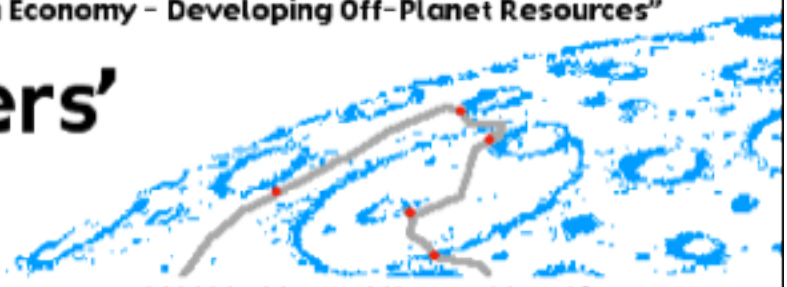
"Towards an Earth-Moon Economy - Developing Off-Planet Resources"

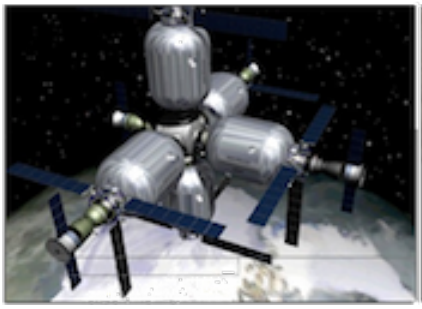
Moon Miners' Manifesto



www.MMM-MoonMinersManifesto.com

MMM Classic Themes — **Touring The Moon**

A Compilation of Relevant Articles from MMM's first 25 years, issues 1-250



As of end of year 2009, lunar tourism is already a near term option. Russia had announced that it would take a tourist on a loop-the-Moon tour that included a 2-week stay at the International Space Station, for the sum of $200 million, with two years notice, needed to build a logistics module to mate with a Soyuz capsule for the trip. Next, Space Adventures, partnering with the Russians, announced a $100 million loop-the-Moon tour, skimming over the heavily cratered farside during daylight, but without a stop at ISS. This would presume Russia had already built the needed logistics module.

As the Age of Space Tourism unfolds, prices will come down at all levels, edge-of-space, low Earth orbit, orbiting hotels and resort complexes, and loop-the-Moon tours. As the first tourist landing on the Moon would not require building an outpost, but be an Apollo-style "picnic" - "take pictures, leave only footprints" affair, it could occur before the first space agency manned landing to erect an outpost.

Next tourists will demand a place to stay at on the Moon, and at first a simple "hostel" would do. And perhaps the lunar lander crew cabin could be amphibious - with a deployable chassis and motor. Winched down to the surface, it would drive to the hostel and dock, lending the latter its galley kitchen, toilet, and life support systems (the hostel being big dumb volume: sleeping, eating, and recreation space.) For excursions, the lander would undock from the hostel and visit nearby craters and rilles, then taxi back to the rest of the landing rig for the journey home.

Once the lunar frontier opens to settlement, any tourists will want to visit these lunar towns. As more settlements are built in other areas, the pioneers will be motivated to make each different: different architectural styles, different plants and gardens, different cuisine, and so on, all to attract variety-seeking tourists and the added income and prosperity that they will bring.

The Moon seems monotonous only to the unobservant. When you have seen one crater, you will not have seen them all. There are rilles, plains, crater central peaks, permanently shaded craters and last, but not least, lavatubes. In time tourist facilities and concessions will facilitate visiting all these features.

On Earth, there are tourists who pay for the privilege of working, on "architectural digs," for example. This is something we may see much of on the Moon. Some tourists will pay to explore, to help build, to help prospect, and more. Tourism will be a cornerstone of a young lunar economy. **MMM**

[**Note:** The reprinted material below is not organized by topic or theme, but by order of publication sequence. Also included are some articles that deal with **aspects of frontier life that will attract tourists and their dollars**. Some of these articles suggest that it may be up to us space enthusiasts and entrepreneurs alike to help predevelop technologies that can make all this happen.]

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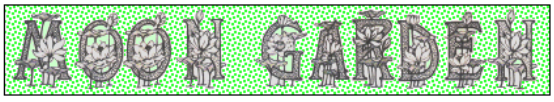
NOTE: Many of the articles included below, describe things that would be of interest to tourists visiting early lunar frontier settlements.

MMM # 2 February 1987



MOON GARDEN

[First of a series of articles on the need to predevelop the software of 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, would hardly find this conducive to morale on a lifetime basis. A settlement of colonists chosen for their indifference to the "real thing" could hardly be called "human."

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 anti-septic, but Nature is just outdoors. On the Moon there is no world of living nature just outdoors, and 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; 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 colonists to cycle light and

darkness to their gardens on an artificial 24 hr schedule. True, 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 onsite 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. (Glass, but 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're 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 even if Congress were to provide NASA and Space Studies Institute [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 engi-neering to make a Moon settlement a success. There is so much more to human civilization than that.

The work needed 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.

Meanwhile those of you who fancy your-selves possessing a green thumb, take this as a call to arms. If enough of us were to 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? *

[To learn more about the MiSST and LUNAX experimental lunar agriculture efforts that followed in the early 1990s, go to http://www.moonsociety.org/chapters/milwaukee/lunax/

The above article is online at: www.asi.org/adb/06/09/03/02/002/moongarden.html

MMM # 3 March 1987

Moon Mall

[The 2nd in an article series on the need to predevelop 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 (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 Gimbels or Schusters 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 mall the first few decades? The settlements will be small, though growing, and "upports" up Earth's steep 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 materials and resources as best they can. No one ever said pioneering would be easy. The frontier may be exciting, but like frontiers from time immemorial, it'll have 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. 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 small factories, 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 downtime 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. In this way, just as one can dial a pretty pattern by the turn of a kaleido-scope, a consumer could order a unique set of dishes or a unique bolt of fabric, to give two examples. At the least, small production runs in each of many styles could be made without extra expense. Without this

commitment to design Lunar or 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 possibilities like this 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. So there will be designer mediums, designer palettes, designer frames, and chassis, etc. The designer who leaves the most scope for unique finishability 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 popula-tion 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

By Peter Kokh kokhmmm@aol.com

A few weeks ago [January 1987] 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 foretaste 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 but a trace element on the Moon)? Not 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 top or 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. Add assorted bells and cymbals, "saws", xylophones, and even marimbas with metal, glass, or ceramic resonator tubes will work. Music is also played on keyed set of drinking glasses. And, why not the electric guitar, but 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 volume amplification needed! While the band's repertoire included 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 a space society chapter to have a small "Lunar Ensemble" to play at various public events? A steel drum or two, a xylophone, a marimba, some bells, cymbals, and castanets? You may 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

Difficulties are just things to overcome, after all. – Earnest Shackleton

A successful man is one who can lay a firm foundation with the bricks others have thrown at him. – David Brinkle

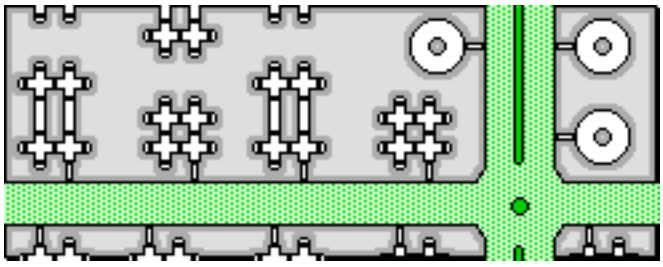
MMM # 5 May 1987

"M" IS FOR "MIDDOORS"

On Earth we have been familiar with the distinction between indoors and outdoors for many thousands of years. In the recent decades, 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 (the "nightspan") to fluctuate 10° F on either side, say from 55-85° 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 become!



Section of a neighborhood: individual homes open onto pressurized "middoor" streets that host most of the settlement modular biosphere.

LUNAR ARCHITECTURE

[4th in a series of articles on the need to pre-develop "Software" for 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 space station and burying these in the moondust.

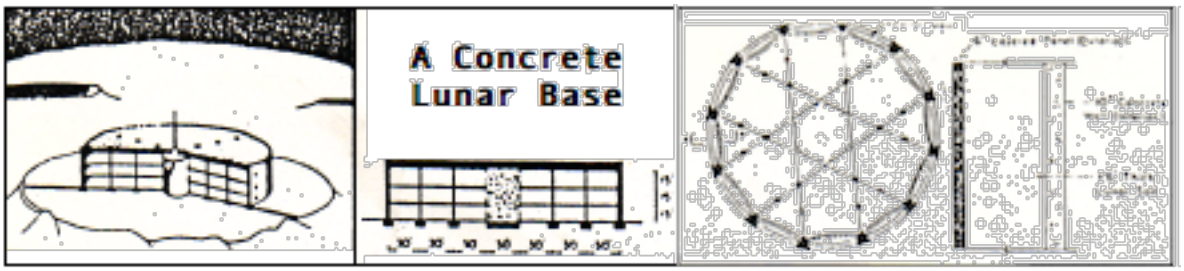
A less expensive method of erecting a base of similar limited scope is Dr. Lowell Wood's plan (of Project Columbus) to use inflatable kevlar bags (air pressure would be more than enough both to inflate them and to support the overburden of protective soil).

[This research would lead to NASA's SpaceHab Project, whose technology was then licensed to Bigelow Aerospace after Congress zeroed out the TransHab project from NASA's 2000 budget,]

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 initially possible. T. D. Lin's proposed 90,000 square ft, three level, 210 ft diameter concrete structure might be ideal 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.



If expansion is to be an afterthought, it will end up being a forgotten dream. Such a truly Lunar base might be large enough to support the open-ended goal of developing non-token Lunar agriculture, pilot materials processing industries, and production-scale 100% Lunar-sourced building materials and construction/erection equipment and methods. 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 duty) 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 start, "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 brick masons and carpenters for interiors, but they have no place in erecting the pressure shells of Lunar indoor and ”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 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, unpost-ponably. Anyone can handle sardine-can living for a limited time. But for those who are looking at staying long term, this is not a prospect to be enthused about. Add-on space will be difficult, risky, and expensive if it involves removing shielding already in place and maintaining pressurization throughout the construction. 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 the 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 prefabricated space station habitat module spaces. Even if manufactured on the Moon, they would be more energy intensive in their construction and almost guarantee a stiflingly stingy allotment of cramped space in turn for the ever unfulfilled promise of more spacious quarters "when the settlement can afford it."

A limited amount of technological home-work 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 (Tom Meeks of the U. Tennessee). This would be ideal for road surfaces, floors, and airlock aprons. We know that the soil can be melted into cast-basalt tiles ideal for flooring and other uses, with 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.

http://www.moonsociety.org/chapters/milwaukee/mmm/mmm_1.htm

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

ESSAYS IN "M"

“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 (there will undoubtedly be protocols). When the two match-ports are aligned and locked vehicle-vehicle or vehicle-city, the narrow (less than 1 cm) vacuum gap will be slightly over-pressurized allowing port doors to unseal and open easily inward into vehicle or 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 3 common match-port sizes: one for personal surface vehicles, one for public surface transports, and one 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.

Defeat is not the worst of failures. Not to have tried is the true failure.
- George Edward Woodberry

MMM # 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 home world.

From a Lunan’ 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 there 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 this period 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 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 that 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° 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° (12° 11' 27"). 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°. 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 will returned to the same dates of the year after 19 years (228 calendar months = 235 lunar months). The Metonic period is important for anyone who would devise a calendar to respect the 29.53 day lunar month or sunth, and yet reconcile it with Earth's 365.25 day year at least periodically. **MMM**

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 that is of the four season cycle.

On the Moon, however, the four seasons do not apply -- except for astronomers. The over-arching pacer of life will be 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.

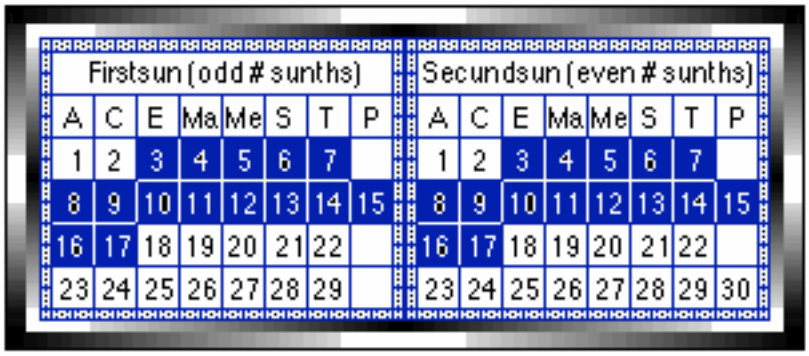
Keeping the standard 24 hour day/date

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.



Firstsun (odd # sunths)							
A	C	E	Ma	Me	S	T	P
1	2	3	4	5	6	7	
8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	
23	24	25	26	27	28	29	

Secundsun (even # sunths)							
A	C	E	Ma	Me	S	T	P
1	2	3	4	5	6	7	
8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	
23	24	25	26	27	28	29	30

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. Here are three (of many) 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 stars 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.

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.

P.S. Fiscal Considerations

For Commerce with Earth, it may be more practical to use the common Earth Calendar, yet shipments in either direction may have to pay some attention to whether the shipping or receiving point on the Moon is sunlit or not. **MMM**

MMM # 8 September 1987

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; honeybees 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 much 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 -- could 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 always have two or more) 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. Student associations could sell goat products 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

COLONIST'S QUIZ on Plants and 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 Settlements?
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 1991 ABC made-for-TV lunar helium-3 mining settlement movie 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!
   [This diversity will mean that once a visiting tourist has seen one lunar town, he/she will not have seen them all!]

The Quiz and article above are online at: www.asi.org/6/9/3/2/008/animal-life.html

PARKWAYS

Pressurized Greenways within Lunar Towns

[Sixth in a series of articles on the need to pre-develop 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 carefully chosen "urban wildlife"; last but not least, flowering and blossoming plants to support honeybee colonies [Australian stingless species?]

Such a utilitarian selection (here is where the software predevelopment 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 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 Consi-derations 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 "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 town's biomass & biosphere.

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

MMM # 9 October 1987

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 sidewalls could be thick one-way glass, allowing spectators to sit behind.

Table tennis or pingpong, 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 sixth-weight on traction, acceleration, speed, bounce, trajectory, braking, etc. could be taken into account. Game 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 simulation 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 that bear only a curious relationship to their design ancestors, Thus, English Rugby is a distant precursor of American Foot-ball 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.

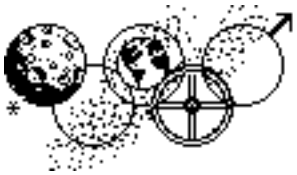
Income-generating sports telecasts

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. Those thinking about a future tourist visit to the Moon might want to include some of these unique sporting events in their itinerary. 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 growing 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 lunar frontier supporters! [As of the end of 2009, no one has picked up on this suggestion.]



The 2046 Olympics
"The Space Games"

* moon icon © Simon Rowland

APPAREL

EVERYDAY AND OCCASIONAl MADE-ON-LUNA CLOTHING FOR THE EARLY SETTLEMENT

By Peter Kokh

PROHIBITIVE COST of imported clothing: the need to maximize "lunar content"

When token humans first return to the Moon, their clothing will come with them and be resupplied from down-the-well as necessary. Once the limits of the beachhead are burst and settlement begins in earnest, it will become necessary of success to cut avoidable upports to the bone. What about clothing?

The most important consideration is fabric content. Only fiberglass with currently limited apparel applications is totally Moon-sourceable. Baring (and/or until) discoveries of and access to sources of supposedly Moon-exotic elements such as hydrogen (H), carbon (C), and nitrogen (N), fabrics that contain the smallest proportion of these in comparison to Moon-sourced oxygen (O) will be the cheapest to manufacture on location.

Most synthetics besides rayon consist of H, C, N, and even chlorine (Cl) almost exclu-sively, and there will be no advantage to making them on the Moon. Indeed, considering both the amount and nature of the waste byproducts of their manufacture, such fabrics are most cheaply made and imported from the source worlds of these elements: Earth at first, then possibly the Martian moon Phobos, or an Earth- approaching carbonaceous asteroid. Without any growth-defeating subsidies, such fabrics as nylon, orlon, dacron, acrylic, polyester, etc. will be quite expensive in comparison with Moon-grown cotton, especially since they are not biodegradable or recyclable (except by incineration with attendant nightmares for small biospheres) and represent possibly permanent "banking" of these precious elements - permanent withdrawal from the mini-biosphere. The early settlement might well put such synthetics on the contraband list. Does the frontier begin to look "rough?"

COTTON to the rescue?

Fortunately, cotton is still the most versatile and comfortable fabric known to man. It can be made into many forms: broadcloth for shirts, muslin & percale for bedding, flannel for shirts and nightwear, velour and velvet and chintz for upholstery, terry for towels - the list goes on. Before you breathe too deep a sigh of relief, however, be aware that some of our modern processing techniques for cotton will likely be taboo on the Moon. Mercerizing treats cotton yarns or fabrics with caustic alkali under tension, in order to increase its strength, luster, and affinity for dyes, is an example. It renders cotton less biodegra-dable. Modern colorfast dyes are derivatives of coal tar, and both in themselves and in the application process, "contaminate" the fiber further. Not all bleaches are ecology friendly. Where does this leave us?

Taking Clues from Earlier Frontiers

Settler resourcefulness with cotton will not need to start from scratch. We need only to turn back the clock to an earlier age for a whole litany of ways to treat and embellish cotton wear. To start with the seed fiber itself, not all strains are the same natural white. Egyptian cotton is rather beige or tan in hue. By including several strains of cotton, a natural cotton-palette of shades could serve as a starting point. Might genetic engineering come up with cotton pre-dyed with such natural colorants as indigo (denim blue), henna (red-orange), chlorophyll (green), etc.? This could be a useful, ecologically respon-sible line of experimentation. If we began experiments now, we could conceivably make a lot of money in the terrestrial "green" market among the growing numbers of environmentally aware consumers.

Where bleaching is desirable, gentle bleaches such as prolonged exposure to sunlight, or more probably, (with less side-effects injurious to the fiber) hydrogen peroxide (H2O2), a

cousin of water. Vat dying of the yarn or finished fabric or item can be with done with biodegradable indigo, henna, and other naturally occurring vegetable pigments. Lessened exposure to sunlight, and more extensive use of sonic laundering methods might prolong the half-life of these gentle colorants

At home, settlers can take bolts of material or finished items and tie-dye them, use biodegradable "paints", etc. Batiking, which works best with unsewn yard goods, is another possibility.

Premium on Efficient Fabric Use

Since lunar cotton still represents a 50% investment in "foreign" hydrogen and carbon, there will be strong incentive to use it efficiently. I am reminded of the yearly contest run by POPULAR SCIENCE for designs in plywood: the most important criterion was most efficient use of the whole sheet or half-sheet as the case may be. Patterns to be featured in books for the lunar home sewer will likewise take care to use the whole of the required yardage. This may mean "fuller" garments or accompanying accessories made of the same piece: ensembles. Any scraps can be used for doll-making, patchwork quilts, oval-braided and other rag throw rugs. These latter items will also be the next stop for worn-out clothing items. Beyond that, if care has been taken in processing, will be full biological recycling.

Role of Early Settlement Enterprise

Instead of home-dying and home-sewing, yard goods stores will profitably include do-it-yourself dying and sewing areas with libraries of pattern and how-to books and hovering adepts. Because of the small size of the market, pre-dyed goods are likely to be available only in staple solid shades. Variety will be introduced by end users or by entrepreneurs willing to produce limited runs of prints, etc., on speculation or on commission.

Pre-sewn finished items in common sizes and colors will be available as something to fall back on for those too busy or disinclined to fashion their own wardrobes. The penalty will be a somewhat uniform look. For everyday apparel, this may be tolerable for most. But for some, some of the time, and for a few, all of the time, personalizing embellishment of “standard issue” will be important.

Getting Fancy -- Adornments

The least expensive personalizations and perhaps the most versatile will employ all lunar materials: self-colored (metal oxide) fiberglass fabrics for appliqués, shoulder wraps, and other add-on, wear-over items; medieval and cheerfully anachronistic chain-mail wear-overs for formal occasions; American Indian style glass-bead belts, pocket flaps, cuffs, collars, etc.; macramé shawls using glass and metal beads; metal and glass composite (non-brittle) sequins; buttons of colored and marbled glass, cast basalt, cut and drilled breccia rock, metal, dried and carved peach pits (a lost Chinese art); tassels of colored yarn, or even shorn human hair; etc.

