved for recyclable uses in food production, biosphere maintenance, and industry for lunar settlements, and not blasted out the nozzle of rockets in a squandering one-time use. - PK]

Now often one reads that the real action will be in "Earth-crossing" and "Earth-approaching" asteroids and/or extinguished comets. The energy cost of round trips to these bodies will be even less than to PhD because one will not be infringing on even the shoulder of a planet-sized gravity well. But this expectation conveniently (naively ?) overlooks one of the paradoxes of celestial mechanics: the more neighborly are the orbits of two bodies (e.g. Earth and asteroid 1982B) the less frequent are the synodic launch windows between them. With such bodies we are talking about opportunities decades apart, not just every 25-26 months! That is not to say that unique one-shot opportunities shouldn't be seized. But for regular trade in volatiles, Phobos and Deimos have it all sewed up.

If LEO (low Earth orbit)-based commercial interest haven't already developed volatile processing on the "hurtling moons of Barsoom", any newborn Lunar settlement will be sure to do so as a matter of its own survival. An initial highly automated small crewed/tended station on Phobos/Deimos would be coupled with an advance Mars' pre-exploration base that would continue Martian studies from orbit and via teleoperated rovers, planes, balloons, and dirigibles. As (and if) permanent habitation of this preciously legendary planet begins, the PhD outposts will grow into major transportation/ logistics nodes adding some home-grown wares to the heavy equipment being transhipped to Mars from the Moon. Logical items: plastics and pharmaceuticals, both hydrocarbon rich, to be shipped both to the Moon and down to the rustic settlements on the frigid deserts below.

But how could humans live on Phobos or Deimos, except in rotating tours of duty, with their physiology-wise negligible gravities? One possibility: a maglev train of habitat-cars on a steeply (89+ degrees) banked track within the lip of 3 mile wide Stickney crater on Phobos circling about every 114 seconds (307 mph) would simulate the 0.38g of Mars itself. MMM

The above article is online at:
www.asi.org/adb/06/09/03/02/006/marsdestiny.html

MARS!? - AS I SEE IT

by Peter Kokh < kokhmmm@aol.com >

For most of this century, there has been a steady retreat from the poignantly romantic portrait of a still living but dying Mars painted by Schiaparelli, Lowell above all, and Burroughs, and echoed even in Heinlein and Clarke. For many of us, the minority who pay attention to the News, this tenacious vision went "poof" with the first photos of the crater-pocked southern hemisphere of Mars returned by the fly-by of Mariner 4.

Rebouningd, our spirits hitched a ride on a more complete set of pictures from the first orbiter, Mariner 9, which revealed tantalizing clues to a once-upon-a-time warmer and far wetter Mars. Was Mars in the midst of some temporary cyclic dormancy? Would the planet reawaken someday? Were there primitive but unique Martian lifeforms holding out in some incredibly long hibernation ready to be aroused from their long stasis by the kiss of some new epochal Spring?

Meanwhile the pictures steadily flowing in from the Viking orbiters revealed not so much a moon-like surface, as one as hauntingly beautiful and awe-filling as our own southern Utah and northern Arizona. For millions raised

on celluloid sequences of cowboys chasing and being chased up and down Monument Valley, Mars began to look like an unbelievably beautiful -- if barren -- setting in which to imagine all sorts of futures.

In our racial loneliness, most of us hoped that life would be found on Mars after all, in however humble a form. I remember well my own high excitement at the first teasing results of the pyrolitic release experiment. But when these suggestive indica-ions were not borne out out by other subsequent tests, I was filled with a crushing and abysmal disappointment that lasted all of twenty seconds before giving way to a new euphoria: IF there is no native life on Mars, THEN Mars is "ours!" by default -- ready and waiting for our own life. Mars took on for me the raiment of a virgin world with mankind serving as the male reproductive agency of Earth by which Gaian Earth-life would fertilize Mars and bring the long-waiting sterile world to the glory of planetary motherhood to which it could never aspire on its own -- no matter how long we left it alone.

Mars is still an easy #1 in any popularity poll of off-Earth destinations. Membership in the Planetary Society which openly capitalized on the feline longevity of the Martian Romance is ten times that of the National Space Society. To be sure, there are those so unforgiving for the shattered dreams of yore, and now so preoccupied with new alternative space futures that they write sour-grapes articles such as "The Case Against Mars." Meanwhile, unapologetic "planetary chauvinists," cheerfully adopting this put-down label -- are not put off by such petulance.

As I weigh it, one of the greatest lessons learned at the feet of my mother, an amateur decorator among other things, is that any apparent disadvantage or "eye-sore" has the hidden potential, correctly approached, to become a unique asset, even a focal showpiece, around which to organize one's whole treatment. But you have to have the right frame of mind to discover the creative opportunities such "problem" features pose. Evidently not all have such an outlook. The human "redecoration" of Mars will be no different. To arrive at the best, even stunning results, it will be necessary first to uncover, then to face honestly, the whole bag of tricks today's Mars has to roughen the path for various human dramas.

Those involved in the triennial CASE FOR MARS Conference in Boulder Colorado (# III will be held July 18-22, 1987) have their eyes wide open to such opportunity-laden problems; they are undauntedly brainstorming a human beachhead on those frozen rusty shores. It would be a mistake to dismiss them and their efforts. Yet despite their considerable progress in surmounting obstacles prematurely thought to be show-stopping, is not yet cause to sound the rally call for a major national/international effort to put man on Mars in the adjacent future.

To begin with, the public at large is not yet finished with the romantic Marscapes of yesterday's speculations. Witness that no one -- save a few oddballs like me -- would volunteer to settle Antarctica. Yet, in reality, Antarctica is not only just as awesomely beautiful and challenging as Mars, but it is warmer, has dense, breathable fresh air, is bounded by shores teeming with life and food, has an unlimited amount of pure -- not mineral saturated -- water, and even has inexhaustible energy in the steady, strong, reliable winds that blow incessantly from the pole out to the sea -- winds with much more force than those of Mars. Antarctica is a far, far friendlier, more forgiving, more welcoming "world" than Mars. If most people would unhesitatingly pick Mars, it is probably testimony to their flawed notions of what Mars is really like, rather than to some surprising hardiness responding to an unsurpassed challenge. To build public support, as the Planetary Society is doing, on the quicksand of public misinformation, is inviting a collapse from which it may be impossible to recover for generations.

A step by step approach to the humanization of Mars would begin with the establishment of a viably sized settlement on the Moon, followed up without delay by a complementary volatiles mining and processing facility on Phobos and / or Deimos, doing double duty as a forward base for the continued tele-exploration of Mars itself. Before then, of course, unmanned probes such as PHOBOS, VESTA, and the MARS OBSERVER, will have garnered much more knowledge of the Red Planet and its dark moons, and we will have a better idea of what is in store for us and how to tackle it. But this knowledge will remain sketchy, and Mars seems possessive of its secrets. We will still know far less about how to build, live, and survive on Mars than we already know about the Moon.

Nor will it be enough to have picked out "safe (for landing) yet geologically interesting" potential base sites. But from a forward base on Phobos or Deimos we could answer such important questions as: what minerals are where? How extensive is the permafrost layer? How thick is it? How deeply buried? How mineral-laden? How metal-poisoned? What soils can be processed to serve what functions? It certainly makes much more sense to have an indefinite series of sample returns to a lab a few thousand miles away on Phobos than a very limited one-shot sampling sent many millions of miles back to labs of Earth!

What about seismic activity? Are there any useful geothermal or areothermal hotspots? Are the soils in some areas more suitable as growing mediums than those elsewhere? How many differently sited settlements will be needed to provide all that is necessary for stable self-sufficiency? Will there be any logical export opportunities to pay for imports from the Moon and Earth? Someday, our homework done, the time will be ripe to set foot on this world of so many dreams -- not just to picnic and return home, but to stay. *Not now, not yet.*

But the cry "less ARMS, more MARS!" is strong and the Planetary Society may succeed in getting the nation to pick exploration (of Mars) over development (of non-terrestrial materials from the Moon, Phobos, etc.) as the reason-for-being for the space program in the coming decades.