You begin to see that settler resource-fulness will be much aided by a complete reference library to ethnic and folk methods of the pre-modern era. The effect will be a greater library of “anything-goes” than we are used to in modern society where our seemingly endless variety operates within subtle fashion dictates.

Inter-Settlement Trade & Specializations

Outlying settlements (road stations, specialized mines, etc.) may specialize in particular processes or fashions, developing them to a salable level. At any rate, Luna City will become the Paris of Space. For its wears will be the cheapest to import or copy for those living in Low-Earth-Orbit (LEO) or other Cislunar free space settlements.

Next to the Skin

Those not used to cotton underwear will have to forego silk and nylon, etc. If it is decided not to import elastic or Spandex banding, multi-snap boxer-style waistbands may be needed. Bras may be hard to come by, nylon hosiery as well. But there will be ample other means of accentuating and highlighting sexual differences.

Beyond Cotton?

Beyond cotton? Linen, better used for bedding, tablecloths and upholstery, is also a pure vegetable fiber and is cost-competitive with cotton. Rope making fibers fit the same class. If wool is to be introduced eventually, cavies (Peruvian Guinea Pigs) and goats are alternate sources. These may be introduced primarily for meat and dairy products and the availability may be restricted enough to add a market premium on such wool, over and above what is warranted by import-content.

Tourists from Earth to the rescue!

Wiling incoming could, on their trip out to the Moon, wear items made of fabrics unavailable there, and exchange them for made-on-Luna equivalents, duty-free. A "pressure valve" lottery and other means of allowing Lunan pioneers to win or purchase such imported exotic fabrics and special apparel items could be set up. This "trade" would be a win-win for both tourists and settlers: duty-free souvenirs for tourists; import-fee surcharges for settlers. The mass of such goods coming and going should cancel each other out.

Tourist-settler barter on other items impossible for the latter to buy on the Moon, might also be arranged. Thus Earth tourists could alleviate some of the rough edges and restrictions of life on the Moon.

Incoming settlers fresh from Earth can get into the act by wear borrowed costumes for the journey, which upon arrival would go to theater wardrobes and/or to masquerade costume rental stores, it being bad taste to wear such terrestrial items except on very special occasions.

A settlement-run lottery might award vouchers for rationed imported fabrics in lieu of cash prizes for a healthy outlet to the frustrations of usual choice restrictions.

[in MMM #15, May 1988, NSS Chapters Coordinator Aleta Jackson sends her constructive comments. See "THREADS" reprinted below.]

The Moon will be an interesting place to live, and to visit. -- Peter Kokh

MMM # 15 May 1988

RURAL LUNA

By Peter Kokh

If the Moon, all 14.5 million square miles of it, is not "rural", what is? To be sure, the first beachhead bases will be preoccupied with doing Lunar Science and successful demonstration and pilot plants that produce Liquid Oxygen from moon dust. Such footholds will hardly amount to small "hamlets".

But upon first expansion, the Moon bases will concentrate on feasibility demonstrations of various forms of lunar-sourced construction; they will then proceed to the manufacture of a spectrum of building products for use locally, in Earth orbit, and in Mars orbit. Leveraging on these beginnings, if we make a serious effort to fully diversify on-Luna manufacturing to exploit the LEO and Mars markets, then one or more genuinely urban biospheres will arise.

So back to the question: given this incipient "urbanization" of one or more lunar sites, will there be any room on the Moon for homesteaders who prefer more elbow room and looser ties to civilization?

Well beyond the outskirts of "The City" (until there is more than one, locals may not pay much attention to proposed proper names), there may be a growing number of mobile nomadic science & prospecting camps searching for economically abundant concentrations and deposits of useful elements that exist only in taunting traces in the soils around The City. If such lodes are found, new settlements may be founded to mine and ship them to urban factories or to render them into marketable products on the spot.

Depending on the market for any such products, the new site may remain a rural village or grow to become a rival city. Bear in mind that rich concentrations of specific ores are not to be expected on the Moon. On Earth, most ore deposits have been laid down in multi-million year long episodes of hydro-tectonic leaching, a process probably unique to Earth and Io in our Solar System.

Yet we may find relics of the impact of particularly mineral-rich asteroids. But there are different soil types: highland soils, and a variety of mare soils deposited by success-sive episodes of lava flooding. Further, some crater central mountain peaks may be upthrust mantle material such as relatively dense pyroxene. The prizes may be useful concentrations of copper, platinum, lead, etc., all of which, would be unlikely, however welcome.

Both underneath sites well known for the reddish glows of TLP (Transient Lunar Phenomena) and elsewhere (where there are no leaks) there may lie deep underground pockets of unreleased volcanic gases or volatiles. No matter what their composition, detection of these reservoirs will likely lead to new home-stead locations. Particularly harvestable water ice and/or carbon dioxide ice deposits (when mixed, called 'clathrate') will call for at least temporary encampments as well.

Thus a number of lesser towns or even rival cities may develop, all feeding the local lunar economy, which in turn supports ventures in Low Earth Orbit, and in the Mars PhD area, and sooner or later in the L4/L5 locations. Roads will be built apace, and along them, at intervals, will be needed way stations that support road maintenance, fuel stations, vehicle repair, closed life support system recharging, flare shelter, inn-space, food, first aid, communications, etc., and probably serving not only travelers and truckers along the main routes, but also off-road excursions for tourists, prospectors, and scientists.

Where the beaten path takes a long detour about some obstacle such as mid-mare wrinkle ridges, rilles (ravines resulting from the collapse of lava tube roofs), or sand scarps, for example, is it not plausible that entrepreneurs might build bridges, fjords, or cuts and rightfully establish tolls for the shortcut they provide? Here and there, the run-of-the-mill lunar scenery ("once you've seen one crater, you've seen them all" will be far from the truth) is relieved by some exceptional vista e.g. the Alpine Valley, the crater rims of such unique beauties as Tycho, Aristarchus, Copernicus, and Theophilus come to mind; such spots may support tourist inns.

A site along the east or west limb (90° east or west) will afford monthly Earthrise and Earth-set (caused by libration resulting from the Moon's eccentric orbit about Earth). The Earth will rise a few degrees clear of the horizon and a fortnight later be a few degrees below it, affording "twin skies": half the time a picture-window postcard scene of the Earth-kissed horizon, half the time (with Earth out of sight) the Milky Way will fill the sky with a brilliance we can only imagine. Here, especially along preexisting roads, would be a good spot for a honeymoon motel or a get-away-from-it-all retreat house, etc.

On the bad side

But not to wax too romantic, there will be dampening facts of lunar life. Firstly, to insure that there is a sufficient economic basis for such rural locations, a lunar authority would do well to license them, restricting them to minimum intervals depending upon current traffic volume projections.

Survival without traffic support will be far, far more difficult than it is on live-off-the-land-friendly Earth!

Applicants or applicant groups for rural openings may well have to bid for them, based on skills, abilities, talents, experience, and financial resources.

At first the niches for such rustic rooting will be few, but they should grow exponentially as the multi-site economy expands and diversifies.

Yet hermitages and single-family mines, inns, or farms, etc. may be both unsafe, and unendurable. The reason is that unlike on Earth, where we all share the same biosphere,

on the Moon, each city, town, village, hamlet, camp, and isolated homestead must be a biosphere unto itself. And the smaller the biosphere, the less stable, less diversified, and less satisfying the sustenance it affords.

Unless you and yours are stoics content to live on chlorella and algae mush, there will be a certain minimal size to any such isolated biospheres. o support a bare minimum exchange of service functions and division of labor as well as menu variety and social outlets, the village-sized, or at least hamlet-sized, island of humanity will likely be the smallest the Moon could support. As in lunar towns and cities, individual residences, greenhouses, workplaces, etc. will all be interconnected by pressurized passageways to afford the convenience and safety of integrated biospheres.

And you thought the Moon would be the ultimate get-away-from-it-all! Best head for some of the less settled areas of good old Cradle Earth! Our challenging gray neighbor may have room enough for small towns and villages, but the antisocial need not apply.

On the good side

Such rural settlement as does occur will undoubtedly provide opportunity for diversification of food crops, meat animals, ornamental plants, and specialized arts and crafts. Separation combined with ingenuity and diverse mineral endowments will suggest unique feature products for which the town or hamlet may someday be renowned.

A rural subculture will surely arise. Radio, folk song and dance, and country ballads, as well as its own special etiquette, brand of hospitality, and other "ways" will instantly distinguish lunar rustics from city people.

But they will share the Moon, a common bond which will set them uniformly apart from Earthsiders. The future of both urban and rural Luna will rise or fall together.

For the city dwellers, the existence of a number of rural communities will be both a safety valve and a constant source of cultural cross-fertilization and enrichment, as all Lunar citizens seek to continue their accul-turation and adjustment to the new home world.

For the tourist from Earth, Rural Luna will offer a variety of off-the-beaten-path experiences to treasure for a lifetime and to brag about to fellow tourists who only visited the Big City. What is more, they will come home not only with photos and videos but with souvenir arts and crafts food preserves, clothing and other items not available in "Luna City." – Take it from an experienced off-the-beaten-path traveler!

The adventure, both for the pioneers and for visiting tourists, should not be boring.

-- Peter Kokh

More on Made-on-Luna Frontier Apparel

[See "Apparel" from MMM #13 above]

By Aleta Jackson

I am a long-time SCAer: Society for Creative Anachronism.[1] Part of the joy of being an anachronist is researching period clothing. I have learned to card, spin, dye and weave my own cloth. I've studied the fabrics and dyes used in various cultures and continents. If you can get some SCA people together for a weekend brainstorm about Lunar clothes, you will probably come up with some really dynamite ideas.

i think you're wrong about silk; silk last a long time, masses very little, and has many applications, even after it's starting to rot, which won't happen unless you severely mistreat it. It won't evaporate like poly-ester. It's strong and elastic even under extreme temperatures, and can take tremendous punishment.

I bet someone on the Moon could make a bundle of money importing silk clothing items.

[Think tourists, as mentioned above. By wearing silk clothing to the Moon and exchanging it for made-on-Luna clothing, the steep import cost and tarrifs are avoided.]

And eventually a silkworm farm might be a great industry in some rural hamlet. [2] And mulberries (the leaves form the diet for silkworms) make tasty pies, too.

And don't forget ramie, a vegetable fiber. Combined with rayon (which was developed to replace silk during WWW II and which I love almost as much a silk) it makes a lovely fabric. Ramie combined with linen (from flax), cotton and silk produces fabrics that take dyes very well. It also helps "wick" sweat from the body into the fabric and so promotes evaporative cooling.

Another vegetable fiber that combines well with cotton is agave. I bet you can find all kinds of uses for agave, which thrives in desert conditions. I have an agave bedspread that has been through the wars and is as soft and supple and lovely as new. I grew up in Arizona, where we grow both agave and cotton. Cotton takes a bunch of water. Agave is a water conserver, produces a good beverage, flowers, and fiber.

You can get some really neat dyes -- deep, rich, long-lasting colors -- from minerals mixed with everyday biodegradable chemicals such as urine, which is useful for all sorts of things. [3] I no longer have my wonderful dyeing books or I'd be able to write the formulae here, but check your local spinning guild [or the arts and crafts section in your local library]; I bet they'd be really interested in lunar clothing possibilities and they might have good suggestions.

Drawstrings have worked nicely for centuries, and I still make a lot of my pants with them. Skirts, too. Comfortable bras can be made by combining drawstrings and cleverly woven cloth that has been cut to give as the same "give" of elastic. Sometimes better and longer-lasting that elastic, it's what was done in the old days.

Unless, they're redesigned, what you will probably have to give up is zippers and return to laces and gussets, which aren't made from valuable metal or easily degraded plastic.

For a bleach substitute, dilute lemon juice and put the soaked fabric in sunlight which will work wonders. That's how I bleach my find hand-woven linen Rumanian blouses and dresses. Which brings up a question you may have answered but I've missed: "whatcha gonna do for soap?" [4]

Sincerely, Aleta Jackson

Editor's notes:

[1] The SCA adds much color to Science Fiction Conventions.

[2] Silk requires extremely labor-intensive unraveling of zillions of silkworm cocoons. If machines can be invented to do this task well, we may have an enterprise proposition.

[3] A Junior exhibit in our recent SW Wisconsin High School Science Fair showed good cotton-dyeing abilities for coffee, tea, onionskins and beats; and poor results with spinach and carrots.

[4] ? We'll have to look into that one

MMM # 16 June 1988

JEWELRY

Dressing Up in the Settlement with "Made-on-Luna" JEWELRY

By André D. Joseph and Peter Kokh

For some, nothing in life could be more unimportant or irrelevant than jewelry. They would prefer to do without, thank you. For others, it is a matter of putting on the dog, of asserting status, class, sophistication -- something more than individuality. Then there are those gypsy-kindred souls who only seek cheerful decoration and for whom the true or perceived market value of their baubles is meaningless.

No Gold, Silver, Platinum, or Copper --- Using Iron, Aluminum, Magnesium instead

What materials can Lunan artisans use to create ornamental items to wear? The time-honored jewelry-making metals of Earth - gold, silver, platinum, copper - and their alloys will be extremely hard to come by as they would seem to be present on the Moon only in minute, non-concentrated traces. Magnesium can be worked if it is heated to about 400° F but is dangerously reactive with the oxygen in the air [magnesium is the basis of fireworks.] But Aluminum, that once precious but now mundane and pedestrian commonplace, can be worked cold. So we might assume that some aluminum alloy would become the metallic medium of choice for the jewelry maker in Luna City. But bear in mind that iron will be the cheapest metal to produce on the Moon and here and there in Earth's past it has been pressed into service of adornment.

Diamonds and Gemstones

Given rediscovered metals to work with, what can be added? It is probable that diamond dust of meteoric origin is a widespread trace. But diamonds of visible size seem unlikely, as they are constituted carbon, with which the Moon is not naturally endowed. What about synthetic diamonds and cubic zirconium?

In time, perhaps, when there are enough settlers and enough demand, many other gem stones such as ruby, sapphire, amethyst, agate, onyx, jade etc. might possibly have formed at great heat and pressure deep within the Moon and brought towards the surface, as on Earth, by past episodes of volcanism. The elements for their recipes are certainly present, But we won't find them on the highly pulverized surface. Just possibly, future Lunan "spelunkers" will find some here and there in the lava tubes we know to be present in the layers of solidified mare lava sheets. If not, synthetic rubies and sapphires can be made from aluminum oxide (corundum.)

Pearls?

At a premium representing the non-native carbon ingredient, pearls could be cultivated in lunar oyster beds. At a similar premium for non-native carbon content would be dried and carved peach pits, a Chinese art form, and small decorative items made from such hard and richly grained orchard woos as apple, pear, and cherry. Indeed, given its character and the pressures for not withdrawn it in quantity from the biosphere cycle, would might be one of the most sought after media for bauble-making on the Moon or in free-space oases.

Ceramics and Glass

By far the cheapest "stone" will be such all-native-content creations such as glazes ceramics, synthetic crystals and clear colored glass. Gems of "paste" are actually a very hard form of glass with a high lead content. Lead will be quite scarce and potash glass might be the next choice. Another route will be vitreous enamel glazes on metal similar to cloisonné but filing carved bas relief bays in the aluminum rather than bays created by superimposing gold wires on a brass base.

As was already mentioned in a previous article "Apparel" [MMM #13] glass beadwork and metal chain mail will certainly be viable forms of expression for frontier artisans. Perhaps, too, some ordinary moonrock breccias, when cut and polished will have satisfying appeal.

Play Jewelry

For temporary recyclable "play jewelry," gaily colored papier maché items, glitzed up with seeds and kernels, would be one choice. And a necklace strung with bits of pyrites (FeS, fool's gold) might bring a smile to any Lunan lass.

Concentrating on the practical

Jewelers might concentrate on more prac-tical items such as buttons, belt buckles, hair clips, scarf rings etc. than on purely super-fluous items as necklaces, bracelets, rings, broaches, and earrings. Making artfully what must be made anyway is a more honest function, and this sort of values will be a badge of the frontier. Exported Lunan jewelry, or items brought home by visiting tourists, of will serve mostly a souvenir function, until the proficiency of Lunar artisans working in new media comes into its own.

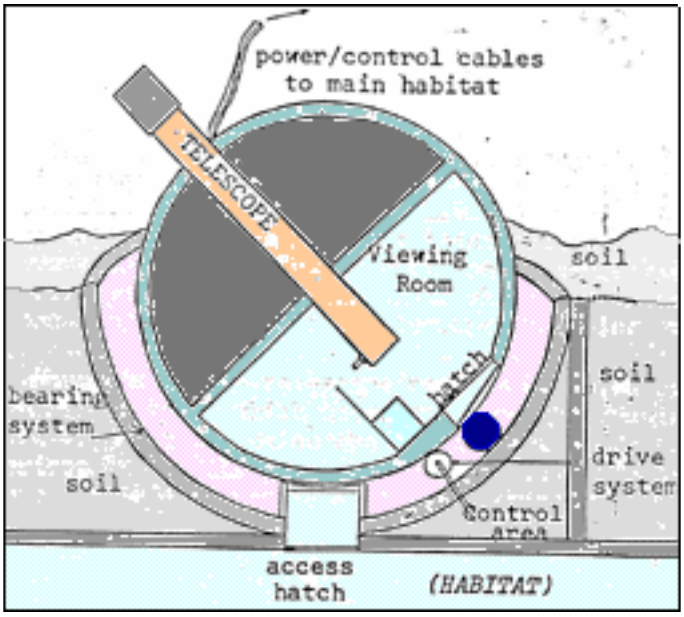
Again, tourists to the rescue! Visitors from Earth may not want to bring precious jewelry to the Moon only to be traded item for item with the souvenir quality "jewelry' made on the Moon. But they might wear well-designed and crafted jewelry made of less precious materials, such as can be found at many arts and crafts fairs. As an even exchange free of import/export duties and associated transportation costs, this kind of barter would enrich the lives of Lunan pioneers and visiting tourists alike. MMM

MMM # 20 November 1988

AN AMATEUR LUNAR TELESCOPE DESIGN

Tourist Forward: Many a lunar tourist will be an amateur astronomer on the side. They will wonder how, and indeed it, their hobby can be practiced on the Moon. Surely, you can't put on a space suit, go outside and look through an eyepiece while wearing your helmet!

Visiting one or more local amateur astronomers is likely to be high on their visit to-do list. After all, all one's fellow amateurs back home will want to know!



Submitted by Milwaukee School of Engineering (MSOE) student and MLRS member **Ron August** of Hubertus, Wisconsin, this concept involves a moving, spherical shaped viewing room, with the telescope an integral part of it, that is completely pressurized, heated, and accessible from the habitat below. Entrance to the room is by way of an airtight hatch system.

Once inside the viewing room, the observer will be strapped into a viewing chair that has all controls for movement of the telescope (and viewing room) and focusing of the telescope.

Movement of the telescope/room is achieved by a controller wheel that moves the room into position to point the tele-scope at anything above the horizon in all directions. The room is suspended by a low friction smooth-running bearing system.

This was the winning design in a competition cosponsored by MLRS and the American Lunar Society. Two other entries received honorable mention, including one in which a zenith-pointing telescope had its base within the habitat, the shaft piercing the regolith shielding and open to the vacuum. The scope turnes in a sleeve using a barometric liquid seal and surface mirrors to redirect the view.

[See MMM #17 "Liquid Airlocks" reprinted in MMM Classics #2, pp. 32-34 – this pdf file can be freely downloaded here] www.moonsociety.org/publications/mmm_classics/

NOTE: The editor has been well-received by astronomy club audiences over the years for his talk on how future settlers will pursue their amateur astronomy hobby. He has also stressed that through human presence, we will over time learn much more about the planets and moons.

< **MMM** >

MMM # 21 December 1988

Earlier than you think! -- Lunar Overflight Tours

By Peter Kokh

To be honest, it will be a long time before you can go to your local (or any other) tourist agency and book a two-week tour on the Moon. Even after we have returned to Sol III B [The Moon]to set up permanent bases and installations, even after actual settlement has begun, facilities for tourists may be a while coming.

All the same, within a decade of the start up of tours to LEO, Low Earth Orbit, flyby "overflight" tours out to the Moon will begin. All the talk of micro-gravity processing aside, the real gold mine in space may well be tourism, once new vehicles bring access costs down. Now there is simply not that much of a jump from tours to LEO to following in the trajectories of Apollos 8, 10, and 13 which took three crews out to the Moon without landing, as in the classic novel by Jules Verne. In brainstorming ways to bootstrap an economically profitable return to the Moon, would-be entrepreneurs should not overlook the comparatively low threshold to lunar overflight excursions.

Perhaps you think the prospect of paying good money for a lunar odyssey sans 'Moonfall' would be too much of a tease and disappointment to attract much business? Read on. We offer this future fiction scenario set 20 years from now in 2008. [Well, we were off a bit here.

My Flight on the A.F. Jules Verne

Future Fiction By Simon Cook

The sleek “silver sliver” of our Boeing 8O8B Columbiad gently eased off the rocket sled trolley that served as its 'first stage' at the end of its track at Jose Marescal Aerospaceport just north of Quito, Ecuador and began its streak for orbit. (At 9500 ft. elevation and smack on the Equator, Quito had become the first civilian gateway to space, serving both the Americas. Similarly advantaged, 8600 ft. high Nairobi fills the same need for Europe, Africa, and western Asia. The third gateway, serving East Asia and Australia is Singapore whose sea-level handicap means smaller payloads and fewer passengers to orbit.)

Within the hour the Columbiad pulled up to the new Orbitel SupraTropicana, owned jointly by the three gateway aero-space-lines (Ecuatoriana, Aerospace Kenya, and Singapore Aerospacelines), Terre-Lune (say tehr' loon') Excursions Ltd., and Motel 6 ("the only luxury you want to pay for is the view”). At 1000 km or 600 miles up, the SupraTropicana is the highest orbiting man-rated orbital facility yet built. This avoids the need for periodic reboosting caused by the drag of the tenuous upper atmosphere, but the real rationale behind the orbit choice is that following a zero inclination equatorial orbit, the guests of the orbitel would otherwise see only a narrow swath of the Earth below, repeated over and over - a slice through South America, Africa, Indonesia, and lots and lots of water. But at this higher altitude, at least the entire tropics lie within the orbitel's horizons.

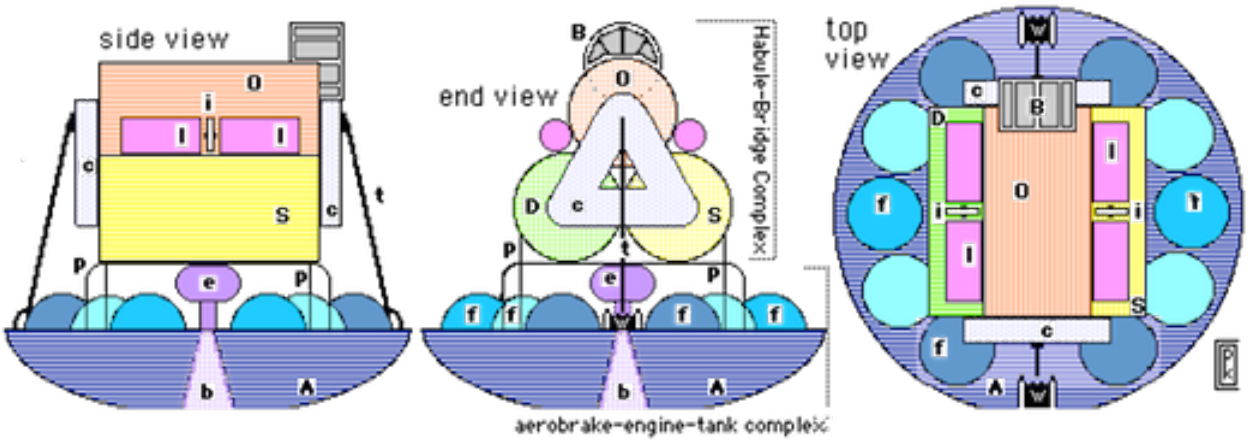
A few hours in the SupraTropicana calms us down from the excitement of the boost up from Quito, and allows us to get our space-sickness medication adjusted. We all enjoy enjoy the Olympian view.

The 36 tourist class passengers and the 12 crew class (we get a fare break for one time service as ship personnel, after a bit of training, of course) are welcomed aboard Terre-Lune Excursions' flagship, the A.F. Jules Verne, by its permanent staff of two, the captain and 1st officer. This arrangement (a crew class in which paying passengers assist) drastically cuts overhead and allows TLE Ltd. to offer more for the money. At these prices, that's a must!

The Jules Verne is quite a ship. The 'A.F.' stands for aerobrake ferry. A ferry is any spacecraft capable of plying a regular route without, however, ever landing anywhere. It is meant for space alone. Being equipped with an aerobrake means it can return from deep space and use the friction of a low-angle graze of Earth's upper atmosphere to shed enough velocity to skip back out neatly into the desired orbit. As the aerobrake apparatus weighs a lot less than the extra fuel, the ship would otherwise have to carry for deceleration, an A.F. has more capacity for cargo and passengers, and that is what pays the bills.

She is a beauty -- once you come to appreciate the elegant efficiency of her design! For she is ungainly next to the **Transatmospheric Columbiad** and doesn't at all remind one of the great spaceliners conjured up by science fiction writers.

At the 'bottom' is the gentle curve of the wide aerobrake shield that has shutters that open to expose the exhaust bells of the rocket engines. Above the aerobrake, are the engines, fuel tanks, and the umbilical tether-cable reel and winch. On a platform above all this sit two of the three cylindrical habitation units or 'habules' (the initiated simply call them 'cans') built by Occupod and brought up on the Hercules Heavy Lifter. One of the habules is a sleeper-lounge whose name plaque reads Moonlight Sonata. The other is the diner-lounge with the pretentious French name (no reference to the cuisine!) **La Vache Sautante** (say la vahsh' soh tahnt') ("the jumping cow").

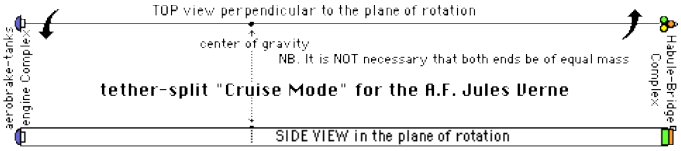


Above, nestled between these is the third habule, the “Claire de Lune” ("moonlight") observation-lounge with roll-top shutters over vista windows along its topside, used during the lunar over-flight, and petal-shutters over the end cap windows which offer views of the receding Earth and approaching Moon on the way out, vice versa an the way back. (Why the ship cruises sideways you'll see shortly.)

Concourse between the three habules

is via a triangle of pressurized passage-ways at either end, the modest bridge being attached to one of these. So this gives you some idea of what the JV looks like during power mode, during the lunar overflight in which it is upside down to afford the fullest view, during aerobrake maneuver, or buttoned up for flare protection, aerobrake towards the Sun. But this only covers a few short periods.

For most of the three-day cruise out to the Moon, ditto on the way back, the ferry is in cruise mode. The habule-bridge complex is then released from its platform, while remaining attached to it by a tethered harness attached to the ends of the observation-lounge (the top one on the stack). The complex is then rotated so the bottom two habules are furthest from the aerobrake-engine-tank complex, and the tether is reeled out a couple hundred meters, while the thrusters on the engine complex start the counter-weighted system slowly rotating at a rate that provides 1/6th gravity enough to make the passengers and crew comfortable and at the same time give them all a chance to experience what being 'on' the Moon itself would be like, vicariously.



On the return, however, with the lunar experience behind them, the tether-split ferry spins the first half of the return at a rate twice as fast to give all a foretaste of Mars, and finally spins up to full Earth-normal gravity to ease their adjustment going home.

Hot-racking is the rule on board, no exceptions. Each berth must be shared by two passengers in rotation. Morning people like me, those who find getting up easy if not altogether a joy, sleep first from 1600-2330 hours ship time. We can retire as early as 1430 but must vacate the berth promptly so the crew class passengers can get them ready for the next shift, the night people, those who find getting up distasteful. They have the berths from 2400-0730 but may tarry untill 0900. (A surplus of either 'morning' or 'night' people is handled first by volunteers and then if necessary, by a draw.)

From 0800-1530 everyone is in either the diner-lounge or the observation lounge. Ship time is set so that the periods when everyone is up coincide with departure from LEO, the lunar overflight itself, and the final return approach to Earth. Time-sharing the facilities allows the

ship to carry twice the number of passengers it could otherwise handle, or to put it another way, charge only half the exorbitant fare it would otherwise need to show a profit.

Terre-Lune Excursions Ltd. goes all out to provide a real 'lunar experience' and I do mean all out. Providing 1/6th G on the way out is only part of it. No opportunity to enhance the atmosphere is overlooked. The three habules are all furnished with materials that the early lunar settlements should be able to fabricate from the soil. This even goes as far as the color scheme: only those coloring agents, metal oxides and ions that the early settlers will be able to extract economically are used. Furnishings are thus mostly of glass-glass composites (Glax™), sintered iron, ceramics, softened by crudely processed cotton, and fiberglass fabrics. Ceramic glazes, stained glass and green plants provide most of the color.

This decor is called "**Lunar Dawn**" in Terre-Lune's promotional brochure. (One of the crew class passengers is a settler-recruit who cheerfully explains all the options open to the settlers in adapting to their chosen home-to-be; naturally, I spend a lot of time plying her with questions.) Add the 1/6th gravity, and those on board are getting a very genuine preview of life in the early settlements. And you thought all we were paying for was an up-close view of a monotonous expanse of cosmic splashprints!

I should say something about the food in "**La Vache Sautante**" ("Jumping Cow") diner. Even here an opportunity to set the stage is seized. When tourists sign up for a cruise, they are all given a list of available food items and asked to check their preferences and preferred combinations and to select from a list of menu items accordingly. Only those food items that an early settlement might expect to raise in its own farms are included on the list. So the variety available excludes all the more exotic choices to be readily had on Earth. Chicken, rabbit, or cavy for meat and that only as an accent, talapia for fish, vegetables and fruits, some herbs and a little in the way of spices.

Beverages include water, vegetable and fruit juices and a few simple fruit juice-added seltzers and herbal teas. But this limited selection gives a healthy and balanced nutrition and variety enough. Now the ship cannot stock to meet every combination of whims. For each meal, each passenger gets to order (and check off the list) only from the food he/she has preordered before boarding. Towards the end of the cruise one's selection becomes limited to what is left. The wiser passengers reserve some treats for last.

Even the games and reading materials aboard are in a form reproducible by an early colony. Now to be sure, some of this 'lunar experience' could be reproduced on Earth, but out here with no distraction or escape, plus the low gravity, the total effect is intense.

We're nearing the Moon!

Finally, after three full days pre-viewing the lunar frontier, we are approaching the old girl herself. Our anticipation is high. This is, after all, the climax we paid for. Slowly, the thrusters despin the tether-split ship and the spring loaded tether reels in our habule-bridge section. Once back together and secure and gravityless, the ferry turns so that its top, the still-shuttered vista windows in the ceiling of the observation-lounge are kept Moonwards.

As it happens on this particular cruise, the Moon is between the Earth and the Sun, or new, and the nearside is dark. Once we are almost opposite the limb and the Sun is off to the side, the shutters open just in time as we approach the sunset terminator now over Mare Orientalis, the great bullseye basin on the western limb. We are still about 800 miles above the surface at this point, but the long evening shadows add dramatic relief to the wider field of view below. Farside is fully illuminated for overflight. What a treat! But I am getting ahead of myself. Before the shutters are opened, those of us who want a filtered experience are fitted with special heads-up display helmets, a spinoff of military technology thanks to espionage which had made continued classification of the technology a joke. These smart helmets scan both the field of view and the direction of the eye's focus and then neatly yet unobtrusively appear to overprint on the lunar landscape the names of whatever features catch your attention for more than two seconds. The heads-up display also gives the estimated ages of the more prominent bright-ray craters we see, as these fascinating features are far younger than the rest

of the 3 1/2 to 4 billion year old surface. With the helmets to provide information, silence is requested and expected during the overflight. An yes, pointing is allowed!

A few refuse the helmets. They want to be fully absorbed in the raw experience of the awesome magnificent desolation of the lunar terrain below (or is it above?). Terre-Lune encourages direct observation, that is to say they discourage preoccupation with photography. The ferry's own cameras are making a very complete record of the whole overflight and can be pro-rammed to pay particular attention to pre-specified features. Videos and slides and prints of this coverage can be purchased from the company for a low fee. Cameras are allowed but we are urged to use them to record on board life, and to keep them shuttered during the overflight itself.

Quietly we glide over the Mare Ingenii-Thomson crater area where robot rovers are even now surveying the site for the proposed Farside Advanced Radio Astronomy Facility (**FARAF**). Someday this ferry and others like it may be delivering electronic mail to FARAF, as a relay satellite at the L2 Lagrange point behind the Moon is frowned on. As planned, this is the very lowest point or periselene of our overflight. We are skimming just 50 miles above the surface. Even though there are no other clues to the scale of what we see, you can tell we are closer by the quicker rate at which the moonscape is whizzing by.

Then we pass over what is easily the most striking feature of Farside, the crater Tsiolkovsky with its very dark mare-filled floor and bright massive central peak. Twenty years ago, crater central peaks were unnamed. Now they are given the first name of the person for whom the crater is named, where applicable. Here, we see Mt. Konstantin.

We have just been informed that the Jules Verne is about to launch a resupply pod destined for one of the nearside bases. This one contains medical supplies, some requested seeds for the farms, specialized tools, and other low weight high value items. Such cargo drops help defray the cost of our passage and perform an invaluable service for the pioneers below.

All good things come to an end, they say, and so we approach the eastern limb at Mate Smythii and the sunrise terminator, and there above the rugged morning-shadowed horizon, Voilà, the Full Earth which so rivets our attention we forget to take a last glimpse at the moonscape below before we slip past the terminator into darkness. Reminded, we now scan the inky blackness below each intent on being the first to catch site of the beacon at Base Two in western Mare Crisium before the vista window shutters close and we revert to the tether-split cruise mode for the 'downhill' coast home.

During next few hours, a few or us talking excitedly, sharing our private experiences. But most of us are quiet. There is some feeling of anticlimax, maybe a hint of mild depression. But the bigger part of our complex mood is simple silence, in an attempt to absorb, assimilate, and relish the flood of visual input.

Not all cruises aboard the Jules Verne are like this one. Some are timed with either the waxing or waning Half Moon (and Half Earth!) None are timed for Full Moon as that would mean that all of the farside would be iin darkness and everyone wants to see some of that area forever hidden to Earth-bound eyes.

But then there are talks on Moon-Mars differences to go with the Marslike gravity now provided for ambiance, and we begin to come out of our withdrawal. A shipboard wedding between two of the passengers certainly helps! To the familiar lilting strains of Christopher Cross' classic “Arthur's Theme” and its great refrain "When you get caught between the Moon and New York City, the best that you can do is fall in love", it is an unforgettable moment.

The closing portion of the cruise features talks and discussions about the disturbing state of the environment on the almost deceivingly beautiful globe slowly growing ahead beyond the petal-windows at one end of the Claire de Lune. The captain draws our attention to subtle indications we otherwise would have missed of growing desertification, recently clear-cut tropical forest lands, and heavily polluted oceanic currents. I begin to see the deeper significance in the name of the cruise line. This has been not merely a trip 'from' the Earth to the Moon, but a rendezvous with both. [written in 1988]

As in the cruise mode on the way out, our axis of rotation points parallel to our path. At last, still four hours out, we come out of cruise mode spin and secure for the aerobrake maneuver, half of us in the berth restraints, the others strapped in reclining lounge chairs. It is a nervous and tense moment for most of us. It may be routine for the Jules Verne but every last one of us signed on green.

Suddenly the g-forces we feel ease and we free-fall back out to the Orbitel. The Boeing 8O8B is still docked, awaiting our return, with no other assignment during the past week. Her crew and the staff of the SupraTropicana quiz us with an ill-suppressed hint of envy. it's been the experience of a lifetime, and with this sneak preview under my belt, I've lost all hesitation. I am definitely going to apply to the Settler Recruitment Office the first chance I get. **I'm going to go back! MMM Five years later** ... lol!

MMM # 43 March 1991

By Peter Kokh

For the watchers on the ridge, it begins with an arcing flame of light punctuating the still dark eastern horizon -- part of the solar corona, something that the atmosphere-coddled Earthbound can never see, except during locally exceedingly rare 'total' solar eclipses. The Sun's intense disk is now still below the horizon, but this great prominence announces its imminent arrival onto the moonscape.

Here on the Moon, the Sun rises with great deliberation. From 'first contact' when the first diamond glint of light from the solar surface itself breaches the horizon, until 'last contact' when the entire blazing disk has just cleared, the Sun takes sixty ceremonial minutes to make its entrance. For such is the slowness with which the Moon turns on its axis to bring the Sun into view. (On the fast turning Earth, this show is run through in fast forward so that it amounts to no more than a two minute skit.) Two hours later, the Sun will have cleared the horizon by only a degree. It will not reach the far horizon, 180o degrees away, for another 14 3/4 days, better than two weeks.

But already this first standard day of the new sunrise, there is a noticeable shift in settlement activity and a quickening of its pace. Within a few hours of first light, solar panels and/or solar dishes, and the many sun-tracking, grabbing, and channeling heliostats will have all locked on to its life- and energy-giving rays.

The Sun is both workhorse and taskmaster for the little community. With its return, added electrical power surges online. Solar furnaces melt charges of raw, or refined, regolith for the productions of sundry items from cast basalt, ceramics, glass, and glass-glass composites or Glax™. The concentrated rays are also put to work sintering iron fines scattered abundantly in the loose regolith blanket, and collected with a simple magnet, into assorted useful pieces using powdered metal technology. And either directly through focused heat, or indirectly through electricity, industrial-strength sunshine begins cracking water reserves back into hydrogen and oxygen for use in fuel cells aboard field vehicles and, stockpiled until sunset, for reserve night-span power generation.

"Make hay while the Sun shines!" Not only does the pace of mining, processing, manufacturing, and field activities such as construction, road building, and prospecting, rise dramatically, but so does that of farming and home sunspace gardening. Plants emerge from their 'subsistence diet' of reduced artificial lighting during the nightspan, thrive anew and

resume their progress towards eventual harvest. For most of the base personnel or settler population, the tempo of life has significantly accelerated.

More people venture abroad, “out-vac”, either for work or just for a welcome change of scenery, excursion vehicles being the popular choice over cumbersome spacesuits. “Selenologists”, still lazily called ‘geologists’ by their chauvinist Earth-tied colleagues, venture out of their labs to collect fresh samples in the field.

Habitats and pressurized common spaces (the “middoors”) are flooded with soul-warming sunshine, thanks to the heliostats that filter out both the unwanted heat of the infrared and the harmful fury of the ultraviolet rays. Stained glass and prisms turn sunbeams into a painter’s palette and interior and middoor surfaces take on a new glory. Walls, finished with a cheap whitewash of CaO lime or TiO titanium oxide suspended in a waterglass medium of hydrous sodium silicate, make an ideal canvas for these rainbow-bright live paintings. Greenery, its verdant hues more vivid after ‘breakfast’, completes this characteristic settlement color scheme.

Oases of park space tucked into crannies of the various food-raising areas are thronged during free time. Schoolyard recess is imbued with renewed spirit. Those going to and from work along pressurized passageways lined with carefully chosen plantings seem to smile with a subtle new radiance.

Any ship carrying tourists will arrive while the Sun illuminates the area. Perhaps most of the visitors will stay to experience the full rhythm of settlement life, and depart during the following dayspan some three or four weeks later.

Long forgotten is the ho-hum grudging routine of daybreak on Earth, oft’ equated with life before coffee. Here the Sun’s glorious presence transforms everything through and through. For the fourteen plus 24-hour days of dayspan, the life of most settlers will be one of especially earnest industriousness. In every field of dayspan-reserved activities, there will be important production goals to meet if these brash settlers are to “set themselves up” for the quite different, but complementary, routine to follow. MMM

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NIGHTSPAN

For the previous two plus weeks, this unlikely pocket of humanity on the Moon has been a beehive of activity, making use of the Sun’s heat, its life-giving rays, and its electrical generating potential, to work through the more energy intensive portion of the long list of tasks needed to keep the community going. For total available on-line power will drop measurably as the Sun finally reaches the western horizon.

While the light available on the surface will remain full-strength until the final two minutes, ‘down below’ the level of redirected sunlight will have begun to taper off the past day or so as heliostats on the surface, even arranged in purposely staggered rows, begin to eclipse one another, cutting off solar access.