Do we pout and sit on our hands? Do we play the role of good loser and pitch in? Or is there a third, much better option? We must "second the motion" for Mars, aggressively pointing out that if the Mars Program funds (or co-funds?) a liquid oxygen processing facility on the Moon first, the Mars fleet will be able to fuel up more cheaply in LEO and then top off the tanks at L1 and thus be able to carry much more cargo to Mars. And the groundwork would be laid for follow-up missions.

We also aggressively help by pushing the Mars Program to fund an advance party to Phobos (the prior launch window 780 days earlier) to set up a facility to process fuel for the return* and do continued remote/robotic research. Our prize? We get our foot in the door for free on both the Moon and Phobos and we benefit from free (to us) R&D for life-support systems and transportation hardware that we will also need. Not compromise but the co-promising cross-fertilization of our dreams! In retrospect we might title this article.

At right: Alternate title for this article seen in retrospect

* [Here we clearly pre-stated the mission philosophy soon to be developed by Robert Zubrin, calling for in situ production of fuel for the return to Earth portion of any Mars Mission.]

MMM

Moon Miners' Manifesto # 7 – July, 1987

ESSAYS IN "M":

Month or Sunth; Meridian: Metonic Period

by Peter Kokh < kokhmmm@aol.com >

M FOR MONTH, OR SUNTH:

Originally, of course, the term "month" meant the span of a full set of four phases of the Moon, e.g. from full moon to full moon, or from new moon to new moon, terms which render the appearance of the Moon to the inhabitants of Earth. On the Moon itself, this lunar month of 29.53 Earth days would rather appear to denote a full set of phases of Earth, e.g. full earth to full earth, *except that* this definition of month would seem irrelevant to anyone living on the Farside from which Earth was never visible.

Rather, to the Lunar Settlers, this period, called a lunation by our astronomers, will simply signify *the period from sunrise to sunrise or from sunset to sunset - wherever* they happen to live on their adopted new homeworld. From a Lunan's point of view, it's all about where the Sun is in *their* sky, and has nothing to do with Earth at all. Earth could cease to exist and their would be no more "full moons" or "new moons" to reckon by. Just the interval between sunrises (or sunsets).

Introducing *"the Sunth"*

Accordingly, pioneers might well prefer to call it simply the "sunth." This term is less stuffy than "lunation" which is really a geocentric term signifying the period from "new moon to new moon." The term "sunth" and avoids confusion with our own Earth calendar months of Roman origin which do not coincide at all with lunar months as they average about a day longer in order to divide the year into twelve neat periods with no leftover days. The Sunth then would be the natural way of reckoning the passage of time on the Moon.

The sunth will also be the primary consideration in scheduling activities which depend upon the availability of sunlight and/or solar power. This will include mining and industrial operations, road building and prospecting, The local time of sunth will also determine the timing of agricultural chores.

M IS FOR MERIDIAN:

The Replogle globes of Earth and Moon alike are divided into 15 degree longitudinal segments. For the Earth, this is a natural, since 15 degrees is the width of the idealized "time zone" (15 x 24 = 360).

On the Moon, however, the slow daily crawl of the terminator line dividing sunshine from darkness is just over 12 degrees (12 deg., 11 min., 27 sec.). So for the purposes of settlers of the Moon or for people on Earth who want to better comprehend what life on the Moon would be like, future Moon globes might display meridians marked every 12 degrees. Thirty 12° sections equals a full circle of 360° Thirty quasi "date zones" if you will. Even if these zones do not precisely measure the sun's slow crawl across the sky they would offer a close enough approximation to allow Lunan students and others to easily estimate by how many dates the sunth is retarded or advanced in his/her location in comparison to other settlement sites and outposts on the Moon.

M IS FOR METONIC PERIOD:

A 5th Century B.C. Athenian by the name of Meton noticed that the Moon's phases returned to the same dates of the year after 19 years (i.e. 228 calendar months = 235 lunar months). The Metonic period is important for anyone who would devise a calendar which respected the 29.53 day lunar month or sunth, and yet reconcile it with Earth's 365.25 day year at least periodically. MMM

The original essay is online at:
www.asi.org/adb/06/09/03/02/007/sunthessay.html

Moon Calendar

A Moon Calendar for Lunar Settlements

by Peter Kokh < kokhmmm@aol.com >

To be sure, there will be settlers on the Moon with "Tory" hearts, i.e. unwilling to give up the ways of Old Earth, however inappropriate to the new world. Earth's calendar is one such piece of baggage best left at home. On Earth, counting time by "moons" may be convenient for nomads and rustic hunter-gatherers, but the overriding temporal fact of life since the dawn of the agricultural age remains the length of the year: the four seasons.

But on the Moon, however, the four seasons do not apply -- except for astronomers. The overarching pacer of life will the the sunth (see M is for Month, *above*).

Since the slow rhythm of sunrise and sunset cannot be ignored on the Moon, the calendar should be organized around it, no ifs, ands, or buts.

Keeping the standard 24 hour day/date

Because of Earth's proximity to the Moon and the high density and intensity of Earth-Moon communications and commerce (as compared, for example, to Earth-Mars intercourse), it will be convenient to keep the standard 24 hour day -- probably called "date" on the Moon to avoid confusion with the longer sunth.

A simple calendar of alternating 29 and 30 date sunths will do the trick, especially if every fortieth date (or on the closest weekend thereto) an extra hour is added (as we do in the fall switching from daylight-savings to standard time) to make the sunth average 29.5 dates exactly.

Then a two page calendar would always be valid even as to the times of local sunrise and sunset to within the hour, per location.

This system would be enhanced greatly if the sunth were four weeks exactly, which would require adding an eighth day three weeks out of eight.

Advantages of an occasional 8-day week

Such an extra day would be a logical choice for religious feasts and holy days and for secular holidays alike. Since the extra day would not be a working day but an off day providing three long weekends out of every eight, it should be a popular feature and add cultural color to life on the Moon.

This way sunrise and sunset would occur, for a particular place, not only on the same dates of the sunth but also on the same days of the week which will be important for business and industry (see article: POWERCO in this issue)

Naming the days of the Week

Since, obviously, such lunar weeks and weekdays would not line up or keep cadence with those of Earth (no need to), new names are in order. The reader may have some suggestions. Let me offer three possibilities, naming the days of the lunar week after:

- The major moons or satellites of the solar system:

  Luna, Io , Europa, Ganymede , Callisto , Titan, Triton
  (and 8th Titania , 3 weeks out of 8)
- The s tars in the Big Dipper or Plough which can be seen on the Moon anywhere north of 30 degrees South:

  Dubhe, Merak, Phad , Megrez, Alioth, Mizar, Alkaid
  (and 8th, Alcor, 3 weeks out of 8)
- The stars of the Pleiades which can be seen from almost anywhere on the Moon:

  Alcyone , Merope, Electra , Celaeno , Taygeta , Asterope , Maia
  (and 8th, Pleione and/or Atlas, 3 weeks out of 8. They were the parents of the famous seven sisters).

  Note: “Pleiades” was the name chosen by Artemis Society International, for its original short-lived newsletter.

Fiscal Considerations

For fiscal and accounting convenience - divisibility into “quarters,” for example - the calendar should have twelve sunths invariably -- like the Islamic model rather than the Jewish one (which sometimes has thirteen). This would yield a short "year" or *“ennium”* of 354 dates that would slip seven sunths out of alignment with Earth's calendar after nineteen years (see M is for Metonic Period *above*.)

The Metonic Period: 19 years & 235 Sunths

So every nineteenth year an extra seven sunth period could be added, to be called “the Renaissance” and devoted to constitutional and institutional renewal, reform, and rededication, thus bringing the Moon's calendar back into step with Earth's and providing a predictably popular generation-long rhythm as a creative fringe benefit of which lunar civilization could be proud.

There are alternatives of course, but why compromise with those inappropriately attached to terrestrial customs. It's a brand new world and why not start fresh with new traditions? "Tories" can always import Earth calendars and keep them under their pillows.