Industries dependent on harnessed and concentrated sunlight will have been located to avoid this problem, so they can keep working on full throttle for the full duration of ‘sun-up’. Finally, however, the great solar furnaces and turbines will be shut down and the activities they support will stop. Those industries that depend indirectly on abundant electricity generated by solar arrays must likewise phase down. For whether supplied by standby nukes, fuel cells, spinners, or hydroelectric generators (where rille or crater slopes allow the possibility of pumping up water surplus by dayspan to let it fall during the nightspan), the total amount of on-line electrical power will be likely be appreciably reduced for the fortnight to come. Industry after industry will switch gears, taking up now the rather more labor-intensive tasks that it had strategically postponed during dayspan.

Maintenance, repairs, and change-out of equipment; assembly and finishing; packaging for shipment; bookwork and inventory; - for many workers, it will be rather like switching jobs every two weeks. And perhaps that will be a welcome break in the routine, an anticipated and appreciated periodic shot in the arm, an essential element in sustaining personal and communal morale.

Workers who by dayspan crew those industries that do not have a proportionate list of postponable energy-light labor-heavy tasks to keep them busy during nightspan, might shift to quite different company co-owned ventures that are task-lopsided the other way. Unneeded farm workers might move to food-processing duties etcetera. Continuing education, especially in the line of one's work, might be preferentially scheduled for nightspan.

The Sun now set, Lunans, temporary personnel and permanent settlers alike, will find more leisure time for arts and crafts and cottage industry pursuits. Music, dance and other performing arts will vie for attention. Now there may be more time for shopping and flea market barter. Perhaps only necessities will be bought and sold during dayspan when able persons are best occupied building up export inventories to defray import costs, and producing domestic items to reduce import demand.

Fresh new pioneer recruits may have arrived shortly before sundown. This will give them a taste of what dayspan settlement life is like, saving more intensive orientation for the nightspan when extra senior personnel will be freed up from other duties to devote themselves to this task.

The public spaces of the settlement - its mid-door squares, streets, alleys and passageways - might be more crowded during nightspan with people free to linger leisurely and enjoy activities for which there was little time the two hustling weeks before. Such places will come alive with entertainers and soap box orators, artists and craftsmen selling their wares or demonstrating their talents and taking in serviceable but prosaic "issue" items for customizing makeover into items of pride, hucksters selling similar items on commission, second-hand stalls and exchanges for recyclable items, shelves of produce harvested from in-home gardens and specialty jars of preserves put up by enterprising home-canners - you get the idea.

Ambience provided by electric lighting can take several forms. Great electric lamps might use those same sunshine-delivery systems slaved to heliostats during dayspan to provide periods of simulated daylight each nightspan 'day', with subtle mood-setting lighting for nightspan 'nights' (night life and sleep time).

And color? Colored bulbs as well as stained glass diffusers and dividers will be one way to provide a magically cheerful touch. A harvest of neon and other noble gases adsorbed from the Solar Wind to the fines of the Moon's regolith soil blanket, and recovered by heating during the routine soil-moving processes of mining, road building, and construction, could lead to ample and creative use of neon lights. The "Greek Isles" look of the community's middoor and indoor spaces, in which sunlight splashes whitewashed walls accented with luxuriant greenery, will be upstaged now by quite a different enchantment after dark. It seems unlikely that our future Lunans will fear the night!

At last, the end of the long nightspan will draw near, and the final evening meal of nightspan may become a special one in settler homes, filled with anticipation, maybe even ceremony: "Sunrise Eve"! MMM

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Will Lunans mark the days by the Month or by the

It should be clear from the above pieces that the arrival of sunrise and, a fortnight later, of sunset will radically determine the scheduling of almost every activity within a lunar

community beyond eating and sleeping and making love. Given that most Lunan industries and enterprises must stop to shift gears at both sunrise and sunset, it will be of no small benefit to their efficient operation to schedule “weekend” breaks so that they always fall at the same time in relation to these all-transfiguring events. As the Lunar settlement will be “under the gun” to produce enough exports to balance the cost of needed imports, as well as enough domestic goods to minimize that import need, achieving such smooth operation is not a goal to be dismissed .

But here’s the rub. Sunsets repeat every 29.5 days (twice every 59 days) or 12 times a year with 11 plus days left over. The Jews and Moslems have such a calendar of “lunar months” (a tautology, when you think of it). But the Romans, while inappropriately keeping the word, altered the “month” so that an even dozen fit in each solar year. For us on Earth, where the really significant repeaters, affecting business cycles as well as agriculture, are the seasons whose onset is determined by our annual orbit around the Sun, quite irrespective of the lunar phase of the moment, the solar “month” (that grates!) makes sense.

If the word “month” is no longer ‘honest’ for our calendrical tomes of 28-31 days, neither does it fit the sunrise to sunrise period on the Moon itself. From the viewpoint of one on the Moon, it is the Sun’s aspect which is significant. Hence our suggestion [“Calendar” above] that the term “sunth” be coined for the purpose. Astronomers use the term lunation, but as this properly refers to the new moon to new moon period (that is, reckoned from local sunrise at 90° East), it is not sufficiently generic, and again inappropriately refers to the Moon, not the Sun (we would accept Lunar Solation).

Back to our question. Will future Lunans mark the days by Earth’s months or by the local sunth? Perhaps they will use both calendars side by side, or a special calendar with dual dating. To visitors from Earth, as to those serving temporary tours of duty with no intention of staying for the rest of their lives, the Earth date will be the “real” date, as if our arbitrary notation were some cosmic fact. Even “tory” settlers (those who have made the move in body but not in spirit) will feel reassured by a glance at our familiar Gregorian calendar.

Meanwhile, not only will settlement life totally ignore terrestrial conventions out of practical need, but both exports and imports and the arrival and departure of tourists will pay heed to the local Sun angle (the time of sunth) rather than to the date on Earth. Business and accounting cycles for Lunan entrepreneurs will follow the march of sunths, not months. Even those businesses on Earth trading with the Moon will need to refer to the lunar calendar (or at the lunar phases shown on most ‘normal’ calendars) to help determine shipping times.

From the 59 date sunth-pair to a full “lunar” calendar is a big step, however. For adopting a twelve sunth year of 354 days would put Lunans out of synch with Earth. IF they decide that this is not important, they have three basic options. A) they can simply let their ‘years’ (or ‘calendars’) advance over Earth years without any attempt to make an adjustment, as does Islam, giving it 33 years to our 32, or B) they can add an intercalary thirteenth sunth every second or third years, as does Judaism, or C) let the differences accumulate and add 7 extra sunths at the end of every 19th year (conveniently, there are precisely 235 new moons every 228 calendar months). If this last option seems far out, it does present a neat opportunity for a once-a-generation built-in period for institutional and cultural review. Those extra seven sunths could be collectively be called “renaissance” or “renewal.”

IF keeping in sync with the year as reckoned on Earth is to be desired, sunths could be numbered 1 to 235, rather than named, in a cycle repeated every 19 years, while the year began and ended in lock step with the familiar Earthside cadence.

However the solar year/sunth incongruity is handled, using the sunth to mark the timing of events and activities within the lunar settlement will mean abandoning synchronization with the Sunday through Saturday rhythm so ingrained in us that we assume the day of the week must be a primeval cosmic framework valid in the most distant corner of the universe, even predating it, as some fundamentalists would insist. In fact, not only is the length of the day a purely Earth-local matter of no cosmic significance whatsoever, but the pegging of names to days in a certain suite with a once and for all calibration, is, however traditional, 100% arbitrary.

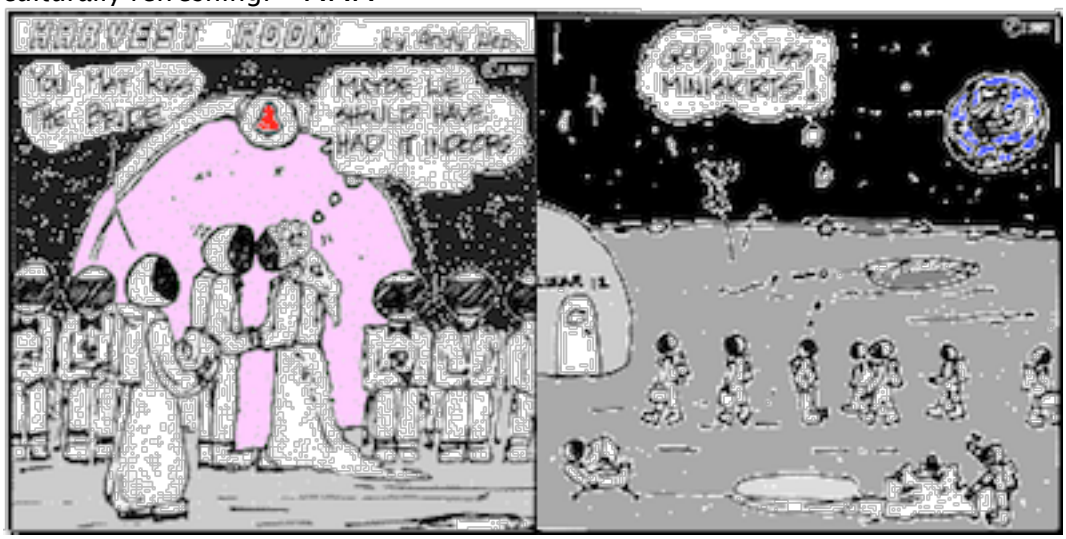
Nonetheless the week, as it has been handed down to us, is the most stubbornly ingrained piece of our "cultural infrastructure" and has survived all attempts to tamper with it.

Making the switch to sunthtime, if pursued in earnest, will mean pegging 'weekends' to this beat, i.e. an integral 4 weeks per sunth, i.e. no leftover days, with each sunth starting the same day of the week. But in every 59 day sunth-pair their are 3 days more than an even 8 weeks. An adjustment can only be made by making 3 weeks out of every 8, 8-days-long instead of 7. If each of these extra days was placed to make a long weekend, and used for all holiday observances, this would provide 18 holidays a year, quite in line with American practice, but in a non-disruptive format. A "leap hour" every 6 or 7 'weeks' would keep the 59 day rhythm from drifting, as the sunth is 44 minutes longer than 29 and a half days.

To avoid confusion (Monday on the Moon while it is Wednesday on Earth, at least this week etc.) Lunans will most likely adopt a totally new set of 7(8) names. The previous MMM article alluded to above, has some creative suggestions for the pioneers.

Another major question to be settled is whether all Lunan communities will observe the same weekend schedule, no matter how many 12o-wide 'date-zones' they lie apart from one another, or whether local week-ends will fall with local sunrise and sunset. There are strong tradeoffs and they must weigh and choose.

Such a culturally radical switch in timekeeping would neither be to the point on Earth, nor stand as much chance as a snowball in a supernova. However, Lunans will be living in a workaday environment quite unlike anything ever experienced by any Earth bound community to date. For many settlers, the need to declare cultural as well as economic independence from Earth may be strong. In some form or another, Lunans will adopt conventions of time reckoning that pay only loose homage to our week and month. The year will survive, however, not because the Moon shares the Earth's orbital motion around the Sun, but because the two worlds lie in each other's backyard, assuring a high volume of trade and real time communication*. I think it will be culturally refreshing! - **MMM**



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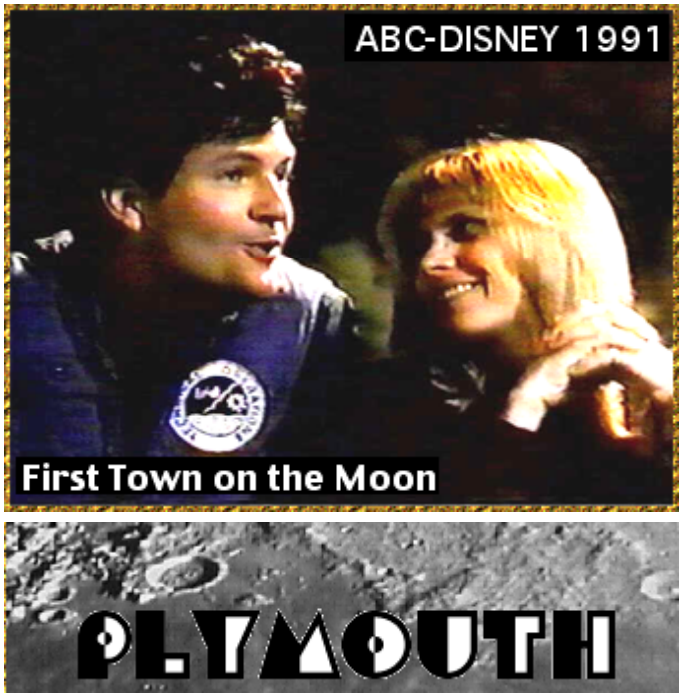


ABC Made for TV MOVIE

Focus on the Community Life of the first Mining Settlement on the Moon

AIRED by ABC Sunday, May 26,1991, and again a year later.

SYNOPSIS from Columbia Pictures Entertainment Inc.

A space shuttle sweeps across the stark lunar horizon, preparing for its descent to the desolate surface below. Once its passengers have safely disembarked, the people of Plymouth, Oregon will have completed the final phase of a five-year relocation plan to a new town - on the Moon.

Plymouth's grizzled mayor, Wendell MacKenzies (Richard Hamilton) is among the last emigrants. On the final leg of their journey, he recalls the events that transformed his family and friends into the first Lunans: the toxic accident that rendered their small logging town uninhabitable; prolonged negotiations with UNIDAC, the global conglomerate responsible for the tragedy; and the unique reparation agreement that was struck.

Besieged with labor and financial troubles at its fledgling Helium-3 lunar mining base, UNIDAC accepts Wendell's proposal: they will construct a permanent, controlled-environment community and relocate some 250 displaced Plymouth residents to run the mining operation that provides Earth with Helium-3, a pollution free energy source.

The arrival of this final shuttle reunites this tightly knit community, but could signal the departure of Plymouth's beloved town doctor, Addy Mathewson (Cindy Pickett). A widow with four children, Addy has been living for the past few weeks with the secret knowledge that she is pregnant. If she returns to Earth with the shuttle, the impact of re-entry into the Earth's atmosphere could place the fetus in jeopardy. If she remains, Addy risks the unknown and potentially dangerous consequences of pregnancy in the Moon's 1/6th gravity. Even if her baby is born without complications, it might never develop the lung capacity or muscle strength it would need to leave the Moon.

Word of Addy's pregnancy spreads through the small lunar town. Plymouth's town council convenes to discuss the problems and choices Addy and the community now face,

but the meeting is interrupted by a solar flare alert. All activity is suspended for mass evacuation to sub-lunar radiation shelters.

The first burst of the solar flare has cut off communication with the mining and engineering crew working on the lunar surface. Addy's sixteen-year old son, Jed (Matthew Brown) is one of the stranded crew members -- and there is no way of warning them.

Remembering that an old search module is buried near the crew's location and could provide shelter, Gill (Dale Mitkiff) [UNIDAC employee responsible for Addy's pregnancy and blamed by the towns-people for the crisis this has caused] tears off to commandeer a lunar rover [the first lunar hot rod put together by one of the settlers in his spare time - this is its maiden spin] and race to the work site. As the second stage alert begins, Gil fires up the buggy's rockets and shoots out across the lunar surface.

Meanwhile, Addy's precocious son Eugene (John Thornton) and his newly-arrived friend Simon (Joseph G. Levitt) have gone exploring in the Construction Zone, and are trapped behind a passageway sealed shut in response to the solar flare alarm.

With three minutes left 'til impact, a distraught Addy realizes it will be hours before she knows what has happened to her loved ones.

EDITOR'S COMMENT: How does it all turn out? You'll have to watch if and when it is aired again, or get a copy. Unofficial copies do exist on both VCR and DVD.

This is the first Sci-Fi movie (made for TV or not) made on the premise that space is a place to get resources to help solve problems on Earth.

All the right buttons are pushed and the artistic and scientific license is minimal, especially in contrast to everything put on screen prior to Plymouth. At a special screening for many of the 750 attending the International Space Development Conference in San Antonio, the wave of applause and cheering that swept through the audience at the conclusion was verdict enough. This was a crowd weary of Star Wars special effects and monster of the week series, a skeptical crowd that Writer/Director Lee David Zlatoff won over with few reservations.

The film does a lot to correct unrealistic expectations and gross misconceptions of a public used to Star Wars, Star Trek, Space 1999, and Dr. Who. Originally conceived as a series pilot [has sat on the shelves all this time, because ABC didn't think people were ready for reality. As of 2009, this film has never been re-aired, nor released on VHS or DVD - only bootleg copies exist.

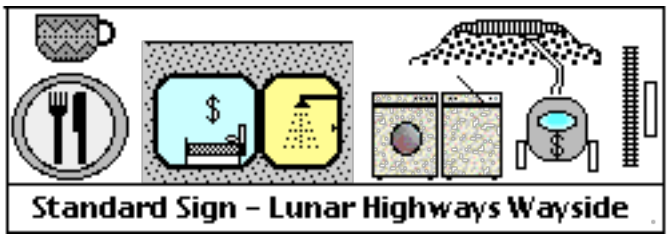
Effect of the film on space advocates, would-be pioneers, and would-be lunar tourists.

We think that this is the first realistic enough film to have a positive effect both on pioneer wannabes and on prospective tourists. It may not have had everything right, but it is close enough to give you some idea of what life could be like pioneering the Moon.

The new Plymouth on the Moon was very much like the old Plymouth back in Oregon: a place where people worked, lived, loved, and were reasonably happy. Yes the setting is different, but people's lives will be much the same with this difference: pioneering gives one opportunities to start over, start fresh, get in on the ground floor, to do things that really mean something. This has been the lure of new frontiers since humans first started wandering out of Africa. MMM

Develop success from failures. Discouragement and failure are two of the surest stepping stones to success. - Dale Carnegie

Failure is success if we learn from it. - Malcom Forbes



NATIVE BORN

NATIVE BORN

We can't wait to see if the Moon is "safe for children". Until we're sure that the 2nd native generation is healthy and fertile, we won't know. Delay will be self-defeating.

By Peter Kokh

In the recently ABC-aired Disney movie about a pioneer lunar mining settlement, "Plymouth", the

central drama was the emergency dilemma of whether to return a pregnant pioneer to Earth, risking the unborn fetus in a high-G descent, or to allow her to bear a child on the Moon that might never be able to survive on Earth. Indeed, birth of the first human offspring outside the womb-world (Birth Squared!) will be a momentous mile-stone, easily eclipsing any mere demonstration of hardware and technology. If we are to build a system-faring civilization, sooner or later pioneering humans must forsake a return to Earth and begin to raise families, to live and die in space. As obvious as that seems, many of us cling to pathways of realization that are most unlikely to allow such a natural development.

There are pro-space people and there are pro-space people. The conservative peer-conscious shadow-fearing space-proponents who abound in high places see space as an arena for technology demonstration and ascendancy, for national prestige, and yes, for exploration, robotic and even human. They do not see it as a place for out-settlement, for a cradle-break from Earth. That's something left to Trekkie fandom and other wild-eyed crazies like ourselves.

As long as our frontier-blazing activities are guided by the official wisdom of politicians concerned first and foremost with covering their butts with their similarly fretful and risk-shy constituents, its hard to see how such a decision to go ahead with a pregnancy and birth on the Moon could every be sanctioned. Those who are not personally accepting the risk cannot be expected to have anything but a distorted perspective. So there will be calls for many years of animal experiments, to see how they survive, mature, and breed, and if their issue are fertile - above all to see how well Moon-born animals survive the return to Earth. But getting our feet wet, experimenting with real humans by allowing them to do what comes naturally? - heavens forbid! [No! Heavens demand!]

It is the pioneers themselves who must accept the risks, and who can be expected to welcome them fearlessly. "Plymouth" is realistic in that official sanctions and taboos will sooner or later be ignored or foiled, and secretively or not, the first human child will be conceived and born in a lunar outpost with everyone a part of the conspiracy to keep it secret until it is to late to foil. Sometimes it is necessary to force an issue with a fait accompli. Politicians like mules, beg to be hit between the eyes with a 2x4.

The problem is, as "Plymouth" brings out so well, getting over the hurdle of trepidation and endless what-if worryings to cross the threshold of commitment to settlement - not outpost or garrison - settlement. In the rebellious tradition of the Heinlein who wrote "The

Moon is a Harsh Mistress" and the erstwhile Bova, who wrote "Millennium", there must come a time when the pioneers seize their own destiny, and accepting all risks, knowingly plunge ahead, consciously burning their bridges behind them. While the first childbirth off Earth will be a real milestone, the underlying assent to destiny by the pioneer community will be The Milestone with a capital M. This is a step no colonizing Earth government is likely to advocate or bless. Indeed aversion to such a development may be treated as a litmus test of political correctness on the part of would-be pioneer candidates, in government efforts to avert such a turn of events.

As to animal tests, experiments with small creatures with relatively fast life cycles, using artificial fractional gravity in orbital facilities, should give us an early indication of any potentially show-stopping disorders of physiological development under Moon-like conditions. These are unlikely, to say the least.

But in last analysis, we can't know for sure if the Moon is "safe for children" until we bear them there, watch them grow up and mature and have their own children, and see how well the second native-born generation does. For some undesirable traits might not show up until then. Some 20 to 40 years into the commitment to settle, the verdict will be in. For most of us, it is simple a matter of choosing to believe the most favorable outcome. The pioneers who choose to go and gamble with the rest of their lives and those of their yet unborn children, will be of like mind. There is no shortcut from here to there. "There is only do".

But why should this daunt anyone? After all, we are all involved, every last one of us, in a similar high stakes gamble that we can continue to exist as a technology using species in long-term harmony and equilibrium with our host planet - something we can't know for sure without the risks of trying.

Will native-born Lunans grow tall and lithe? I don't know. Americans of our day are much taller than our ancestors, but because of a change in diet rather than gravity. Will Lunan children and the adults they become be muscleless featherweights? This is unlikely. For mass and momentum remain the same. The likelier outcome is that musculature will be different, not less.

What about their cardiovascular circulatory systems? It will take less heart to pump blood from legs to head, but the same amount of heart muscle to power exertion in work and sports. So there might be a problem with the inactive child and sedentary adult, but it will not be as likely with those whose physical life is full.

Lunan sports will likely be new creations rather than caricatures in sixthweight of sports familiar to the Earthbound. Such sports will play to the peculiarly lunar mix of one sixth gravity and traction versus full normal momentum. Isometric exercises will be more important than weightlifting ones. Will the attempt, by those wanting to leave Earth return options open, to retain "hexapotent" (the six times greater Earth-normal level) muscle tone result in grotesquely exaggerated physiques, at least by the new Lunan aesthetic standards?

Certainly the image of the ideal male and female physiques will shift dramatically as the new native-born generation comes of age and becomes numerically larger than the immigrant population. Miss Luna and Mr. Luna will not likely appear on the same stage with Miss Earth and Mr. Earth. The pretentious Miss and Mr. Universe pageants may disappear.

Lunan standards of grace will show themselves in new dance forms, popular, ballroom, and pseudo-classical and modern ballet. You'll be able to look at someone and know at once if -he is a native-born Lunan, but that -he is human, there'll be no doubt.

After the first few years of settlement-with-children on the Moon, there will be an interesting suspense about puberty and adolescence, but hardly any surprises. The first real drama will be the rate of healthy births to native-born Lunans. How many miscarriages will there be? How many complications in childbirth itself? How many malformed infants? How many retarded? All these risks will have to be faced and willingly accepted.

There are those who feel that after eons of evolution to the tune of Earth-normal gravity, Earth-life cannot adapt. But the whole history of evolution is one great saga of adaptability after another. That we have not adapted to another gravity level is simply because the challenge of doing so has not faced us. Our prediction is that it will be no problem. The worrywarts can stay on their 1G space colonies.

But gravity is not the only thing about which there might be legitimate concern. The mix of trace elements in lunar regolith and the agricultural soils derived from them will be subtly different. There may be deficiency diseases preventable by mandatory intake of dietary supplements and vitamins manufactured on Earth. There may be some level of chromium-toxicity, varying in seriousness from locale to locale. Careful choice of a settlement site considering agricultural needs should prevent severe incidences. Will there be any late-blooming consequences? Probably nothing outside the wide range of dietary variation on Earth.

Again, we must resist the temptation to cater to the perpetually fretful, to those unwilling to cross the mental threshold from the idea of human presence in space to the idea of true human out-settlement beyond Cradle Earth.. Have children we must. And if unlikely medical or genetic disaster does occur? We will have tried. That will be our badge of honor.

[Editor's: the courageous decision to go ahead with pregnancy, childbirth, and the raising of families will be done only in settlements founded outside the sponsorship of governments who answer to a risk-averse public, letting the tail wags the dog.] MMM

FUNERALS **BEFITTING FUTURE SPACE PIONEERS**

By Peter Kokh

To date, no one has died in space, though as of 1991, at least ten (Apollo 1 and Challenger) have been killed on the way up and at least four (Soyuz 1 and Soyuz 11) have been lost on the way down. Sooner or later someone will meet his/her end in space, and unless the nature of the death makes the remains unrecoverable, be brought back to Earth for burial with full honors.

The first such deaths are likely to be individual or group accidents due either to mechanical failure or to human error or carelessness. Sudden natural deaths will also possible. As the numbers of people in space grow and the off-planet community becomes ever more and more typical of human society, crimes of passion and even calloused murders of convenience will occur. Slower acting diseases will take their toll, even after early diagnosis, as people decline passage home "to die." Some deaths will be in the line of duty, even self-sacrificial. Others will have no apparent "meaning."

When tourists start going into space, and on to the Moon, some of them will die too, even as do tourists here on Earth, wherever they go or vacation. We all expect that.

From time immemorial, countless numbers of people have met death and been laid to rest far from their homelands. The sea has claimed hundreds of thousands or more. Many a sailor and explorer lies beneath some marker on an inhabited shore on a distant island. Some have even been vaporized in nuclear explosions and scattered forthwith by the four winds. But

never has a person been born, who has not been reclaimed by the bosom of our womb world, Earth.

There is a steep psychological threshold here. Commitment of a person's body to "the void" or laying h-- remains to rest on some alien planet, moon, or asteroid will burst the envelope of our sense of "world". We will have been forced to integrate sterile off planet horizons with those of our fertile parochial oasis. If we define WORLD not as the arena of human life provided by the surface of our home planet, but as the continuous set of horizons within which humans live, work, and relate to one another, such a baptismal integration of our planetary circumsolar hinterland into the human world will become natural, easy, and inevitable.

Laying someone to rest 'out there', or on the surface of some other world or worldlet, will consecrate that place forever more as a human place.

How the remains of an explorer, pioneer, or traveler will be disposed of will depend upon circum-stances. On long deep space voyages, it will be natural to follow naval tradition and commit the body to the "Void". When storage of the body is convenient and the preference of the deceased's is known, internment can await arrival on the planet, moon, or asteroid of destination.

On Mars, traditional burial or cremation are likely options. But another interesting possibility - once the pioneer settlement is advanced enough to make it handle the logistics - is to lay the body to rest atop mighty Olympus Mons (75,000 feet high) under a canopy of UV resistant glass (to prevent blackening of the flesh) and allow it to freeze dry or desiccate naturally in the near vacuum and deep cold beneath the ever-shining stars - a "desiccatorium".

But on the Moon and similar volatile-impoverished worlds where, a) there is an established pioneer settlement encradled in a tightly recycling biosphere and where, b) volatiles are of communal economic necessity considered "rented" not "owned", options will be more constrained. A settler of means, whose estate can afford the replacement cost, at current market-deter-mined values, of the exotic/precious elements invested in the body and who so desires, should be able to be "wastefully" buried Old Planet style. While this should be legal, there is no guarantee that one's fellow settlers will not look on such a choice as obscene and insensitive. Instead the common course will be cremation, with return to the "biosphere" as CO2 and water vapor and ash.

As to the unconsumed ashes, even though they are not as precious as the C, H, and N that constitute the bulk of the body's mass, are a resource still. Again, it should be legal to place them in an urn for placement in a private or communal memorial repository.

A more popular and acceptable choice may be to have them spread on a communal memorial garden - not a garden of vegetables, but one of flowers, with no purpose but to add color, scent, beauty, and an island of peace to the pioneer community.

What if someone wishes a more utilitarian disposition? The settlement is very likely to contain experimental agricultural plots where new and improved Moon-hardy varieties of vegetables, cereal grains, herbs, medicinal and dyestuff plants are being bred and developed to improve life on the frontier. Having one's fertilizing ashes spread on such non-production experimental gardens might be another choice for disposition with full honor and due respect.

"Dust thou art," etc. (Personally, I prefer a rerendering of Genesis to read:)

"Stardust thou art, and to the stars thou shalt return!"

The point is we are of the Biosphere and the Biosphere shall reclaim us. On our cradle world where the elements our bodies incorporate are everywhere in profligate superabundance, there is no injury to "the plan" in delaying decomposition by either burial or mummification. However, in the minibiospheres that we'll need to re-encradle our existence on volatile-scarce worlds, there will be some real urgency to dust to dust reinvestment. "Banking" one's "rented" constituent elements for generations by traditional burial would be profligate waste, with a high toll on the shared cost of living on adopted shores.

For those of you with substantial means (count me out, but I wish you didn't have to) stuck against your will here on Earth, it now becomes an option to plan your estate to include a trust fund that would pay to have your remains (cadaver, or at least ashes) transshipped to the Moon when the day finally arrives that a frontier biosphere has been established there. Whereupon your elements can add to the infant biosphere's sweet air and fertile soils to contribute to the infant settlement's prospects of prosperity. Why not?

Death is a Fact of Life spelled with a big F. Yet to transcend the finality of one's mortality, one only need contribute, create, produce - in short develop one's own talents - thereby investing in the community of one's survivors, - be it only anonymously, be it only fleetingly - rather than just dissipate one's years consuming and spectating.

We can do so also by rearing and educating, however informally, and so bring life and light to those who will carry the world (new expanded sense) forward when we are gone. It is in choosing how we will extend the significance of our lives beyond their apparent ends, anchoring them in the community at large, that we find identity and give our lives meaning. It is no surprise that those who never give a moment's thought to such concerns also never find themselves, never grow to know who they are. And so it will be on the Space Frontier as well. MMM

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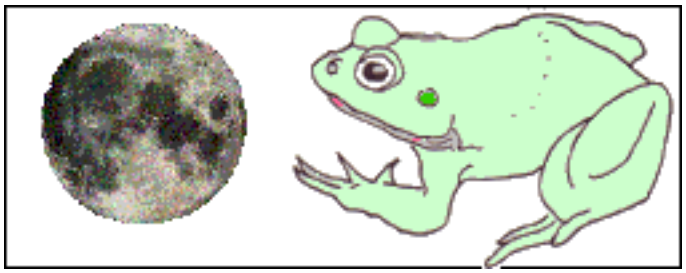


Amphibious Space/Surface Vehicles May Play a Role in Early Lunar Surface Tourist Excursions

[The following article is heavily excerpted for those portions relevant to the concept stated above.]

LOWERING THE THRESHOLD TO LUNAR OCCUPANCY

An Alternate Concept for both First Beachheads and Secondary Outposts

Peter Kokh, Douglas Armstrong, Mark R. Kaehny, and Joseph Suszynski
Milwaukee Lunar Reclamation Society

[A paper presented at the International Space Development Conference in San Antonio, Texas, May 26, '91 - with all the tourism relevant portions printed below.]

FOREWORD: Our purpose here is to outline an approach that will promote more timely and wide-ranging human presence on the Moon. In the event that the nation does not commit itself to a fully equipped Lunar Base, the hostel approach described herein could offer a less expensive alternative, a minimal but functional "tended beachhead", a humble yet significant step beyond the Apollo achievement.

> "Hostel", a term for sheltered sleeping space available to traveling campers, here refers to a pressurized structure offering minimally, inexpensively furnished "Big Dumb Volume" space for the private and communal use of visiting staff. The concept cosignifies a visiting vehicle that can close-couple with the hostel for the duration, in order to provide a complementary "Small Smart Cranny" component.

Such a partnership promises to allow hostel and vehicle to function conjointly as an integral, reasonably complete outpost in support of exploration, scientific research, prospecting, and processing experiments, allowing longer, more comfortable stays at minimum expense. In some later time of expanding presence, roadside hostels would facilitate safer, more regular travel between fully equipped distant outposts or settlements across the globe. By not duplicating equipment and facilities that are standard equipment aboard the visiting space-craft, both the total amount of cargo landed on the Moon and the number of crew EVA hours necessary for establishing a given level of capability, are minimized. Thus the hostel approach has the potential to keep the economic threshold for an initial operational beachhead significantly lower than in other mission paradigms.

Our objectives are four:

1. Define the logical division of functions between visiting vehicle and a shelter, and how these differ with the particular purpose of the hostel and the prospects for its future
2. Define design constraints on the visiting vehicle. Such co-design will be necessary if the potential of the hostel approach is to be realized
3. Outline logical paths of evolution towards stand alone status
4. Examine possible architectures, whether for prefabrication on Earth or for construction on the Moon using native materials.

During the six Apollo Moon landings, the landing craft did double duty by offering minimal camp shelter on the exposed surface. The Lunar Excursion Module, or LEM, offered hammock-type sleeping. But it allowed only enough floor space to permit two whole steps at a time in a single direction. No one has yet slept in a bed on the Moon, or taken an indoor walk, basic humble everyday functions.

As shelter from the elements, this Grumman-built lunar camper protected those within from the incessant soft mist of micrometeorite infall and from the Sun's ultraviolet rays. It actually offered negative protection from cosmic rays or the occasional solar flare, for its thin unshielded hull served as a source of troublesome secondary radiation.

After a lengthy retreat, we now propose to return in style with a fully shielded permanently staffed base complex long on scientific and experimental capability and exploration support, but short on personal and communal space. Several missions would be required to set it up and render it operational As has proven to be the case with the Space Station, such overreaching skip-step designs must inexorably work to defeat the timeliness of their realization. Is there indeed a middle ground, a reasonable set of design choices that will lower that threshold enough to let us get on with the show without delay?

The hostel paradigm combines the complimentary assets of a relatively inexpensively equipped but more spacious shelter space with base-relevant compact and expensive standard equipment aboard a coupled visiting spacecraft or other vehicle in a synergetic partnership that allows the two to function together as an integral "starter base".

The hostel paradigm is offered as a strong statement, even a protest, about the need for more elbow room in lunar outposts than the more orthodox approaches can affordably provide. But to evaluate the feasibility and practicality of the hostel concept, we have to explore both sides of that special relationship, consider how this dynamic balance may change over time, and suggest how it might be realized in the concrete.

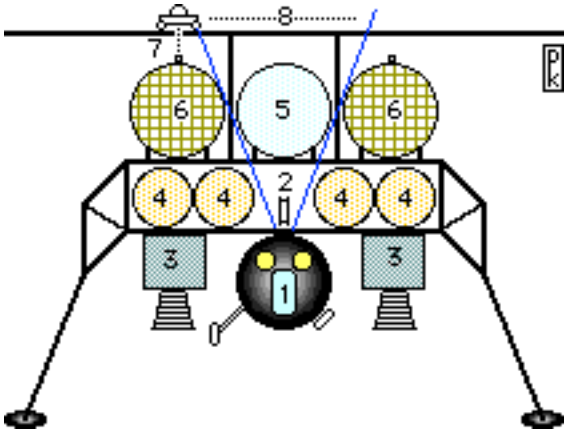
I. THE VISITING "AMPHIBIOUS" VEHICLE

Design Constraints

The design and outfitting of the visiting vehicle is critical to the workability of the hostel concept. The visiting craft must close-connect with the hostel structure if the facilities and equipment it brings are to be used to support any sort of practical routine, and the linked pair are to function together in an integral way. Exercising reasonable precaution, a visiting spacecraft would land a prudent distance from the waiting shelter. But bridging the distance by some sort of pressurized passageway, the tens or hundreds of meters between would prevent efficient use.

Thus craft must be designed (a) to "taxi" en masse to the porch step of the hostel, or (b)* to lower a conveniently under-slung detachable crew compartment, with its relevant equipment, to the surface so that it can separately taxi the distance on a chassis provided for the purpose. We suggest that this is the design choice to make, as it leaves the unneeded and ungainly landing frame, with the rocket engines and primary tankage, sitting on the pad site. When the crew's visit to the hostel is completed in a couple of weeks or months, this mobile cabin would uncouple from the shelter and taxi back to the pad site, reconnecting to the waiting descent/ascent portion for the trip back to LLO or LEO. To highlight the amphibious space/surface character of such a configuration, we have dubbed it the "frog".

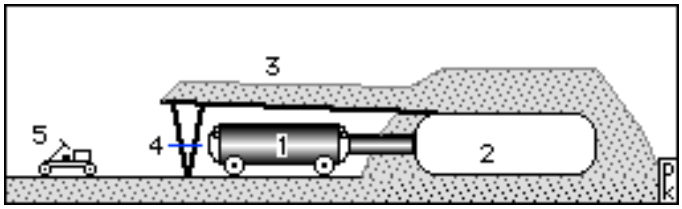
Figure 1: The amphibious "Frog"



KEY:

1 Frog (detachable mobile crew cabin)
wheel on right retracted, wheel on left extended

2 Winch to lower/raise frog
3 Main rocket engines
4 Fuel tanks - 5 Oxidizer tanks - 6 Cargo pods
7 Overhead crane/winch for cargo
8 Central clear-vision area for top viewport navigation



Generic Sketch of Hostel Concept

Frog vehicle docked/coupled to Hostel under shielded open-vac canopy for duration of crew visit.
1 Frog - 2 Hostel - 3 Canopy - 4 EVA airlock - 5 Open-vac rover

Frog vs. Toad

The descent/ascent stage could also be designed to take off without the crew module, picking up a new one at LLO or LEO. The original crew compartment vehicle would continue to serve as a lunar surface transport. This "toad" version, would require a more rugged chassis, more serviceable engine, and some sort of refueling arrangement. If we are to settle the Moon in a self-leveraging way, "toads" introduced to serve remote outposts, may be the ideal 'dues-paying' way to import the surface craft needed before the settlement is able to self-manufacture its own coaches. Thus, whether the crew's came through open space or across lunar terrain, the vehicle that actually couples with the hostel structure will be functioning as a surface vehicle at the time.

The frog/toad/coach arriving on site could

(1) be designed to hard-dock, in which case it must
  (a) be able to level, orient, and align itself properly for the task, and
  (b) be able to either lock or deactivate its suspension, perhaps with retractable legs. (If the suspension were allowed to continue floating, the hard-dock seal would be under continual stress with personnel moving back and forth.) Alternately, the vehicle could
(2) be designed to link-up with the shelter via a some-what flexible and alignment-forgiving, short pressurized vestibular passageway
  (a) extending from itself to the shelter, or more logically
  (b) tele-extended from the shelter to itself by a prompt from within the vehicle. There would seem to be engineering, weight, and safety tradeoffs between these hard- and soft-dock options and we do not suggest which would be the more practical in the short run.

[One criticism of our frog concept brought to my attention at the conference was that, as illustrated, it involved a pair of widely separated engines, one to either side of the centrally suspended mobile crew pod, introducing potential instability if either engine had to be shut down for any reason. Our response is simply that there is so much to be gained by using frog-like vehicles - however they be configured - that it is very much worth the trouble to find or develop engineering work-arounds of this problem feature (e.g. a single top center engine with the exhaust split between pod-flanking exhaust bells). By hook or by crook, there has to be a way! - PK]

Outfitting constraints

To play its part, the coupling vehicle be outfitted in a way that the capabilities it offers are complementary to those offered by the hostel shelter. It would seem that the repertoire offered would vary according to the customary length of trip for which the vehicle was designed. The possibilities suggest two general classes, the 'commuter and the traveler.

(1). Commuter class vehicles would include shuttle craft plying between the lunar surface and either an orbiting depot or a more substantial orbiting mother craft such as an Earth to Moon (or LEO to LLO) ferry. Also fitting the description would be suborbital hopper linking mutually remote lunar sites. In either case the commuting craft is occupied for only a few hours at time. Thus it may not contain berth space, galley (though food stores are likely to be a major part of the cargo), or head, though some emergency-use only arrangements would be a prudent option should the craft go astray or be forced to land far from its destination.

Even here, we have a vehicle that could bring something to a hostel partnership. For both shuttle and hopper will have communications, navigation, and computing equipment which do not need to be duplicated in the hostel. And either will likely have an emergency first aid compartment complete enough to serve the crew in its hostel stay, as well as other emergency survival provisions. Finally, its air recycling equipment (a water recycling capacity is less likely) and ventilation fans, might easily be oversized without too much weight penalty, so as to also serve the hostel space well enough in a close-coupled configuration.