This article is online at:
www.asi.org/adb/06/09/03/02/008/mooncalendar.html
[The Lunar Calendar issue will be revisited in later issues of MMM.] MMM

POWERCO - The Lunar Power Company

[Fourth in a series of articles on the need to pre-develop the "Software" for a Lunar Civilization]

by Peter Kokh < kokhmmm@aol.com >

What does power generation on the Moon have to do with software? We'll soon see. Perhaps the most commonly proposed source of power for an initial Lunar Base whose requirements are in the 100-1000 kilowatt range, is a form of fast compact nuclear reactor such as is being developed in the SP-100 Program for space applica-tions. Systems considered are thermoelectric, in-core therm-ionic, and Brayton-alternator types. Rather than use precious water* as a coolant or thermal transfer medium, we could use "NaK", liquid sodium / potassium which is a good eutectic medium and can be wholly lunar-sourced.

[Now that Lunar Prospector has since discovered water ice at both Lunar Poles in 1998, it would be legitimate to use some of it in closed coolant loops for this purpose. NaK, it seems, is nasty stuff, and we did not realize that at the time of writing. - PK]

Nuclear vs. Solar Options

The usual reason for pro-posing the nuclear option is the need to have steady power all month long. It is imagined by nuclear proponents that since the Sun shines on the Moon for 14.75 days at a time (dayspan) alternating with equal periods of darkness, a Lunar settlement that relied on solar power would have to power-down to an ultra-inactive state of torpor during the long nightspan.

Having grown up in Eisenhower's Atoms-for-Peace era, I was naturally ardently pro-nuclear in my youth. This frame of mind has long since been replaced by the opposing prejudice that the only good nuke is a dead nuke or no nuke at all. But however you feel about the question, please bear with me while we take a second look at the solar route.

The advantages touted for solar power on the Moon are not to be ignored. The collectors are easily made from lunar materials. Solar power is intrinsically modular. A solar plant can be added to, cloned in the next neighborhood, sized specially for industrial areas and so on. Solar power makes a good neighbor and generates no "Danger: Off Limits" signs. On the air less, cloudless Moon, the intensity of sunlight on the surface is steady and much greater than on Earth.

Fear of the Lunar Night

"But the night! But the night!" chant those easily discouraged through O'Neill on down. Yes, the night! Two considerations: energy storage and energy usage.

Hydro-Solar Power Generation and Storage

The very nature of living conditions on the Moon suggest an elegant answer to nightspan power generation. On the Moon, even with any possible polar permashade deposits [since confirmed in 1998], water will be a premium, a resource dearly earned or made possible by costly imported hydrogen, a resource never to be squandered. Water will be as precious, as sacred to the "Lunans" as it was to the Fremen on Frank Herbert's Dune-world of Arrakis. We will want, nonetheless, not just enough to make the life and industrial cycles work, but a healthy reserve.

How do we bank this reserve? In the from of tanks of liquid hydrogen? In the form of idle ice in tunnels beneath the city? That's like putting money under the mattress. No, the water reserves can, and should, and must be put to work in two ways.

First, it will be a justifiable investment in public morale and in the psychological well-being of the inhabitants to allow for some open water in parks and/or parkways. Why not recirculating fountains with goldfish ponds? Why not a meandering trout and canoe stream? Beside renewing and uplifting the spirits, such open double-duty storage will be a strong symbol of security, a tongue stuck out at the parched surface of this new / old world.

Second, by making use of the solar power cycle, we can deposit *water reserves in an* "interest-earning account." During the long sunshine-rich energy-productive dayspan, the solar power plant(s), sized comfortably above expected dayspan power needs, is/are also put to work disassociating some part of the water reserves into hydrogen and oxygen. This could be done by high temperature catalytic cracking, a much more efficient method than that of electrolysis. This may not even require additional power if the waste heat generated by the solar power production is sufficiently high in temp-era-ure to be put to work in this way. That will depend on how well the solar power system design can be optimized to "bust" water as a design by-product.

Then comes the nightspan! The solar power system shuts down at sunset and adjacent to it, modular banks of hydrogen / oxygen powered fuel cells (such as those designed by Westinghouse) come to life, slowly recombining the hydrogen and oxygen into pure water to refresh the city's systems and generating considerable amounts of electricity in the process. The contribution to the water purification-recycling burden is a not-minor fringe benefit. What are the advantages of this plan?

- *Clean*
- *Dependable,* far less liable to shut down
- *Modular* - maintenance on individual units will not noticeably interrupt the smooth flow of power.
- *Dispersed units* throughout the city - far less vulnerable to a breach by meteorite, accident, or willful sabotage.

The high modularity of this "hydrosolar" (solar/ water cycling fuel cells) system also means that system improvements and design breakthroughs can easily be taken advantage of. One is not frozen into a premature technology. Finally, the modularity of the hydrosolar system means the city can grow smoothly and not in the spurts held hostage to construction of added large centralized nuclear systems.

Dayspan-Nightspan Power Use Software

But this is still hardware, right? Right! So where's the "software"? Well, our second consideration was to be nightspan energy usage. Not being an energy systems engineer, I do not presume to estimate how much power the hydrosolar plant would generate during nightspan as compared with dayspan. This ratio will surely improve with system design and sizing. But I think it safe to say and honest to advise that during the fortnight of darkness, power available will be somewhat less than that available during the fortnight of sunshine.

There should be enough power, however, to make it quite unnecessary for the settlement to "hibernate" provided a whole new philosophy or approach is taken to the design of production systems, operations, and enterprises.

On Earth, where energy supplies are taken for granted, energy-eating production facilities function around the clock, even in some cases seven days a week. Now in any enterprise, there are processes and tasks that use more energy and those that use less (e.g. inspection, wrapping, book work, etc.), and these are are usually done side by side by separate personnel.

For the Moon, it will be important for every prospective new industry to totally redesign its manner of operation to sequentially separate, so far as possible (and here goodwill and repeated reexamination and rethinking will be needed) all its process elements into

1. a higher energy-using portion that can be done during the dayspan half of the month
2. a lesser energy-using portion that can be saved for the nightspan period.

This won't be easy, and for many industries and businesses, the division will be quite unequal in terms of man-hours involved. Once such a thorough and resourceful “precipitation” of heavy and light tasks is made and the light portion comes up short, it may serve the enterprise to consider if some of the operations normally done by suppliers or outside contractors, or perhaps even by entrepreneurs using one's by-products and waste materials could be incorporated to fill in the nightspan man-hours budget and keep everyone productive.

This would be the preferred method of balancing the work load through the month. If an enterprise still comes up short on the energy-light task side of the equation, it could also explore diversification into an unrelated appropriately sized light business to be activated when work is needed to fill predawn dates.

Now in a city of any size, there is bound to be quite a variety of activities, some energy-heavy, others energy-light, all needed to make the economy purr. Before we go to the Moon, probable mix scenarios should be thoroughly investigated over and over for various stages in the settlement's growth. Individual production operations, optional paths of industrial diversification, priorities for product development and enterprise incubation designed accordingly.

Such a system will look and work quite differently, but also more efficiently, than our business-as-usual. And may I predict one enormous fringe benefit: worker morale.

For many people, employed by such task-separating firms, the ho-hum of work-a-day routine will get a twice monthly shot in the arm at sunrise and sunset as they switch tasks, jobs, and duties.

Such switches will usually but not always occur, in the same job location or work place. For example, a worker might cast iron on the sun-up dayspan dates and make art crafts from slag during the sun-down nightspan dates. Or edit by night and print by day. Or separate ores by night and refine them by day. Or make tiles by day and lay them by night. The various possible combinations are endless and the list will grow ever longer as the lunar economy becomes more diverse.

Conceivably, some may have one employer by dayspan and another by nightspan. Then one could keep a dayspan job indefinitely while periodically switching nightspan jobs whether in search of something more interesting and suited to one’s talents and aptitudes, or for something that pays more. Or vice versa.

It will be refreshing. Asking another “what do you do for a living?” or “what kind of work do you do?” will have an extra twist in the Moon towns. The pioneers will have given up much to come to the Moon, including outdoor sports and many hobbies. But having two jobs that rotate in sequence will do much to alleviate the dreary boredom that is the lot of many a wage or salary earner on Earth.