(2). Traveler class vehicles would include such landing craft comprised of a shuttle module delivering a "through-cabin" crew-pod transferred from an Earth-Moon (LEO-LLO) ferry. As on the coast to coast Pullman sleeper cars passed on from one railroad to the next in an era now long gone, the crew coming to staff the hostel would ride the same "through-cabin" all the way from LEO, or even all the way from the Earth's surface.

Also in the cruiser category is the "overland" coach (from an established settlement or full base) designed for trips cross-lunar excursions of a day or more in duration. In either scenario, the visiting craft will contain serviceable if cramped "hot-rack" berth-space that can serve in the hostel-hookup as emergency infirmary beds if isolation or quarantine is called for. And certainly the craft will have at least a minimally equipped galley and head (possibly with shower) as well as a compact entertainment center with some recreational extras. Such more fully equipped vehicles would serve especially well as hostel complements, leaving the hostel to provide what it can offer most economically and efficiently: hard shelter from the cosmic elements, and plenty of elbow room to serve the less expensive low-tech but space-appreciative aspects of daily life -- private bedrooms and communal areas for dining, gaming, exercising, etc. LRS

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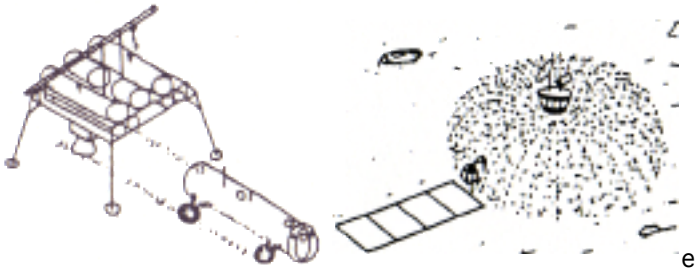


Above: Frog left en route to Hostel right. A match made in Moon Heaven

The Magic of Symbiosis

Life clings to rocks in the frigid wastes of the arctic Tundra in the form of lichens, a symbiotic partnership of green algae and colorless fungus - neither of which could survive alone. Similarly, little smart "Frog" and big dumb "Hostel" might combine their assets to create a "full-function" lunar base.

We examine the magic of this symbiotic relationship in depth in Part II of “HOSTELS” below.

General Philosophy

Approaching the suggested vehicle-shelter functional partnership from the point of view of the hostel itself, we must keep in mind both the economies to be gained by keeping the shelter as low-tech and inexpensively simple as possible while still serving its purpose, and the competing consideration that we might want it to design it so it can evolve over time into a fully configured autonomous base. The underlying concept of the lunar hostel is that base functions can be physically and spatially separated into two broad types.

(1) Cranny-loving functions. The first includes the compact but expensive equipment that is needed to maintain human existence outside our native biosphere, to maintain the health of the crew, to support the crew’s scientific and exploratory research tasks, and to maintain contact with the rest of humanity from which it is physically isolated. The whole evolution of vacuum-worthy craft has been to make such equipment ever more compact and lightweight while ever more functional, productive, and capable. This first category thus principally includes those things that the crew must always have access to, whether it is settled-in on the Moon, or in transit between Earth and Moon, or simply orbiting the Earth.

(2) Room-loving functions. In contrast, there is a second broad category of functions which principally includes those things that are not missed in the short run (and so need not be provided for periods of the order of Earth-Moon transit times or shorter) but are needed over the long term (and thus are ideally provided by durable in-place shelter to be visited for extended periods.

These are the functions which, because we lacked the lifting capacity or out of sheer economic necessity have been at best shoe-horned-in on spacecraft and orbiting stations, but which for personal and group morale and psychological well-being should really be offered on a far less space-stingy basis: honest to goodness personalizable private quarters with ample space to move about, arrange one’s personal effects, display (if only for oneself) any personal treasures or hobby work; pleasant dining, assembly, and meeting space (wardrooms); quiet places for reading; places for shared entertainment or gaming; places for space-hungry exercise routines.

These long-term needs were necessarily ignored on Mercury, Gemini, and Apollo because the space to serve them could not be set aside. Nor have such spaces been more than suggestively and teasingly provided on the Shuttle or even aboard the relatively voluminous Sky-Lab. True, sardine-can packing can be sustained even for months if there is light at the end of the tunnel, as ample submarine experience has demonstrated. Yet it hardly contributes to morale.

More to the point, such elbow-to-elbow jostling may prove to be much less tolerable over any length of time in settings where the outside environment is one of unsurvivable desolation, however magnificent; where a play of sterile grays and blacks, is nowhere relieved with soft and friendly greens and blues; where there is no wildlife to be found at all, not even ‘alien’. Space Station planners have endeavored to give some consideration to these needs, exploring design innovations that might make the station’s unavoidably cozy spaces more human.

Since on the Moon, the task of maintaining individual and communal morale and mental health will be much more challenging than in low Earth orbit, if there is a way to provide both more generous private and communal space - not just workspace - without undue expense, it should be prioritized. It is our premise in this paper that by not unnecessarily duplicating equipment and facilities already needed aboard the visiting craft to sustain life in space, appreciable dollar and fuel savings can be gained which can be spent to this purpose.

Gray Areas

Before we consider how in the concrete such liberal camp-space shelter can be offered (that is, building materials, construction methods, architectures, and deployment options), we

wish to consider some gray areas, facilities and outfitting whose proper placement - in the coupled visiting craft or in the hostel space - might be debated. We did not attempt to reach definitive answers. But in each case we list considerations that seem pertinent.

(1) Communications/computer center: The need for redundant systems is inarguable. But their placement may be a matter for dispute. Accepting that the hostel would never be occupied without a visiting vehicle coupled to it, one might still argue that the various systems aboard the visiting craft necessary to maintain life and contact with metropolitan humanity should be duplicated within the base structure itself as a matter of simple precaution. Here one should keep in mind that spacecraft systems are already by them-selves provided redundantly. But the point might still be made that the coupled spacecraft is unshielded and therefore could be knocked out by a rare meteorite of sufficient size. A testy rejoinder would be that anyone that concerned about remote possibilities, doesn't have 'the right stuff' and shouldn't volunteer for such duty.

But accepting the challenge made, we can more constructively reply that it would be possible to offer shielding protection, not to an intact conventional lander, but to the detachable crew-compartment become bus (i.e. the frog or toad), under a shielded but vacuum-exposed carport-like canopy extension of the hostel structure. Such a "ramada" would also shield routine doorstep and porch outside activities: outside vehicle maintenance, storage areas for surplus supplies and discarded items; items awaiting shipment, etc.. But if such sheltered parking space is provided, the vehicle's antenna would be effectively blinded. Therefore the hostel must be equipped with the necessary antenna(s) for joint operation.

(2) Electric Power Generating Capacity: The power systems aboard the docked vehicle will be sufficient to take care of its own needs in transit, probably via fuel cells with a couple of weeks of emergency reserve power at best. While the activities the hostel itself is designed to support within its own confines will consume relatively little power, and even less to run whatever minimal housekeeping equipment, if any, is needed in between visits, we are left with some real challenges.

(a) Compact workstations aboard the vehicle may need more power when the vehicle is parked and functioning as an integral part of the base combo than when it is in transit.

(b) a modest solar power array If the landing vehicle does have one, this is most likely to be a part of that apparatus left on the pad. Connected to the detachable crew compartment or frog, such arrays might be effectively disabled if the frog docks with the hostel underneath a shielding canopy out of sunlight's reach, as recommended.

(c) Nightspan power needs must be taken into consideration, even if these are minimized by apportioning base operations into energy- vs. labor-intensive tasks reserved for dayspan and nightspan respectively.

Thus for a stay of any real duration, the location within the integrated base (frog or hostel) where the power is actually consumed becomes irrelevant. The apparatus to generate it and store reserve supplies will be weighty, no matter which path is taken. Therefore principal power generation and reserve storage must be the contribution of the hostel component, with the apparatus necessary a part of the original hostel endowment package. This hostel-provided power system could also electrolyze whatever water that had been generated in the frog's fuel cells en route to the hostel, so that its hydrogen and oxygen fuel reserves were fully replenished for the return trip. Any surplus gas could be stored in shielded tanks outside the hostel as a handy and welcome fuel/water reserve for the next visitation. Under this arrangement, fuel cells aboard the frog, which would go off-line for the duration of the coupling, would be fully available as backup for short routine repairs to the principal system or for 'mayday' emergencies.

(3) Air Quality and Ventilation: Any crew-rated spacecraft is going to have redundant systems serving this need. It would seem that it would be cheaper to oversize these aboard the visiting vehicle so as to handle the extra coupled volume, than to install separate and independent air management systems in the hostel. However, it may be necessary to put complementary

equipment in the hostel to dehumidify and sterilize the air within after the crew departs, so that the next crew to visit doesn't walk into a dank and moldy place. An automatic cycle that would dehumidify and then heat the air to perhaps 70° C for a relatively short time would possibly do the trick, allowing the air to stand without further treatment or control until the next visit when a short, perhaps vehicle-assisted procedure would restore the proper humidity, temperature, and ionization level. This still allows housing in the visiting craft of the bulk of the equipment needed to treat air currently being.

(4) Thermal Management Systems: This need includes tasks that could be appropriately apportioned between the partner elements. With suitable architectural attention, the hostel could be built and shielded to be thermally stable. Between occupations, the hostel could either be designed so that the interior temperature falls to that of the the surrounding soil blanket (-4°F or -20°C). Alternatively, the hostel could be designed to harvest and store heat from dayspan sunlight so as to coast at some higher but still level still on the cool side but from which recovery to (and maintenance of) comfortable room temperatures will be easier and quicker

Most of the activities for which the hostel space is designed to make room should generate little heat. If the coupled vehicle is parked under a shielding canopy, extensive heat rejection arrays for excess heat generated within might likewise be unnecessary. But if a thermal surplus is expected nonetheless, the radiators indicated would best be a hostel feature, easily integrated with a solar array, or possible placed on the permanently shaded underside of attached ramada areas. Meanwhile, the control apparatus could be housed in the visiting vehicle if it doesn't require much space, since the vehicle already houses ventilation and air quality apparatus which would have to be integrated with the thermal management system.

(5) EVA Airlock and Open-vac Rover: An airlock for suited exit onto the surface needs to be a part of any functioning lunar base. For this purpose, if the visiting crew vehicle already has its own EVA airlock as standard equipment in addition to its docking adaptor, as seems likely, this should serve the joint vehicle-hostel operation quite adequately.

The hostel need only have a docking adaptor and connecting vestibule with which to interface with the visiting vehicle. Personnel would then exit onto the surface through the coupled vehicle. Again the hostel would not be occupiable without the pressurized vehicle attached, and any contingency that is likely to make the latter unusable or unenterable, is likely to doom the combined base at any rate.

In sum an additional airlock as part of the hostel proper, would be an option of definite eventual value but not an immediately pressing need. If not original equipment, such an accessory could be added latter, as part of a docking port extension, as increasing use of the facility and the prospects for its evolution into a fully equipped base warrant. For exploratory sorties to nearby spots of geological interest of resource potential or for recreational change-of-scenery jaunts, a separate unpressurized Apollo-type rover would be carried along by the first vehicle to visit the ready hostel, to be left on site.

(6) Recirculating Water Systems along with waste water treatment equipment are unlikely aboard visiting commuter-class vehicles, put plausible in traveler-class ones for which the hostel concept is properly tailored. If the prospects for the particular hostel to be transformed into a permanently staffed autonomous base are positive, such systems will be an early addition to the hostel's offerings. But at the outset, almost by definition, the vehicle will be wet, the hostel dry. This implies the following:

(a) Toilet and personal hygiene facilities will be offered in any non-commuter type craft, in which case installing additional plumbing and waste treatment facilities in the hostel space from the outset would seem to defeat the purpose. But carry-in-and-leave convenience plumbing-fee toilets that shunt their wastes to external shaded holding tanks where they will freeze, are to be recommended for placement within the hostel space if they can be designed so as not to need special venting. For the alternative of keeping the wastes sealed within tanks aboard the visiting vehicle, presumably for disposal in space or for return to

Earth, would not only add to takeoff weight unnecessarily, but would constitute almost criminal waste of what, on the Moon, will constitute an invaluable exotic volatile-rich resource to be husbanded with care. Even before the onset of lunar agriculture, which could compost such wastes and recycle them so as to enrich the regolith-derived soil, it will cost nothing but storage containers to bank these wastes, inertly frozen, until that day does come. Even if a particular hostel site is not destined to become a full-fledged base or settlement, its stored freeze-stabilized wastes could be collected at any convenient later date and transported to wherever they can be used to enhance on-Moon agriculture.

(**b) Food preparation and dining** would seem to another task apportionable area: the food preparation, scrap handling and dish washing capability of the vehicle's galley need not be expensively duplicated; relaxed casual dining complete with 'atmosphere', can be cheaply arranged within the hostel's more spacious setting. The vehicle may have a locker for the fresh food supplies it has brought along for the mission. But a pantry for long shelf-life contingency rations would logically be put within the hostel along with a snack bar.

(c) Laundry tasks may also be apportioned. Given the water treatment and recycling facilities on the vehicle, if crew stays were long enough to make laundering desirable or necessary, and if space could be found in the vehicle, that would seem to be the logical choice for washing. Clothes drying could easily be done anywhere within the hostel, which might even have space enough for hanging items 'out' to dry, if such an option did not burden humidity control. If the planned hostel stay is sufficiently short to make laundering unnecessary, each crew could simply bring in their own fresh clothes and bedding, taking the soiled items with them when they left. - in keeping with a recommended leave-as-you-found-it, bring-with/take-with honors code protocol. But alternately, soiled fabrics could be allowed to accumulate in shielded but sterile vacuum outside so that their exotic and precious imported carbon content would remain on the Moon as an endowment, to be reused or recycled in some existing or future settlement. Replacing carbon-rich fabrics from Earth with new goods will be marginally less expensive than bringing soiled items all the way back, then returning them cleaned.

(7) Medical Facilities: Medical care presents another gray area. Cabinets of medical supplies and common procedural implements, especially those needed to handle accidental injuries and trauma cases as well as the more common fast-developing transitory ailments, are likely to be standard features of any visiting craft. The hostel, in turn, offers roomy bed space for patients. This allows any much less generous berth space aboard the coupled vehicle to be pressed into service where isolation or quarantine is advised, even as sealable morgue space if need be.

But expensive, diagnostic equipment, compact or not, with the instruments and medical supplies needed to handle the full range of more plausible eventualities is something that may not be provided at all at first. Such a level of medical capability might be added later, however, and preferably within the hostel itself as the frequency and duration of visits increases. If any of the personnel must be returned to Earth for medical reasons via the coupled vehicle, everyone else must leave as well; for in the coupled vehicle/hostel scenario the hostel, by definition, is not configured to function separately. It will be a priority in the evolution of the particular hostel, to minimize the likelihood of a premature abandonment.

(8) Workstations and Laboratories: Provision for geological and mineralogical analyses is a primary design criterion. And the need for facilities to support lunar materials processing feasibility studies will be of increasing importance as the human return to the Moon becomes more earnest. The first relevant consideration is whether the proposed workstation is wet or dry. The second is whether the supported research can be done in a compact space or needs extensive floor/wall space.

The logical division would locate compact testing and analysis workstations, wet or dry. aboard the visiting craft. This would allow convenient change-out and updating of equipment on return visits to Earth or Earth orbit. "Dry" research needing extra space can be provided within the hostel structure proper. "Wet" research or experimentation needing extra space should be examined to see if the wet and dry tasks can be separated by location without too

much convenience. If so, the dry part of the operation would have a claim to hostel space conveniently near the docking passageway. The hostel, in turn, would offer inexpensive and liberal sample storage lockers, and sorting and display areas.

But in deciding where to house various workstations, we must also take a more comprehensive look at the mission context of such hostel-stays. If there is more than just one hostel site for a single vehicle to visit, it will indeed require less expensive duplication to provide such space aboard the vehicle, so long as the equipment involved is not particularly massive. If, on the other hand, we are dealing with a single hostel visited by a small fleet of similar vehicles, it would require the least duplication to put such workstations within the hostel structure proper. Again, if each frog is specially equipped to support a particular research agenda that changes with each stay (the pattern with Space Shuttle missions to date), the pendulum swings in the other direction. The question cannot be fully resolved outside of the mission context and the hostel's evolution through use.

If in general, most workstations are in fact built into the visiting vehicle, reserving the hostel principally for off-duty functions, such a segregation of activities would lend itself especially well to shift-scheduling, with on-duty personnel clustered in the vehicle, and off-duty personnel within the hostel. A two shift setup with shared social time might prove the most workable and best for group morale. Whether such a separation of activities by area is practical or not, we suggest that the passageway space, short or long, connecting the two areas of the outpost combo, be designed with sound-buffering in mind. However all such considerations are secondary in deciding where each workstation should be.

(9) Exercise Areas and Equipment: These are best placed according to the nature of the activity in question. While some daily ritual types of exercise need little room and can be performed in a compact exercise area within the vehicle such as the wardroom area, other exercise routines are space-hungry; to provide for these, any portable equipment needed could be brought into the hostel and left there. The hostel's interior spaces and overall architecture might conceivably be designed and arranged to incorporate a banked peripheral jogging track, or even a "sixthweight" caricature of a bowling lane. A billiards or ping-pong table, even a handball court are all imaginable, given enough cheap dumb volume.

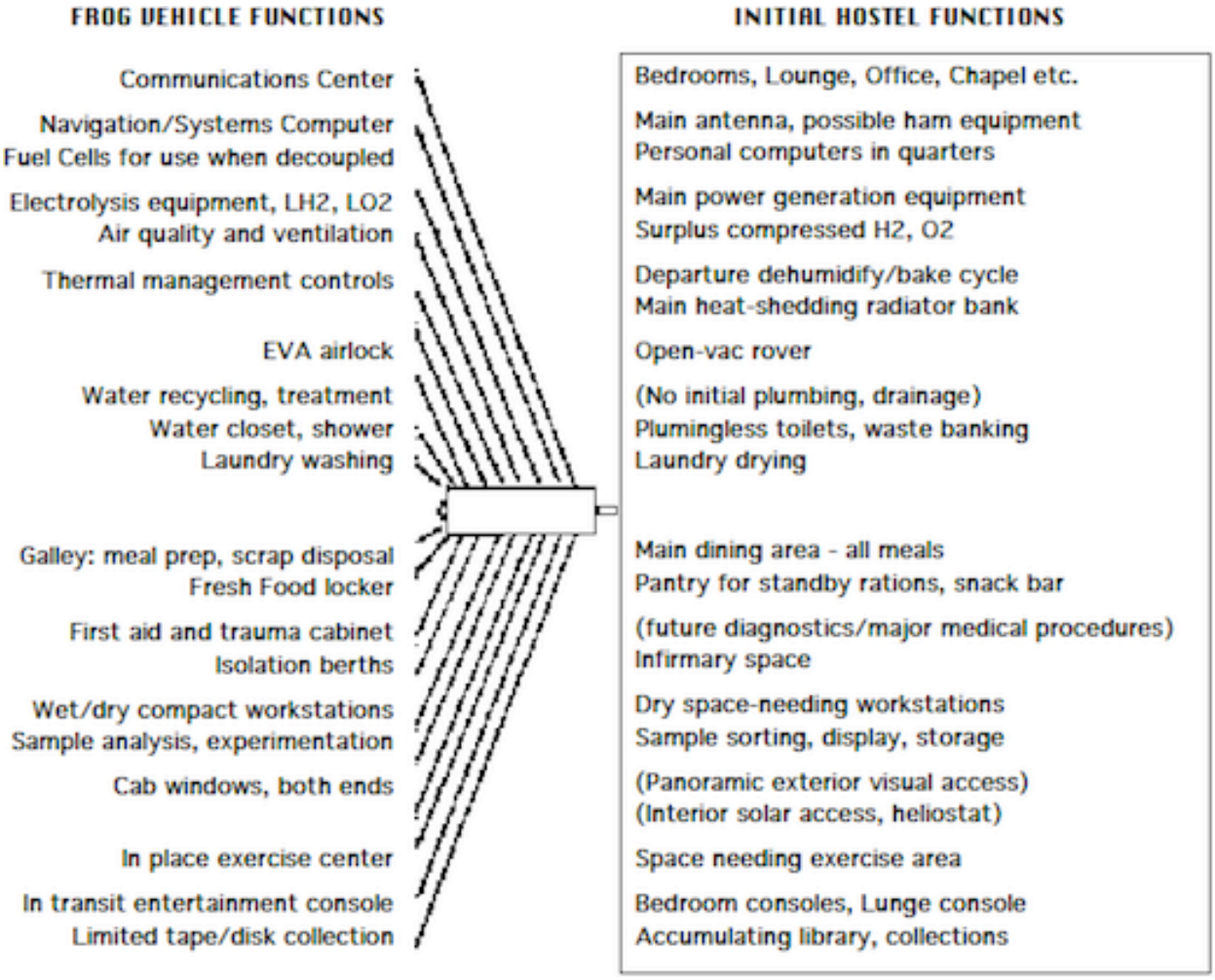
(10) Entertainment and Recreation. The visiting craft will doubtless possess its own entertainment console and a modest audiovisual library. Small personal audiovisual consoles would be an inexpensive and welcome feature for the private quarters within the hostel. With ample space, separated communal viewing and listening/reading areas could be provided. Additions to the hostel's audiovisual library, extensive reading materials on CD-ROM, [written before the arrival of DVD technology] even a modest collection of low-weight art pieces, could be carried in and contributed by each new visiting crew, continually enriching the cumulative samples of Earth culture available on the Moon.