Tailored to a mode of power generation which does not ignore lunar rhythms but harmonizes with them, this unique bi-modal operations system will make its mark in lunar culture and civilization.

But to prepare for it, a lot of SOFTWARE homework can and must be done now. Industry by industry, business by business must be looked at in a new light. Much of what we will decide to do differently on the Moon to harmonize with the ebb and flow of available energy through the sunth will have no applications here on Earth. But it would be quite surprising if some of the lessons learned were not exported back to Earth. High morale means higher productivity and that is a top goal on any world.

And you thought that Lunar Power Generation & Storage would be a boring topic! MMM

The original article is online at:
www.asi.org/adb/06/09/03/02/007/powerco.html

Animal Life

in Settlement Biospheres

(Followed by Colonist Animal Life Quiz)

by Peter Kokh < kokhmmm@aol.com >

In her recent article in the first issue of Moon Miner's REVUE: "Some Preliminary Considerations for Lunar Agriculture", MLRS member Louise Rachel brought up the topic of animal life. Red worms in composting trays; honey bees and nectar sipping bats for pollination duty, honey, and guano; fish and chickens were mentioned as early contributors to the settlement's biosphere.

I have had lots of experience with bats (no doubt, some will say, in my belfry), but I had thought of them mostly as insect, blood, and fruit eaters. But apparently some tropical and semi-tropical plants depend on them for pollination. Another useful pollinator that might add delight as well would be various species of hummingbirds. And perhaps some species of butterflies!

For meat, rabbits and cavies (guinea pigs -- they are a meat staple in their native Peru, breed fast, put on meat efficiently, and are easy to raise) would be good complements to chicken and fish, and both have extensive cuisines developed about them. For extra incentive, rabbit and cavy fur -- and even cavy wool -- would be welcome complements to cotton.

Two Considerations for meat animals:

First, they should not require special food crops but should be able to thrive on the parts of plants grown for human consumption that are not eaten by man: cobs, leaves, stems, shoots, roots, etc. This way they are integrated into the human food chain and fit in the scheme of things by recycling vegetable and grain wastes. Increased, not decreased, food chain efficiency will result. Of course, the amount of such vegetable and grain waste will then set a limit on how much meat can be raised. But I would _utterly_ disagree with James Lovelock (The Greening of Mars. Michael Allaby and James Lovelock, 1984, pages 126-9) that all animals are food rivals of man.

How much meat per person per day will this sensible stricture allow? Probably a lot less than most Americans are used to enjoying. Meat may either be reserved for special occasions or more likely used more as an ingredient or garnish instead of as an entree -- as in salads, casseroles, and stews, and as in oriental cuisines.

Second, food animals should convert fodder to protein efficiently. In general, smaller animals do a better job. Goats are more efficient milk producers than cows (and no, so far I haven't been game enough to try any) so that if the settlers wanted to move beyond soy substitutes for dairy products, then goats, not cows, will likely find a berth on the next ark.

Urban Wildlife and Pets

But I am more concerned with human-animal interactions and thus with provision for pets and for planned urban "wildlife". In the lunar home, parrots, toucans, macaws, and similar colorful birds would be at home on perches in the solarium-garden and not need to be caged. Parakeets, budgies, and canaries, and other birds would also add song, color, and delight.

Other house animals should be small and sustainable on kitchen and table scraps -- *vegetarian pets* being far preferable for this reason. There might have to be some sort of restriction such as so many pounds (or ounces?) of pet per so many pounds of family members. Vegetarian gerbils and hamsters and show breeds of Guinea pigs would be in line with these restrictions.

Unfortunately, dogs and cats are both relatively large, and what is worse, fare poorly on vegetarian diets. For inveterate dog lovers like myself (I have three) this would be one of the hardest sacrifices of accepting a chance to settle on the Moon. Meanwhile, monkeys, anyone?

If it were decided to introduce goats, thought should be given to restricting the herds to schools where students could take turns caring for them, even on off days. Nothing is better for the growing child than positive personal interaction with *animals large enough to relate to.* Goat products could be sold by student associations to raise money for other activities. Even apart from the benefits of exposure to animal life, such Junior-Chamber-of-Commerce type activity will be invaluable as preparation for adult life.

If the lunar settlement's "streets" are indeed built to be greenways (see PARKWAYS in this issue), I would favor an urban wildlife of song and humming birds, butterflies, maybe even carefully chosen species of squirrels and chipmunks, all chosen with due consideration to ability to coexist with the plant life without becoming pests. A central parkway of generous width, complete with stream down the middle, might also support a small flock of ducks, swans, or even to truly suburbanize the place -- pink flamingos.

Animal haters notwithstanding, in all of human history there has never been a human community without its animals; and a world with no animal life would not be one I'd care to call "home". It is not only man who must go to the Moon and integrate it into the human scene, but GAIA, that is, Earth-life in general, in representative species, plant and animal alike.

Our historic path to becoming human has been inextricably bound up with animal life. We cannot stay human without continuing that involvement. MMM

The article above and the Quiz below are online at:
www.asi.org/adb/06/09/03/02/008/animal-life.html

COLONIST'S I.Q. QUIZ
on Animals

Questions:

1. What species of animal life might over time develop larger forms in low lunar gravity?
2. Why someday might Luna City's floral gardens be famed throughout the Solar System?
3. What effects might lower gravity have on plants in general?
4. Will it rain inside lunar Colonies?
5. What handy feature does the Moon offer for experimenting with new species that might not be compatible with those already on the scene?

Answers:

1. Flying creatures have an upper limit on their growth on Earth that is imposed by weight / lift ratios. But large birds also need lots of room and the lack of this in lunar biomes may be the dominant factor.
2. Stalks could be taller, and blooms larger, without drooping. Floral forests may someday provide enchanting surroundings for romance, weddings, etc.
3. Being laden with fruit or moisture will be less stressful. Fluids will move upwards more easily, downwards less so, signaling physiological change.
4. Dew and dripping condensation, yes. Man-made mists and showers, yes. Rain, no. [Despite a great depiction of such an event in the subsequent 1991 ABC made for TV lunar helium-3 mining settlement classic, *Plymouth*.]
5. The high lunar vacuum imposes a natural quarantine between unconnected settlements or outlying facilities. Thus no two separate moonburgs need have the same flora (plants) or fauna (animals). Vive la difference!

The Quiz above and the article preceding are online at:

www.asi.org/6/9/3/2/008/animal-life.html

ESSAYS IN "M":
Lessons in Biospherics

by Peter Kokh < kokhmmm@aol.com >

M is for Magenta, Maroon, Mauve and other natural plant colors. The lunar settlement's biosphere will be far too small and fragile to absorb the usually toxic and even carcinogenic byproducts of the production processes needed to make today's popular artificial dyes, many derived from coal tar as a feed stock. Rather, cotton - the fabric of choice for the Moon - will be dyed with indigo, henna, xanthene, even with chlorophyll and carotene - all dyes produced naturally by plants. If they are not as bright or as colorfast, that will be of little import in comparison to keeping the air, water, and soil sweet and fresh for tomorrow. Dye-source plants will then be an important part of lunar flora; and if the settlement farms do not have room to grow them, they may well find a place along landscaped settlement streets.

M s for Medicinals: Many pharmaceutical drugs are largely hydrogen and carbon, and low in elements already present abundantly on the Moon. So long as their metabolic byproducts are all eco-friendly and biodegradable, they can be freely imported from Earth and will add to the lunar biomass as a result of being consumed. But beyond that, medicinals will by and large be easily refined natural by-products of carefully selected plants to be frown on the Moon. Other preparations will best be done without.

M is for Musk and other fragrances and cosmetics. As with dyes and medicinals, what cosmetics cannot be organically and naturally produced will have to be done without. They would be incompatible with the lunar biosphere both in synthesis and in decay. Plants with cosmetic value will thus be high on the list to green-up (pressurized) lunar byways. Some natural cosmetics are already on the shelves of health food stores on Earth, but work needs to be done.

M is for Mosquitoes, Moths, and Mice and other unwanted pests. One safeguard against accidental importation of pests along with foodstuffs and seed is to have all such cargo flushed, sealed, and packed with pure nitrogen. The hold of Moon-bound ships should be pressurized with pure nitrogen too, which the settlers needs anyway. Besides, the alternative is to import oxygen (in the air within cargo holds) which the Moon needs like Newcastle needs coal. Import efficiency is Priority # one.

M is for Mushrooms and edible fungi in general which feed on decaying plant matter, a usually neglected "soil" for food production. To achieve enhanced efficiency, a food chain designed for Moon settlements must rely on a strong fungal contribution as an essential element, not only in the form of the common mushroom (agaricus campestris) but making use of other edible species as well for an especially interesting cuisine. In this way, nutrition will be generated from both halves of the food cycle.

M is for Mold spores and airborne pollen In the closed and close settlement "atmospherule" (to coin an apt term) in which the total volume of air per person is vastly less than on Earth, it will be of critical importance to avoid importing, even accidentally, plants or their seed, of species which discharge pollen directly into the air, and of fungal species (sources of mold) which do the same. If such species need to be cultivated for any reason, they must be grown in quarters with a separate air supply and recycling system.

M is for Moisture. Plants will load the lunar settlement's air with moisture through transpiration, This humidity needs to be controlled. Dehumidifiers will produce drinking water as a bonus. Thus plants will be a prime factor in recycling water as well as refreshing the air.

MMM

PARKWAY

Pressurized Greenways within Lunar Towns

[The sixth in a series of articles
on the need to pre-develop
the SOFTWARE of a Lunar Civilization]

by Peter Kokh < kokhmmm@aol.com >

City Planning Considerations

Some months back, Myles Mullikin, the current Milwaukee Lunar Reclamation Society chapter president, and I got into an interesting discussion on how a lunar settlement, more than a mere Moonbase, might be laid out. Myles favored a strictly linear one street city, or at least a single arterial spine, on the grounds that experience with computer architecture showed that this was the most efficient type of layout.

However, even if it means, as Myles pointed out, more atmospheric volume and hence more tonnage of preciously imported nitrogen, I tend to favor some sort of grid system for two reasons. First it enhances physical networking, allowing people to interconnect over shorter distances; but especially since the extra total length of streets per given population would provide the opportunity to plant extra living biomass. The more of this biomass per person, the stronger will be the life-support flywheel for air and water purification, etc.

The Parkway's Role in the Biosphere and ideal plant species for Parkways

Parkway streets and avenues, pressurized and shielded but with solar access, could host such non-foodstuff plantings as pharmacopeic (medicinal) species; plants useful for preparation of natural cosmetics; plants whose extract can be used to dye cotton, like indigo and henna; plants to support a carefully chosen "urban wildlife"; and last but not least, flowering and blossoming plants to support honeybee colonies [perhaps an Australian stingless species].

Such a utilitarian selection (and here is where the software pre-development homework comes in) will do double duty by refreshing the air outside agricultural areas of the settlement and at the same time providing a delightful and luxuriantly green "middoors" environment (see MMM #5, Essays in 'M') in which the settlers can go about their daily business in the reassuring context of "nature".

Ambience

There could be special fruits for the children to pick in assigned season. Sidewalk cafes could grow their own special salad and desert ingredients on location. Care for street-side plantings could be left in the hands of neighborhood residence and/or business associations who could landscape to their desire, providing the opportunity for each neighborhood to have its own unique ambience.

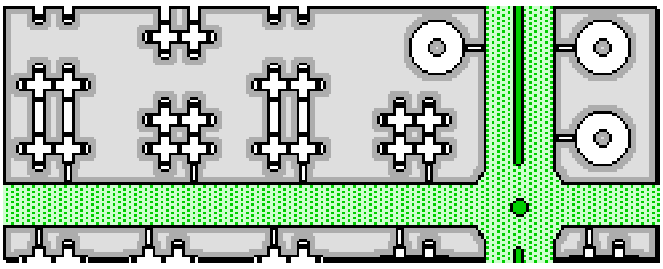
The Parkway Climate

MLRS member Louise Rachel in her article in last month's special premier Moon Miners' REVUE issue entitled "Some Preliminary Considerations for Lunar Agriculture", reminded us that many of the temperate zone plants we are familiar with will not grow and reproduce full cycle in a climate in which the temperature never falls to a cold enough level to reset them. This means the settlement's parkway streets will have to be planted with mostly sub-tropical species and varieties. In the continental U.S. there is only one major city whose climate lies exclusively in our proposed lunar middoor range (55 - 85 ° F) -- San Diego. If you have ever been to this jewel of a city and noticed how different is the local vegetation where you live, you'll get the idea.

The Parkway Ecosystem

We need to know not only what will grow under such conditions but what sort of ecological relationships must be maintained. What animal species are required for pollination, etc.? Should we let some varieties in the lunar community, which will tend to sow themselves and find their own balance, or pick only those over which we can keep tight control? Which plants will need how much care? Above all, which can we import not as seedlings or mature plants but as nitrogen-packed seeds to make sure there are no stowaways? What trees can be grown in dwarf varieties? There is so much we have to learn and the homework can begin now, even by educated laymen, maybe by you! MMM

The original article is online at:
www.asi.org/adb/06/09/03/02/008/parkway.html



The "Middoors"as key Biosphere Component
In a modular settlement, allowed to grow as need be (not a fixed size megastructure based on someone's guesstimate of future needs), modular habitats and other structures are connected to pressurized residential/commercial "streets." These "commons" contain the bulk of the settlement's biomass & biosphere.[artwork fr. MMM #152– FEB 2002]

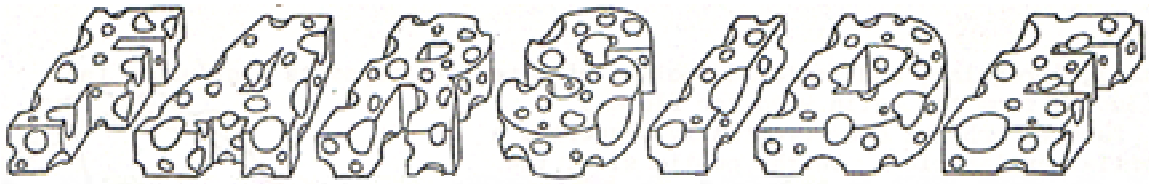
ESSAYS IN 'M':

by Peter Kokh < kokhmmm@aol.com >

M is for Mare Moscoviensis. The "Sea of Moscow" is the prominent mare area in the far northeast quadrant of the Lunar farside. In flagrant violation of the tradition that cals for Lunar Seas to be named after weather phenomena, states f mind, or directions, the Soviet discoverers of this farside lava plain exercised their naming prerogative and christened it after their largest city. I have come upon the apology that, after all, "Moscow is a state of miond." Now I mujst confess, having been there, that ehtere is some subtle truth to this claim. Mujscovites are justly immenselyh proud of the asetts of their 850 year old city, carefully nurtured and built-upon geeneration after generation,. In the interests of good will, I'll withdraw the complaint if the free translation of Mare Moscoviensis as :Sea of Civic Legacy" is allowed. :-)

M is for Marequator (Mare + Equator) -- an imaginary "great circle" belt around the Moon that crosses the Lunar equator near the limbs between nearside and farside, and rises to about 30-35° north near the longitude that passes through mid-nearside (o°) and descends to about 30-35° south near 180°, the longitude bisecting farside. (see the maps in the Farside I article this issue) Such a line seems to evenly bisect both the major mare features of nearside and the skimpy farside placement., Someday a circumlunar highway might logically follow such a route. Another possibility is a superconducting lunar girdle along this path, with regularly spaced solar power stations, half of which will always be in full sunlight, endowing this "dynequator" with continuous abundant energy to be conveniently tapped by most "coastal" (mare shore/highland coast) settlement sites. A magnetic levitation rail route for high speed inter-settlement travel would be a logical adjunct.