(11) Exterior Visual & Interior Solar Access: Visual access to the surrounding moonscape would also foster psychological well being. The portholes in the coupled vehicle serving navigation and driving needs are likely to provide only restricted views. Windows or view screens are likely at both ends of a frog-type craft. Side-wall portholes may or may not be offered.

If feasible, then, the hostel structure ought to provide visual additional and more possibly more panoramic visual access as well. A technique already demonstrated on a low-tech basis in one Earth-sheltered home in the Kettle Moraine region of southeastern Wisconsin, in which pairs of angled mirrors bring in stunning picture-window views of the surrounding countryside through zig-zag shafts, which duplicated on the Moon would conveniently block cosmic rays. This suggests a design approach for hostel architects desiring to visually integrate the hostel's interior spaces with the surroundings. Pulling off the same trick while preserving pressurization against the hard lunar vacuum will require architectural/engineering ingenuity, but seems doable. Such a feature might be more easily built into lunar hostels constructed on site of local materials.

This would also seem to be the case for solar access, channeling in pools of soul-warming sunshine via a sun-tracking heliostat using either a zigzag mirrored shaft or a 'solid' fiber optic bundle to preserve shielding integrity. The shutterable sunshine brought in can be used to highlight focal points or for general lighting during the dayspan. Both of these features may or may not be harder to provide in hostels partly or wholly pre-fabricated on Earth for transport to the Moon. But 'where there's a will, there's a way." To the point, both options are relatively low-tech and space-eating features that can be more satisfactorily provided through the hostel's expansive structure than through the nook-crammed vehicle.

Hostel Division of Labor



III. EVOLUTION OF THE HOSTEL WITH USE

(1) A First Beachhead: If current more ambitious Moon Base plans have to be abandoned and our first beachhead on the Moon is based instead on this hostel-coupled vehicle concept, and if continuing site reappraisal confirms the decision to establish a permanently occupied full-functioned base on the site, two directions suggest themselves. Provided that the architecture and design of the original hostel have been chosen to be expansion- and retrofit-friendly, with each new visit the hostel could be slowly evolved into the stand-alone full-function base desired. Crews would add floor space via plug-in expansion modules or, preferably, by additions constructed of on-site materials as soon as such a capability comes on-line.

Then would come installation of independent air management apparatus, plumbing and water recycling equipment, sundry work stations, laboratories and shops etc. More adequate medical facilities to treat a wider range of needs would be an early priority. The actual order of

improvement would depend on logical dependencies, calculated to prioritize redundancy and safety and to allow an acceptably timely shift to permanent staffing. 2) But if the hostel's chosen architecture and design does not readily allow such expansion and evolution, instead of the hostel being wastefully dismantled or simply abandoned, it could be preserved as an annex of a totally new base built adjacent to it, serving to house guest visitors for whom the new base complex may have no spare room. That is, the hostel could become an attached hotel, the Moon's first. We suggest that in the case of a first beachhead, this is the preferred path.

(2) A Farside Astronomy Station: Our recommendation is different for a hostel designed to serve remote infrequently tended installations such as a Farside Advanced Radio Astronomy Facility (FARAF). Such an installation may well follow, rather than precede the establishment of an original permanently staffed nearside Moon Base, so that the latter could be an advance logistical support node for the farside operation.

Following this scenario, the hostel should be designed from the outset with planned expansion and evolution towards permanent autonomous staffing in mind, and an appropriate architecture chosen accordingly. Indeed, it was to show that there is a happy middle area between the vehicle-tended farside minimalist installation envisioned by NASA and the permanently staffed major installation the astronomers would like, that we set about to develop the hostel concept in the first place.

The Farside hostel should offer more than basic off-hours shielding against the cosmic elements for technicians changing out equipment, repairing, and updating the facility. An expandable astronomical workshop should be an early extra if not part of the original structure, along with a garage and lunar pick-up or tractor. Such assets would make the visits of the tending staff far more productive, especially if limited to once or twice a year, the low level of activity NASA feels confident the agency can support (in lieu of a near-side base!). For as long as visits remain so infrequent, a stand-alone full-function base would be an exorbitant luxury. In contrast, a simple Big Dumb Volume hostel could justify itself with the first visit . Once such a hostel were in place with the appropriate special extras mentioned, the next crew to visit need bring only new and replacement parts for the astronomical installation, and be able to bring more of them, as they wouldn't have to keep hauling workspace and berth space to and fro with them.

Thus the original up front investment in a FARAF hostel, by allowing visiting vehicles to maximize their capacity to carry equipment for expansion of the installation, would promote more rapid growth and development of this facility within the same subsequent budget.

(3) Remote Prospecting Camps: Hostels serving prospectors may or may not develop into anything more. If the prospecting activity does not reveal enough promise and economic justification for further visits to the site, the hostel could be abandoned (to serve as available solar storm shelter or rest stop for anyone happening by) with little waste of investment.

Meanwhile much more extensive prospecting will have been made possible than from a solitary unshielded vehicle with the same size crew. Hostels at remote research and prospecting sites, like the one proposed as a first beachhead, will need to offer a fair amount of unpressurized but shielded work and storage area, to minimize radiation and micrometeorite exposure during routine porch step 'out-vac' activities. So housed repair and maintenance facilities for surface-ranging equipment would be a logical early addition.

(4) Wayside Hostels: A hostel serving as an 'over-night' rest stop and flare shelter along regular trafficways could be built and shielded in one of the ways suggested below for beachhead or research station hostels. But alternatively, such a hostel might simply consist of one or more linked towable mobile modules (perhaps settlement-rendered retrofits of surplus cargo holds or fuel tanks and other scavenged items) parked under the overarching shield of a previously constructed roadside solar flare shelter.

With the lack of right-of-way and clearance constraints on lunar roadways, such mobile units could be built much larger than their terrestrial forerunners. In either case, the roadside

hostel may continue to function as originally set up, or, over time, grow to become the nucleus of an all new settlement, depending on the economic rationale offered by the particular location and the resources of those proposing to exploit any such perceived advantages. In that case, as with the original beachhead hostel, it could either itself be evolved and expanded, or kept as a 'motel' annex for the new settlement. A sheltering open-vacuum ramada/hangar/canopy for roadside vehicle and equipment repair would be a logical first improvement if not already provided, along with a standard-equipment tool and parts crib for user-performed work. A fuel cell changeout/water re-electrolysis station, a battery recharging facility, stocks of emergency provisions and first aid supplies, and stand-by emergency communications equipment, could follow.

In other words, the expansion, as warranted by traffic and location, would first proceed along the lines of additional user-tended facilities. Only later. would regularly scheduled types of full-service be offered by the dedicated staff: the truck-stop restaurant (slowly switching to supplementary on-site food production), the bed and breakfast motel, the on-duty expert mechanic, the souvenir-maker, and the inevitable practitioner of the 'first profession'.

In all cases, docking apparatus should be pre-standardized. If we are indeed going to develop the Moon as an integrated part of a greater Earth-Moon or circum-solar economy, the solitary first beachhead must give way to a multi-site world, and hostels will be at the forefront of that global expansion and acculturation. Any visiting vehicle, frog, toad, or coach, should be able to couple with any hostel.

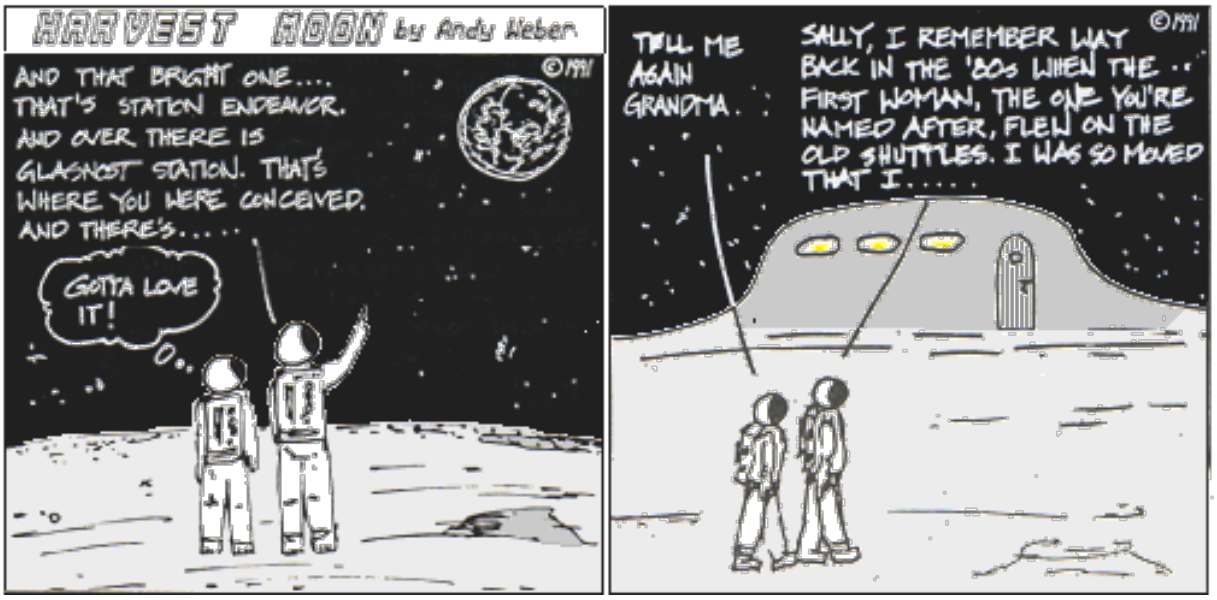
Code of honor protocols governing visitor behavior should also be standard, expanding on the suggestion above.

As to architecture, building materials, layout, size, method of deployment or construction -- these could vary widely depending upon available technology, resources, logistics, prognosis for the future of the site, and innovating entrepreneurial competition. <LRS>

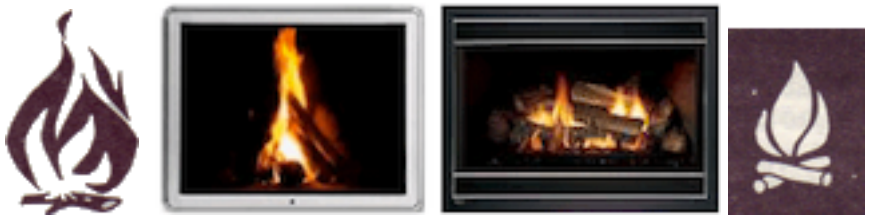
Postscript: Tourist Hostels:

This is an ideal plan for early surface tourism, possibly prior to the establishment of any permanently or intermittently crewed science outposts.

An easy and inexpensive option would be to deploy a Bigelow Aerospace B330 inflatable module in horizontal posture. It could be set into a trench prepared tele-robotically, then covered with an additional meter ~yard of moondust, which together with the module's one foot thick ~33 cm hull, should provide enough shielding against radiation for the intermittent visits by tourists. The Frog would dock with the B330 for sleeping and recreation purposes, then undock for scenic excursions, before returning to the host lander for lift-off. MMM



MMM # 52 February 1992



One age-old social catalyst is the campfire, the fireside, the hearth. Around the fire stories are told, songs sung, and myths and legends passed on. Many a science fiction yarn has its characters plotting by the warmth of a fire on some star-sunned planet - one with breathable air, of course. But elsewhere in our own Solar System, fire's mystic magic may be denied us.

On the Space Frontier, can there be any

FIRESIDE

Fireside around which to gather?

By Peter Kokh

Since time immemorial, ever since the taming of fire, humans have sought warmth, comfort, and company huddled around campfires and hearths. Even today, when a dwindling number of modern homes boast the luxury of a fireplace, nestling around the fire is something we all enjoy - when it is cold or damp, when we are out camping, on a clambake or a picnic in

the park, or just out on the patio or in the back yard for a barbecue or marshmallow roast. And can any of us forget the bonfires after a high school homecoming football games?

While nowadays, such pleasures are scarcely everyday experiences, however infrequently enjoyed, the magic of the fire is so much a universally positive experience that it is still possible to ask: "can it be humanity if there is no campfire?"

In "FIRE DEPT." MMM # 51 DEC '91, we pointed out the very intolerability of open fire, controlled or not, in the very limited atmospheres of mini biospheres. But that is not the last gloomy word, for it only applies to fires in which the combustion products are smoke and toxic gasses.

In MMM # 40 NOV '90 "METHANE" we discussed the possibility of controlled burning of compost-pile derived methane to produce water vapor along with CO^2 for plant nourishment. Such combustion will need to be confined to nitrogen-free chambers so as to avoid unwanted nitrogen oxide byproducts. Could such a methane-oxygen fed flame in a glass-faced chamber serve as a fireplace substitute? Why not?

It should also be possible to devise a tightly confined hearth "substitute" that slowly fed together pure hydrogen and oxygen. If again the burning is confined to a nitrogen-free chamber, the only combustion product would be steam - pure water, which can then be used for drinking or other purposes. In effect, we are talking about a modified fuel cell, in which the $2H^2 + O^2 = 2H^2O$ reaction is run somewhat faster, not so fast as to be explosive, but fast enough to sustain a flame, perhaps with a harmless enough additive (if one can be found!) to colorize the normally invisible $H2+O^2$ fire.

I'd be surprised if either such device now exists, with little market for them - down here. But out on the frontier, a flame-in-a-jar device might create enough symbolic warmth and cheer to become commonplace in settler homes on the Moon or Mars or elsewhere, in gathering spot lounges, even on long trips aboard spacecraft or surface roving coaches.

Why not tinker up such devices now? The methane version could not be used in draft-tight close quarters but a hydrogen hearth might sell to apartment dwellers, especially singles wanting the latest in trendy mood-setting gizmos. Just knowing that we could take such **"fire chamber"** with us, could make the prospects of life on the space frontier just a little less daunting, just a little more reassuring. **MMM**

MMM # 55 May 1992

Tourists visiting early lunar settlements may find them looking like **molehill complexes** - so many interconnected modules all covered with uniform mounds of moondust.That will change. People everywhere soon become conscious of how their abodes and cities look from the outside. See below.

By Peter Kokh

Roofs on the Moon? - where it never rains or snows? Ah, but it does rain - a gentle slow micrometeorite mist, and a steady shower of cosmic rays, plus sudden 'cats and dogs' outbursts during solar flare episodes. While the characteristically imbricated (tile or shingle overlap) shedding features of terrestrial roofs would not be called for, the sheltering function of

the 2-4 meters (6+ -13 feet) of shielding overburden above Lunar or Martian habitat space will be more than a little analogous to the familiar roof, a prehistoric heritage.

To the architect, the roof has traditionally been one of the most important opportunities for statement of style. To give some outstanding examples: the thatched English cottage, the terra cotta Spanish Tile roofs of the University of Colorado in Boulder, the green-patina copper roofs of many early urban skyscrapers, the onion domes of St. Basil's in Moscow's Red Square, the tailored French mansard, and the Pagoda.

It would be natural for future settlement architects in the employ of well-to-do façade conscious homeowners to turn to the shielding blanket as a clay for expression. And for those hired by companies seeking a striking design for their new headquarters building, to turn to lunar "roofs", alias shielding, as a medium of style.

Already, purely for the utilitarian reason of simple convenience, some outpost designers are specifying that their habitats be neatly sand-bagged. The advantage of placing the loose lunar regolith in bags should be obvious. Not only will it keep the construction site cleaner - and safer (from dangerous bull-dozer module collisions) - it will allow the bag-tamed shielding to be easily removed in order to repair hull and joint leaks, to make structural modifications, and to exchange old, or attach new, expansion modules. Meanwhile, by this simple trick of bagging, the external appearance of the outpost is drastically altered. The 'lith-bagged outpost now looks like an on-surface installation rather than an under-surface one, its appearance and presence radically transformed.

An alternative to the bag or sack (made on site from medium-performance lunar fiberglass fabric) would be sinter blocks made from compacted and lightly microwave-fused soil. By varying the size and shape of such blocks and the patterns in which they are stacked, distinctive igloo-like styles should be easily achieved.

Grecian Formula

It does not stop here. There is no cosmic law that states lunar shielding must be gray-hued. If desired, colorants can be added to the material itself, or glazed or even merely dusted on an exposed, rough surface.

In the early settlement, the availability of colorizers will not be great. On the Moon, Calcium Oxide, CaO, i.e. lime, made from highland soil will be a likely early favorite, probably cheaper than mare ilmenite-derived Titanium Dioxide, TiO, also white. Either way, "whitewashing" Lunar settlement shielding mounds might early on become "politically correct", for they would make the settlement a conspicuous very bright spot on the Moon's surface, perhaps even outshining the crater Aristarchus. This would make Earthlubbers more conscious, and hopefully supportive, of their frontier-blazing brethren above - a cheap way to put any Moon town in the "limelight"!

More than empty vanity

By the simple addition of shaping or sculpting or colorizing, the shielding mound will become more than a visual disturbance of the surface. The 'lithscaper's or architect's touch can imbue the protective mound with design, unearthing the presence of the living and work space below and making the otherwise hidden structure visually present above the landscape in an identifiable, pride-investing way.

This transformed self-image of the settlement may have real positive effects on the outlook, mood, and morale of the pioneers themselves. For it can be an early, easily won battle in a campaign to "humanize" the sterile barren alienness of their surroundings, thus contributing subtly to a sense of being "at home" in their adopted raw new world.

Economic opportunities

Indeed, outside of the occasional observation cupola, for most surface settlement habitat architects, the "roof" may be the principal opportunity for exterior public-side statement (other than any openings to also shielded public "middoor" spaces like pressurized roadways, passageways or squares etc.) But the opportunities for "roof"-styling will more than reward frontier architects. This market will also provide entrepreneurial openings for

enterprising settlers to develop the additives, the tools, the equipment, the processes, for making such on-paper possibilities real off-the-shelf choices.

Bower Roofing

Nor need 'roof adornment' be an expensive luxury item. For it could also serve as an at least temporary 'banking' outlet for otherwise hard to recycle used building materials and other non-organic 'debris" - perhaps in shredded or gravelized form - and for various orphaned manufacturing and mining byproducts for which more suitable uses are not yet in sight. These are two stubborn categories which contribute significantly to terrestrial landfills, yet receive little if any attention. Here we could take a page from the bowerbirds (8 species in Australia, 8 in New Guinea) who decorate the interiors and entrances of their nests with "found" objects of all sorts.

Settlement Signatures

Without attention to shielding style, it could well become a prevailing truism that once you've seen one surface frontier town, you will have seen them all. Given human nature and the slightest modicum of discretionary private and public funds, it is unlikely that such will be the case.

Distinctive 'lithscaping and "roofing" styles may become characteristic identifying trademarks, not only of individual structures, but of different lunar towns as a whole.

There will be economic incentive, and payback, for the small expense Involved in the form of tourist interest in "local flavor".

Long before any Lunar towns become large enough to begin to grow small high-rise "downtowns", they may become identified in the tourist mind by their individual mix of "roofing" styles. And all it will really take is a wee bit of imagination! **MMM**

XITIES

Pronounced KSIH-tees' not EX-i-tees

Beyond-the-cradle off-Earth settlements ("Xities") will be fundamentally different from the familiar "Biosphere-I"- coddled "cities" that have arisen over the ages to thrive within the given generous maternal biosphere that we have largely taken for granted. Elsewhere within our solar system, each xity must provide, nourish, and maintain a biosphere of its own Together with their mutual physical isolation by surrounding vacuum or unbreatheable planetary atmospheres, this central fact has radical ramifications that must immediately transform space frontier xities into something cities never were.