M is for Medium range missiles, the so-called "intermediates" whose days seem to be numbered. Let's throw out the warheads [read *bath water*] but not the missiles themselves [read *baby*]. Instead, Let's begin a letter writing campaign to convince the powers-that-be to invest the costs of missile-scrapping in a feasibility study to find ways of ganging these rockets-about-to-be-orphanedm in stages or clusters in such a way as to provide enough thrust to boost some of our growing payload backlog into orbit, with preference given to planetary and Earth-science missions, continually being bullied to the back of the queue. This won't hurt budding entrepreneurs and commercial launchers. There's enough of a workload for everybody. MMM



PART I: Lunar Asymmetry as a Clue to the "Origin Question"

by Peter Kokh < kokhmmm@aol.com >

To many of you in your teens, twenties, even early thirties, the "Farside of the Moon" conjures up no special images. You've always known (or have been able to look up) what that face of our satellite forever averted from Earth looks like. However, for those of us who came of age well before 1959, the term "Farside" will forever carry a lingering thrill of mystery. For all of mankind's history up to that point, now one had ever seen, even vicariously, the back 41% of the Moon that its elliptical orbit-locked rotation kept forever out of sight from Earth-bound vantage points.

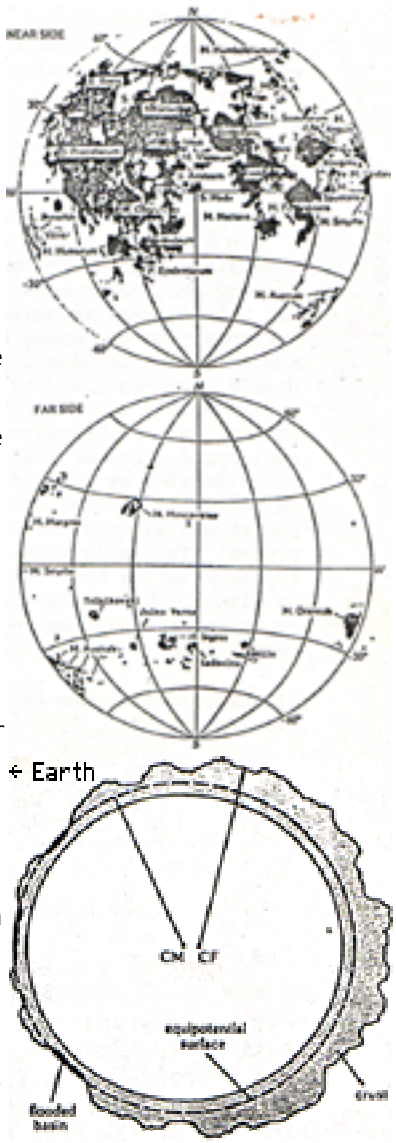
Speculations, of course, abounded, with little to limit them. The most popular and grating misconception was that the "far" side was synonymous with "dark" side. However, these outfacing lunar precincts are equally blessed with the alternating relentless glory of solar two-week-stands and star-studded fortnights.

One memorable fantasy held that the Moon was shaped like some pushed-in deflated beach ball, folded in on itself, so that with the foundations of the rear face up against the roots of the front face, the back was some enormous hollow holding atmosphere, water, life, and of course, a mutually unsuspected and unsuspecting civilization whose differences from our own were left to one's fancy. In contrast, most scientists and educated laymen fully expected the mystery side to look much like the familiar side, i.e. a complex pattern of lighter crater-pocked highlands, and darker mare planes, seas of congealed lava-basalt.

Suddenly, on October 4, 1959, two years to the day after the orbiting of Sputnik I - the Soviet probe Luna 3 in an equally epochal feat, returned the first crude low-resolution photographs of the previously unknown hemisphere which showed at once that while this newly revealed hinterland of Earth's faithful; orbit-mate had the familiar elements of lighter highlands and darker plains, the proportions were

startlingly different, and unsuspected. While the basaltic floods cover a major portion (37%) of the hemisphere that charms Earthbound lovers, creating the "man-in-the-moon" naked eye visage, these lava upwellings have pooled in only a few small and scattered basin bottoms on the aloof side, making it far less photogenic.

At first, no one could suggest a plausible reason for such a surprising variance. But further probes revealed some salient facts. First, the Moon was not all that round. Rather it was slightly egg-shaped with the pointy end facing Earth. Second, the Farside *did* have great basins just like those on the nearside: the South-Pole_Aitken basin is considerably larger than the familiar Mare Imbrium, the Sea of Rains. But these basin were largely "dry" - not flooded with post-impact upwellings of lava. So these basins are categorizes as *thalassoids* - "sea-like"rather than *maria* - seas. Only a few basins-within-asins are thinly and irregu-larly covered with mare-like floods. (I like to call a small, irregular, and isola-ting pooling of mare-like deposits a *diluvium* [plural *diluvia*] from the Latin word for flood.



Further orbital data eventually suggested a partial explanation. On the Earth-facing side, the lunar crust is perhaps 60 km (37 miles) thick, whereas it averages closer to 100 km (62 miles) thick on the private side. Thus the molten magmas of a younger lunar interior had further to go to reach surface release.

Why this crustal different? In the absence of hard data from Apollo or Luna sample-return missions to substantiate any answer, the prevailing wisdom is that the farside crust must be substantially less dense in composition and unlike the nearside highlands it superficially resembles, so as to float higher above the underlying mantle.

It is pardonable that public and private curiosity, driven as they are by the notoriously short attention span of the media, did not allow follow-up sampling missions to these regions to fill in the pieces of what remains the great puzzle over the origin of the Moon. Is the Moon a breakaway daughter of the Earth? Or is it a stunted sister, having evolved side by side from the onset of planet formation? (the pacific basin is much too young to represent a "scar" of such an event.) Or is it a successfully wooed spouse, born and bred elsewhere in the Solar System?

The substantial differences in chemical composition between the lunar and terrestrial crusts seems rule against the first two suggestions, while a successful capture scenario has never been developed to support the third contention. A recent hybrid offering attempts to solve both constraints. According to this hypothesis, the early still-forming Earth was hit at just the right angle by a "Mars-sized" planetesimal (how can anything "Mars-sized" be "-esimal?") vaporizing a significant portion of proto-Earth's pristine crust, the volatile elements escaping in the process to account for the chemical differences (the Moon's crust being generally volatile-deficient) and the heavier refractory elements recondensing in Earth-orbit to form the Moon. This new thesis is gaining widespread currency and might be called the Eve theory (i.e wife from husband's rib.) I propose we call the suspected "Mars-sized planetesimal" *Velikovsky*. Apparentntly we are now to believe such billiard-ball events respectable, so long as they are surmised to have occurred in conveniently early eons!

I remain unconvinced, for two reasons. First, in the absence of plans (except by the World Space Foundation) for probes to Sun-hugging Mercury that could answer the question, I feel that Mercury's crustal composition may be similarly volatile-depleted and bear a far closer match to Lunar element and isotope abundance patterns than the above hybrid thesis can explain. Second, the new impact residue theory leaves totally unaddressed the reasons for the great font-back hemispheric topographical and crustal symme-tries in the Moon that were pointed out above.

Rather I would offer instead that this nearside-farside asymmetry is an accident of capture, an encounter with an aboriginal Earth satellite retinue that remain undigested because the Moon was already far along in its differentiation and consolidation at the time, being perhaps the one last major planetesimal forming in Mercury's orbital domain that instead of being assimilated to the quicksilver planet was ejected from its orbit by Mercury in a close flyby pass whose action-reaction relic is Mercury's present atypically high orbital eccentricity and inclination, not to be expected so close to the Sun. In the absence of contraindicating Mercury sample-returns to disabuse me of this notion, I believe that the new dessicating-vaporization-splashout myth of lunar origin has severe weaknesses. To boot, few question Mars' capture of Phobos and Deimos.

[Illustrations taken from "{Planetary Science: a Lunar Perspective" by Stuart Ross Taylor, pp. 266, 267, and 346] MMM

MOONSPORTS

Moon Sports

by Peter Kokh < kokhmmm@aol.com >

One can easily think of non-team sport activities that might work well on the Moon: gymnastics, swimming, road rallies, and so on. Of course, you can scratch sailboating, sky-diving and other such outdoor sports.

Physical Constraints on Moon Sports

But what interests me here are the possibilities for spectator team sports. On the Moon, "sixthweight" (1/6th G) will allow balls to bounce higher and travel farther (though, middoors, air resistance will have its customary effect) and at the same time reduce players' traction, maneuvering, and braking abilities, all while momentum remains quite "Earthlike."

Promising and not-so-promising models

Even with a greatly deadened basketball, for example, the game as we know it could not be played. The bounce, even if restrained in height, would be slower, and players could not dart about the court as easily, dribbling in slow motion. Baseball, Football, Soccer, and Hockey would be similarly affected. Rather than produce caricatures of familiar and beloved sports, it would be better to start fresh, and invent substitute sports from scratch.

Better candidates for adaptation, serving as a point of departure for "designer Moon Sports" might be handball or racquetball, or its exciting distant Basque relative, *Jai Alai* (pronounced Hi-a-lye) [a game like handball, played on *a walled court* with a hard ball, popular in Spain, Latin America and parts of the United States (Florida); pelota. The ball is caught and thrown with a curved wicker basket fastened to the arm - World Book], but without the parimutuel trappings. For lunar adaptation, the side walls could be thick one-way glass, allowing spectators to sit behind.

Table tennis or ping pong, bowling, and such small-field sports as lawn bowling, croquet, and miniature golf might work well enough, but these are not substitute for the big spectator sports. What can we do now, here on Earth, to help give future lunar settlers a head start in this direction?

We would need to simulate lunar conditions. An awkward and certainly unworkable "game plan" would be to do so by tying carefully metered helium balloons to athletes' arms, legs, and torsos to simulate reduced weight and traction along with undiminished momentum. A much better idea is computer simulation, in which all the effects of sixthweight on traction, acceleration, speed, bounce, trajectory, braking, etc. could be taken into account. Gaming rules would certainly be affected. Side walls could be as important as the playing field or court customarily considered. All the elements of a proposed game will have to be varied: number of players, type of ball and/or other equipment, dimensions, rules etc. until a computer simula-tion resulted that promised exciting, ever interesting and gripping play.

On Earth, we have already taken preexisting games as points of departure and created new sports which bear only a curious relationship to their design ancestors, Thus, English Rugby is a distant precursor of American Football and English Cricket of American Baseball. On a hunch, I'd recommend any would-be Lunar contact sport designer would do well to consider Rugby for inspiration.

Income-generating sports telecasts

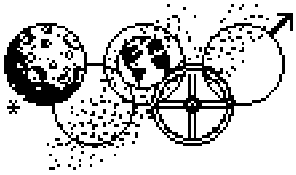
The goal is a number of sports well-enough designed not only physically but in game play to excite spectators and keep them coming back, resulting not only in whole new sections in the Guinness Book of Records, but in heightened Tourist Lure! The Saturday *Wide World of Sports* will have to change to *Wide Worlds of Sports* as telecasts of Lunar sporting events to Earth become commonplace and finally bring home to "Joe Six-Pack" in his Earthbound armchair that, yes, the "world" has expanded to include new turf.

Such telecasts could be a source of considerable income to the settlements, adding in both royalties and purchases of commercial time for sponsors. And here and there will be the young Earthling who will crave to try these sixthweight sports, which he/she can now only passively watch, kindling in them the first ardors of a yearning to join the settlers someday. - MMM

ACTION ITEM

Let's define the above proposed "Design a Moon Sport" Computer Simulation Contest, defining the constraints on playing fields (must be in smaller pressurized structures) and find sponsors for prizes, and then widely publicize the effort! Here is one way besides the hook of Science and Physics to attract a whole new constituency of potential supporters!

[As of 7/2004, no one has picked up on this suggestion.]



The 2046 Olympics
"The Space Games"

* moon icon © Simon Rowland

Colonist Lunar Astronomy Quiz

QUESTIONS

1. How many square degrees are there in the sky?
2. Our stellar coordinates are based on Earth's equator and axial tilt. This is too home-world-chauvinistic a system to take with us to the Moon and beyond. Using celestial coordinates based instead on the ecliptic, the plane of the Earth's orbit around the Sun, is also chauvinistic but would be acceptable to astronomers on the Moon since the Moon shares that plane. But anticipating mankind's spread beyond Earth-Moon space into the Solar System at large, what coordinate system do you think a "Union of Solar System Universities" might adopt?
3. Has any astronomy been done from the Moon?
4. Who was the "Father of Radio Astronomy?"
5. What is the north "Pole Star" of the Moon?

ANSWERS

1. 4 π steradians or square radians. A radian is 67° 17' 44.80624" so this works out to 41,253°^{2} (square degrees.) This encompasses all vectors. If you are situated on a planetary surface, half of this (20,626.5 square degrees) is underfoot and half "in the sky" i.e. above the horizon.
2. The orbital plane of Jupiter, inclined to "our own" "ecliptic" by 1° 3'. Not only is Jupiter the largest and most massive planet, but close to 75% of the angular momentum of the *entire* Solar System, Sun included, lies in Jupiter's motion in that plane. That would make Jupiter's ecliptic the logical standard for the whole Solar System. Transposition of coordinates, thanks to computers, will not be a big deal. We already transpose our own to keep up with the precession of the equinoxes as the points in the sky at which Earth's poles aim rotates in a circle around the poles of the ecliptic over many millennia.
3. Charles M. Duke II, an astronaut on the Apollo 16 mission to the Descartes region, became the "father of lunar astronomy": when he took astrophoto-gaphs of interstellar gas clouds and of the ultra-violet halos around some galaxies (April 21, 1972.)
4. In the early 1930s, Karl Jansky, a young radio engi- neer at the Bell Telephone Laboratories, concerned about the everpresent static that is part of radio reception, detected a very faint but steady noise that could not be traced to any mundane source, and concludes that it came from space. By 1933 he had pinpointed the direction of the source. It lay in Sagittarius towards the center of the galaxy. He received little recognition before his death.
5. Zeta (z) Draconis, a 3.2 magnitude star some 600 LY away. [see chart] This is also the north polar star of the Sun and of the entire Solar System [read: Jovian ecliptic) and as such is the center of the circle traced in the heavens by Earth's north pole as it precesses through a circuit every 25,750 years (Polaris just happens to be our Pole Star during the present period.) Thus z Draconis is "the pole of our pole" so to speak. Perhaps in time Zeta will be appropriately renamed "Zenith Draconis". And at the opposite pole is the Large Magellenic Cloud (Nebecula Major) at "Nadir Doradus."

ESSAYS IN "M"
Focus on Farside

by Peter Kokh < kokhmmm@aol.com >

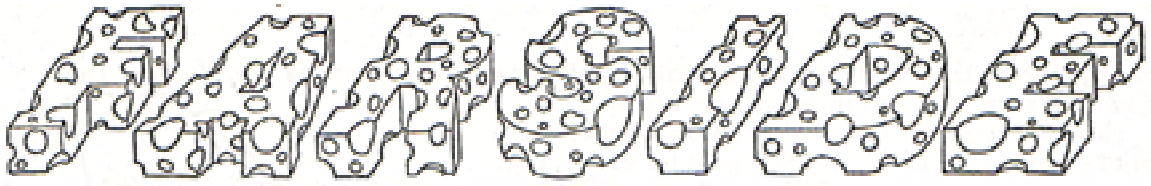
M is for Means of Transportation to and from a Farside Astronomy site.

Powered portions of rocket (suborbital or not) landings and ascents to and from the lunar surface, ought not to be allowed in line-of-sight from a Farside Radio Astronomy installation in order to avoid interference. Instead "Farport" ought to be located at the end of a surface road from the radio telescope facility at least ten or more degrees away and around the Moon's curvature [c. 200+ mi or 300+ km]. It might be best to locate Farport inside the farside zone which is within line-of-sight of the L4 and L5 Lagrange points at all times, say within 35° of the central Farside meridian. Then communications too would be routed via-surface cable to Farport before being relayed to/from the S.E.T.I. telescope facility.

M is for Monastery.

Despite serious inroads both by the age of skepticism and by the current preoccupation with self-fulfillment and self-gratification, a small hard core population remains drawn to contemplation-with-service, free from the burden of life's many distracting hassles. Such persons offer a psychologically stable manpower source that could be tapped for support of personnel at outlying lunar bases and installations (such as an isolated Farside Radio Telescope Installation pursuing the Search for Extra-Terrestrial Intelligence) where a full-spectrum-city-life is unlikely to develop. While they might not reproduce their numbers, neither would they come for limited tours of duty. They would certainly find the "atmosphere" congenial to their way of life.

Here in deep Farside, with Earth never above the horizon, with telecasts from Earth blocked by the Moon's own mass, and with the Milky Way unimaginably brilliant in the night-time skies, will be an ideal site for a monastery tasked with the S.E.T.I search.



Part II. The Ideal Site for Front-Line Astronomy

By Peter Kokh < kokhmmm@aol.com >

A popular theme of science fiction has long been the idea of using the Moon, and particularly the lunar "farside", as a platform for astronomical research. The advantages the Moon offers over today's orbital satellite astronomy are considerable:

1. Shielding over 50% of all vectors (2 π steradians), and with it, halved exposure and vulnerability to cosmic rays, flares, and micrometeorites
2. Greatly reduced radiation coming from particles trapped in Earth's magnetosphere and Van Allen Belts
3. Vastly reduced vulnerability to the swiftly multiplying trash-belt of cavalierly discarded space junk, a trend which, if not soon reversed, will eventually render LEO orbits unusable
4. A rotation rate 400-500 times slower (0.5 degrees or 33 arcminutes per hour versus 240 degrees for the typical LEO-sited facility, and with it the possibility of long exposure times of up to two weeks or more, extreme stability, and long integration times
5. Ease of access for maintenance and changeout of equipment
6. Low 1/6th g which will be a mechanical plus in comparison to both 0g and 1g and which will allow very large instruments and which also serves to scavenge dust out of the environment very rapidly (not so in the "Sargasso sea" environments of LEO, L4, and L5.)

These advantages over LEO facilities are available anywhere on the Moon. Even for radio astronomy, the Earth presents a far smaller cross-section and can conceivably be baffled out-of-sight, especially since Earth's position in any nearside sky remains fixed within libration limits of a few degrees.

Radio astronomy has been at the forefront of astronomical research for more than two decades. At first very crude in its resolving power, integrating arrays of radio telescopes can now achieve angular resolution and detail that optical astronomers can only drool over. But the problem arises with interference from man-made radio and TV signals which make for poor listening even as Earth's thermally shaky atmosphere makes for poor seeing for optical instruments. The idea, long a favorite in science fiction, has been to put radio telescopes beyond reach of such interference on the far side of the Moon. Here we can best listen to the "music of the spheres" from natural astrophysical processes and, some hope, from intelligent species, if there are any out there trying to make their presence known.

FARAF

Not just anywhere on Farside will do, however. Not only should such an installation (let's call it FARAF, Farside Advanced Radio Astronomy Facility) be closer to the equator than the lunar poles, so as to cover as much as possible of both celestial hemispheres, but it should be in the shadow, not just of Earth-direct transmissions but of indirect relayed transmissions from the L4 and L5 Lagrange areas, 60° ahead and behind the Moon respectively in its orbit about the Earth, where the Moon's version of synchronous communications satellites will be placed.

Line-of-sight exposure to L4 and L5 encroaches 60° or more (if "halo" orbits are used) on each flank of Farside thus ruling out such otherwise ideal sites as Tsiolkovsky crater, Mare Orientalis, and Mare Moscoviensis. Rather, only a central "orange-slice" between 155° E and 155° W ought to be considered, restricting outposts to 25° either side of the central Farside meridian, 180°. And a treaty or convention may be needed to prohibit the use of the L2 Lagrangian position behind the Moon for anything but intermittent tight-beam transmissions on a non-casual emergency basis only. Laser-based communications relays via L2 to Farside points are a possible substitute. If such alternative communications systems cannot be developed, it may be neces-sary to make Deep Farside off-limits to home-steaders except at, around, and in support of FARAF.

We have already mentioned some mare/diluvium-floored Farside locations that must be ruled out. Highland type sites abound, of course, and the ivory-tower ideal site at 0° latitude (the equator) and 180° E-W is on highland terrain. However, this would limit us to highland-sourced building materials and rougher topography than would be available at a highland/mare "coastal" or "near-shore" site which would offer the advantages of both kinds of soil and terrain. Further, mare-like areas will be vastly superior for such extended installations as a Socorro (NM) type Very Large Array or even for its design-archetype, the "Cyclops" Array.

Unfortunately, there is no such mare/coastal site anywhere near dead-center Farside. The site I suggest is northeastern Mare Ingenii (variously translated as the Sea of Engineers or the Sea of Ingenuity) centered about 168° E and 32° S. While this location is further south than one might wish, it will still allow full coverage of the entire Milky Way and such important nearby galaxies as M31 (Andromeda) and M33 (Triangulum). Bear in mind that, on the Moon, the apparent celestial equator will more

nearly coincide with the ecliptic -- the plane of the sun and path of the major planets.

The above photo features mare-flooded 70 mile wide Thomson crater in the NE portion of Mare Ingenii. The view is towards the south, opposite the orientation of lunar maps. Mare Ingenii is located at the "antipodes" of the impact center of the Mare Imbrium basin which is the largest basin on the Moon's Nearside. The area has a vestigial local mini-magnetosphere, probably an artifact of the plasma that flowed around the Moon in all directions to this location from the Mare Imbrium impact. This minimagnetosphere might offer some feeble protection for astronomical instruments from the solar wind.

Mare Ingenii is incompletely and thinly covered over much of its expanse with mare lava sheets. The best flooding conveniently occurs in the large (70 mi = 112 km) Thomson Crater in the ENE part of the Mare Ingenii basin. This is surely the ideal site for the next generation VLA (Very Large Array), a "Y"-shaped array of movable, tracked, steerable radio telescope dishes that can provide significant resolving power, working in concert. Ancillary smaller outlying installations for further image integration over longer baselines could be placed at convenient Farside sites outside our "orange-slice" preserve. (It goes without saying that a competing free space array anchored in L4 and L5 with a baseline of about 400,000 miles (643,000 km), should also be built and teleoperated from central Nearside.)

On Thomson's north crater rim are some small deep craters that might prove suitable for a large unsteerable Arecibo-like dish, appropriately scaled up as far as the reduced lunar gravity will allow. Nor need our Mare Ingenii-Thomson site be restricted to radio astronomy. Dedicated optical/infrared observatories concentrating full-time exclu-sively on the two Magellanic Clouds, the major companion satellite galaxies of our Milky Way, lying at (LMC) and near (SMC) the lunar celestial south pole and always above the horizon from our proposed FARAF site, are a logical adjunct.

What about the supporting settlement itself? Not only will astronomers and technicians be needed, but also support personnel to grow food and maintain the life-support systems, in short a whole community of eventually some hundreds. And what about a name for the place? Thomson City? Or tired, stuffy names related to the history of radio astronomy or SETI such as Marconi, Sagan, Jansky, Spielberg, or New Socorro? Personally, I'd like to see something more suggestive of the special vocation of this unique settlement such as *Sussuri* (Latin for 'whispers', i.e. of the stars) or simply *Stellarum* (Latin: 'of the stars').

Sussuri would have a very distinctive ambience. Earth would be out of sight and out of mind. The sunless fortnights would be dominated by the Milky Way in spectacular unrivaled brilliance. The whole mentality would be outward-oriented, astro-empathic, in tune with the stars (and any supposed intelligent species circling them). A major hobby will be brainstorming end-runs around the restrictions imposed by the speed of light and the shortness of human lifetimes. The psychological distance of Sussuri from Earth and its flesh-pot distractions will be far greater than any physical quarter million miles. For some, not all, of course, Sussuri could be a stimulating place to live out one's years. MMM

The original article is online at:
www.asi.org/adb/06/09/03/02/010/farside.html

We hope you enjoyed this first volume of Moon Miners' Manifesto Classics

We hope to produce two volumes (each covering 1 year or 10 issues) every July and January.

We have separated the material covered into two volumes to keep the file size manageable.

Your comments are welcome

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