SKYSCRAPERS on the Moon?

Beyond Mole Hill City

By Peter Kokh

It'll be a while before tourist see something like this on the Moon, but someday!

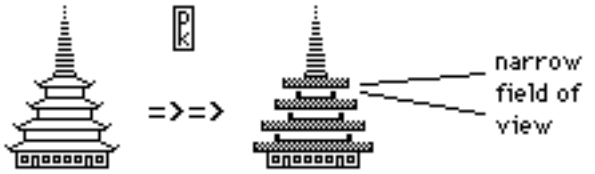
Perhaps you've seen artistic visions of future Lunar and Martian cities replete with modern skyscrapers and flying roadways, all under protective domes of glass or some superior glass-substitute. We touched on this distant possibility in both of the last two issues. Certainly there is much more room for creative license on the part of architects working within the protected "middoor" volumes of megastructures like domes, and shielding vaults such as that illustrated in the Prinzton design study [see MMM #s 26-31, esp. # 29 p.4].

But looking at possibilities in the nearer term, when pressurized structures will be individually shielded, we might ask if Lunar xitiscapes* can escape the mole mold of mound rows of shielding soil, hiding cramped lifespaces below. The appearance of this shielding overburden was our topic in the piece just above: MOON ROOFS. Here let's explore how architectural ingenuity can help a thriving Lunar settlement break out of the terrain-hugging rut.

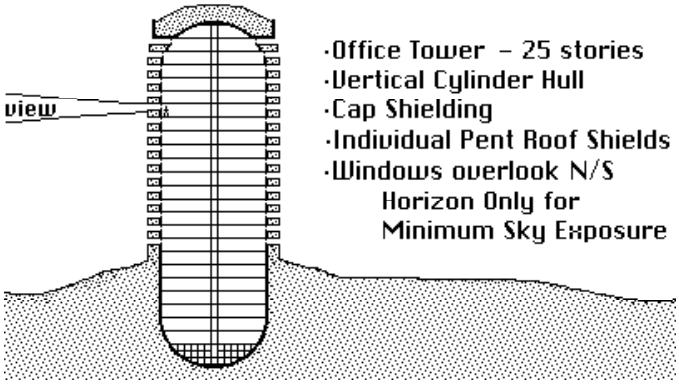
Traditional skyscrapers here on Earth, as varied as they be in style, are basically vertically elongated boxes. Such a shape will not work well if it has to contain atmosphere under pressure against a surrounding vacuum. While higher surface strength to volume ratios allow more freedom with very small structures, on the greater scale of the multi-story building exo-architects will have little option but to somehow adapt the sphere, cylinder, or torus, all of which do a much better job of equalizing pressurization differential stress. There is, to illustrate, no reason that a cylinder couldn't be employed in the upended position, properly anchored, with its internal floors perpendicular to its long axis, instead of parallel to it.

So much for meeting the pressurization challenge. We must still find a way to preserve shielding integrity. A simple outer sleeve a couple of meters (6 ft. or more) out from the cylinder's pressure hull, creating a wraparound coffer dam for filling with soil, would do the trick. But that certainly does not present the architect with a satisfying form of statement. The whole idea of multi-storied buildings is not merely to create an imposing silhouette against the sky, nor to make efficient use of high cost real estate, but also to allow visual access to the ambient outdoors sun/daylight and to the views generous window-walling can provide.

The source of our inspiration is the oriental pagoda with its "pentroofs." In the illustration below you will see how we have transformed this architectural paradigm to hold shielding for separate floors in a "high rise" building.

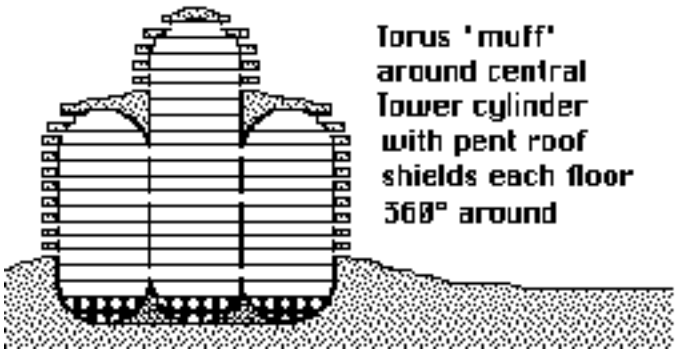


If you accept that such structures on the Moon would be occupied only part time by office-workers, for example, and if you restrict the field of unshielded vision to "a couple of horizon-hugging degrees" or so, vertically tunnel-visioning the view of anyone wanting to look out, the total averaged expo-sure to cosmic radiation from unshielded sky could be kept to an acceptable minimum, even on a long-term basis.



What appears to be tiers of balconies, in this sketch, are really continuous cantilevered coffer dams filled with loose regolith soil shielding. Building occupants are restricted to the interior of the fixed pressure-holding windows to the inside of these "pent roofs".

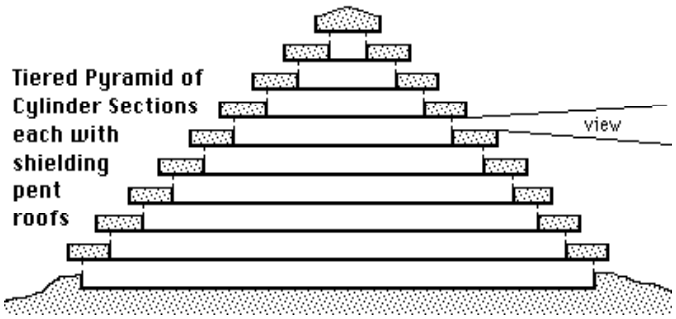
This gives us an architectural "language" that can be used in yet more expressive forms. Below we have a vertically stretched torus "muff" surrounding a central cylindrical tower. The inner and outer walls of the stretched torus would have to be constrained to shape by floor-incorporated cables under tension.



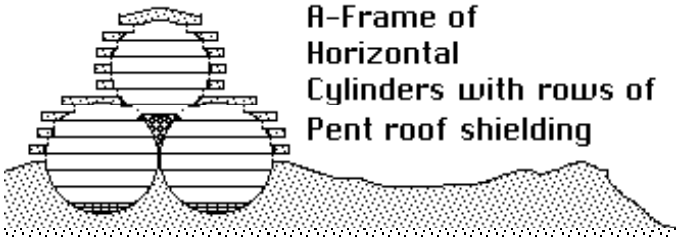
The inner and outer walls of the stretched torus would have to be constrained to shape by floor-incorporated cables under tension.

Another possibility may be to stack (co-axially, or perhaps stylishly off-center) story-thick sections of cylinders of decreasing diameter, each with an attached pent roof soil bin to shield observers inside from the greater portion of the naked light-black, radiation-bright sky above.

The wider the diameter of each story section in proportion to its height, the greater the need to keep floor and ceiling in parallel, not by support pillars under compression, but by vertical (faux column hidden) restraint cables under tension. For unfortunately, the weight of the soil overburden sufficient to provide the needed amount of radiation shielding, is no match in the light lunar gravity for the expansive pressure of the "atmospherule" below against the vacuum outside.



A less pretentious example of sky-scraping is given in the end-view cross-section sketch below, where a number of horizontally placed cylindrical pressure hulls are stacked. The advantage is in longer rectangular floor space.



By whatever structural idiom it is stated, just as in some terrestrial cities, the skyscraper can be given even greater visual impact by siting it on high ground relative to the general surroundings (like the famed Shangri-la inspiring 2500-roomed Potala palace in the center of Lhasa, Tibet) e.g. on a crater wall or central peak, a scarp or lava flow front, etc.

And, of course, purely decorative unpressurized doo-dads such as spires and minarets or other façade-making hull-disguising decor can be added for tasteless kitsch allusion to one or more of the many Earth-legitimate building styles of past and present. We can only trust that most future Lunan architects will see the value of learning to express themselves in authentic world-appropriate forms.
But it is a free universe!

Perhaps you can think of further distinctive directions in which future settlement architects can give vent to their vertical aspirations. If so, we hope you will send them in to MMM so we can share them with our readers.

But, is there a need?

Will lunar settlements ever grow big enough for the real estate at their cores to become valuable enough to justify the extra expense of high rise construction? Certainly not, if they are, or remain, government artifacts. But if settlement is enterprise-driven, first supplying raw materials, then value added products, exploiting every advantage, and diversifying its own domestic economy, there is no reason why the number of pioneers on the Moon cannot rise into the hundreds of thousands or more within a half century of their founding. Remember, for a largely self-sufficient economy, the export sales needed to cover import costs will be relatively small. In the context of a rapidly diversifying economy, in comparison to the rise in exports, the growth of the supported population can be exponential (e.g. a 10-fold rise in exports for a 100-fold rise in population).

The rise of settlement “downtowns” and of metropolitan and regional market centers should be expected if we are to have a real expansion of the human economy through off-planet resources, i.e. a spacefaring civilization. In this setting, the appearance of skyscrapers within or without enveloping xity megastructures should not be surprising.

But settlement skyscrapers should also not be seen as a foregone conclusion. While they might be considered for hotels, offices and corporate headquarters, residential condominiums, government buildings and so on, for each of these needs there are plenty of ground-hugging

horizontal models. Indeed, if there has been adequate xity planning, the need for Manhattan style density should never arise. What multi-story buildings are built may be very modest by Earth standards.

Rather than "scrape the sky", lunar multi-story buildings will "break the horizon". "Spacescapers?"

Indeed there will likely be operative on the Moon a strong disincentive to dense high-rise building: the neighbor's right to unshaded access to the Sun's valuable rays. This may mean that multi-story buildings must have proportionally great east and west setbacks, so that they do not rise above a certain rather low angle above the horizon, say 10°, at the property line. In such a situation, the vertical high rise is no longer an efficient use of real estate. (In theory, the best solution would be a very, very shallow broad-terraced pyramid.) The view (for residents or occupants) and the image (for customers and clients) then, may well turn out to be much more important drivers than the efficient use of "footprint".

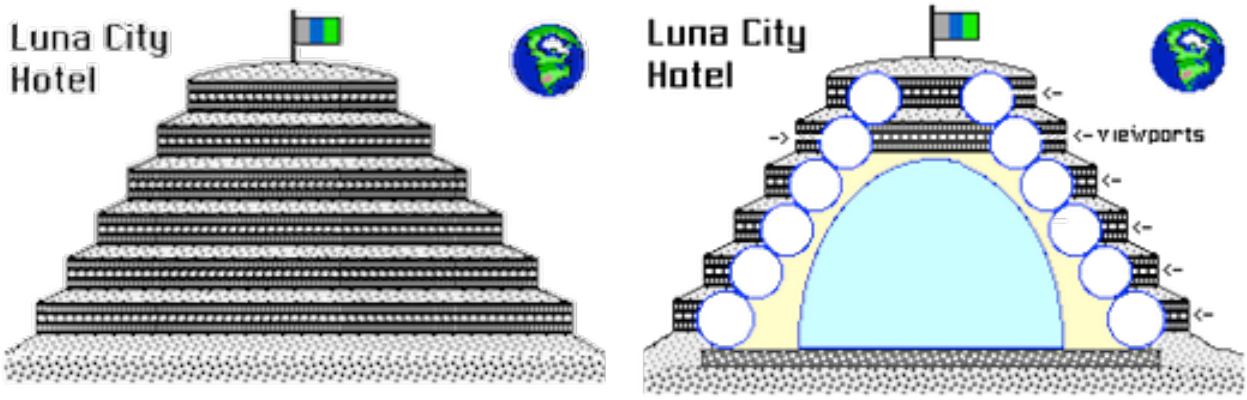
Terrestrial suburban office parks that have become common in the past decade, offer a more realistic inspiration for lunar high rise developers. Rather than "scrape the sky", their constructs will break the horizon. Nonetheless, they will shatter forever the image of lunar towns as "mole hill city".

Visitors to a lunar metropolis will ride "middoor" coaches plying the xity's pressurized avenues within the shared biosphere. But they will also peer out over the surface xityscape from shielded overlooks within the various high rises, and get a good outside perspective from the pressurized out-vac coach to and from the spaceport. Finally, in 1/6 G, a space needle observation tower could easily be a mile high!

MMM

NOTE: We do not really expect that lunar skyscrapers or "horizon-breakers" will really look like this. Our purpose is to suggest possibilities and to inspire future lunar architects. They will come up with their own designs, which will incorporate features we hadn't thought of, and avoiding some of our ideas which prove to be impractical.

We print this article in this "Tourism" issue to signal to prospective tourists, the open ended possibilities that the future may hold. Jumping ahead a few years, below you see a more advanced concept for the "Luna City Hotel" exterior and interior cross-section views. Note that the shielding is kept in place by retaining walls of mold-sculpted, textured concrete, which, if not in form, certainly in hues, blends in with the moonscape.



Each tier or "story" consists of a torus of successively smaller diameter, each resting in contact on the one below. The empty space below is put to good use with an atrium garden.

The tricolor flag that flies above is not an accepted Moon Flag, nor the flag of the Moon Society, but the flag flown by the Moon Society crew at the Mars Desert Research Station in Utah, Feb 26-March 12, 2006 [MDRS Crew #45]

MMM # 56 June 1992

Harbor & Town

"Harbor & Town" – By Peter Kokh

Anyone who has read science fiction stories about the Moon or Mars has come across names like Port Roris, Port Heinlein, Port Lowell, Marsport, etcetera. It seems a natural way to name a space frontier town. Indeed, won't every such burg be a port? Not really! In the first "beachhead phase" of settlement, we are likely to use vehicles like the Apollo era Lunar Excursion Module that could self-land, self-unload, and self-launch - no (space)port facilities needed, thank you!

But this sort of clean operation, efficient and necessary in opening virgin territory, also limits operations. Sooner or later the outpost/settlement-to-be will initiate genuine port functions. There'll be repair shops, fuel depots, landing beacons and paved pads, even smoothways for craft touching down with a residual horizontal velocity. There will be mobile cranes and specialized gantries. Trouble-shooters will service engines and doctor ailing CELSS air and water recycling systems. And a genuine spaceport will have been born.

To avoid expensive duplication, other outposts and towns that can be provisioned overland or by suborbital hoppers may chose not to develop full port facilities. They will have their self-service landing pads and smoothways, of course and they may see the occasional self-unloading freighter or chartered tourist craft, but nothing like the frequent, even scheduled cargo and passenger service of the "central' or "regional" spaceport. And this difference will translate into settlement lifestyles and cultures that are radically distinctive.

In contrast, one almost never hears the word "port" as part of the name of some fictional space settlement or O'Neill colony. Perhaps that is because the word naturally connotes to us the existence of some corresponding "hinterland" which the port serves. And our vision of space oases has been that each is a self-sufficient island unto itself.

How realistic is that? While each space settlement must have docking facilities, sooner or later one will offer special "port facilities" that will attract more traffic, making it a hub from which others are served by secondary craft. Indeed it seems to us more logical that one major spaceport or yard will emerge in the L5 co-orbital field, another at L4, and that a growing percentage of traffic will converge at these facilities, with cargo and passengers increasingly transshipped by barge and shuttle to "hinterspace" settlements.

If full service spaceports emerge on the frontier, what will they offer? In addition to the facilities and services already mentioned, port xity contractors will overhaul, rebuild, re-outfit, and reconfigure aging spacecraft and their systems. There will be a "junkyard" or salvage dealer, maybe even a graveyard for obsolete craft (a museum in the making!) There will be warehousing for incoming and outgoing backlog buffers of cargo. There will be tank farms for liquid and gaseous volatile storage and chemical feedstocks. There will be a fuel depot for the many kinds of fuel likely to be used: liquid Hydrogen and Oxygen, Methane and Ammonia and Silane. There will be hoppers of powdered fuel: Iron and Aluminum and their enhanced performance powdered alloys. There will be containerized unloading and transshipment facilities.

In the nearby town will be the ship chandlers: dealers in ship supplies and equipment. Exporters of heavy equipment will find an advantage in a port xity manufacturing site. The

bigger transshipment firms will headquarter here. Chemical, engineering, biospherics and electronics laboratories will sprout up to serve the growing list of port service contractors.

But the port town will also see the rise of import-export banks and trading houses, of "marine" insurance firms and trade law lawyers. Stock markets and futures markets could arise. Wholesalers will cater to the distribution market, fostering hinterland growth and that of the port xity with it.

Port xities may vie to become the "homeports" of various ships and whole merchant fleets. A sort of "Hanseatic League" of the major port xities in the Inner Solar System might arise to promote free trade, and regulations in their common interest, perhaps even footing the bill for a policing agency to counter piracy and hijacking. Such an alliance could be a forerunner of a loose System-wide political federation.

Port xities will tend to be socially and legally rather liberal in their mores, and noticeably more cosmopolitan in their ethnic and cultural diversity. In contrast, town founders wishing to try some great social experiment are likely to pick settlement sites off the beaten trade track.

Goods, both import and export, will be transshipped to and from the regional spaceport and hinterland or hinterspace communities. Much of this traffic will be containerized, using space barges, overland truck trains, and suborbital hoppers or slide landers, as the case may warrant. Passengers will travel to and from the spaceport xity by feeder surface coaches and suborbital craft or space-to-space shuttle taxis. Material novelties and cultural innovation will ripple outward from the space port centers to dependent outlying settlements.

Detachable holds of speculative trade vessels making circuit rounds between various settlements might be designed "snugline" fashion to slip into special airlocks and taxied or tugged to an in-xity market berth where they could unfold for business, self-contained import shops ready-to-go. Resident hawking agents would vie for the business of visiting trader ships not so equipped to do their own marketing. These trader craft or "circuiteers" would work to increase the amount of trade, thereby helping diversify the art-craft and manufacturing base of each xity on their routes. As a result, an ever-greater percentage of frontier settlement economies would be involved with mutual trade as opposed to trade with the home planet. And an ever-greater portion of that trade might be speculative rather than based on direct customer order.

This trade will be in specialty foods and delicacies, in special fibers and designer apparel, in chemical and organic feedstocks, in strategic raw materials and locally deficient volatiles, in furnishings and arts and craft accessories and gifts. An emporium, for the latest usually unavailable goods hot off the "traders", may determine by lottery who'll have a privilege to purchase items too few to match the demand. There will be barter and haggling. Dealers and galleries will take some spec-ulatively imported art and craft items on consignment. Recognizable spacecraft parts may become fad "canvas" pieces for port artisans, much as old saws for country painters.

There may be trade in salvaged ship decor pieces and "architecturals" in demand by restaurants and hotels to provide space-maritime "atmosphere", or sought by individuals for their dens. Decom-missioned spacecraft might be resurrected as visitor centers, nightclubs, and roadside motels.

And what about visiting spacecraft personnel, the spacers and spacehands of lore? The port xity might offer more spacious and comfortable quarters in which to enjoy their liberty or "shore leave". There will be catering chapels and counselors, recreation clubs and sports facilities, and fast track intensive schooling. There will be medical clinics to treat postponed problems, and specially scheduled seminars to help them catch up on the latest technology in their field. Aso be a place to receive non-electronic mail.

Married spacehands may keep their families in the port xity, their children in its schools. The Moon and space settlements offering lunar standard 1/6th gravity will be the favored homeports for spacefarers, for the adjustment to and from zero-gravity will be much easier. Spacecraft providing artificial gravity are far likelier to offer the lower lunar standard as it is

much less structurally taxing, and means either slower rates of rotation, a shorter radius or both. Few space-farers will call Earth home, or even Mars. “Sixthweight” rules! For the same reason, spacer guilds and guildhalls are likely to be quartered in sixthweight ports. Here too will be the favored communal resting places for spacehands who do not prefer consignment of their remains to the so lonely depths of space.

For the legally or behaviorally footloose there will be the usual spacefront dives and flophouses and dance halls: places where they can get quick fixes of whatever they found themselves lacking on the long journeys between ports. And there’ll be unscrupulous town merchants seeking to trade worthless baubles for shore wages. Tattoo parlors? why not! But also prisons and brigs where needed.

Which brings us to the subject of salutary outlets for people who don’t find themselves fitting in. The port xity will be a place for tired space folk to settle down. And the roster vacancies aboard visiting craft will be a siren for the town’s restless. The port town’s young will be drawn to the spaceport to watch the incoming and outgoing traffic, feeding their wanderlust. It is from their ranks preferentially, as opposed to the young of hinterland and hinterspace frontier towns and out-posts, that the next wave of volunteer settlers will come when some new world or worldlet is about to be opened.

Yet this dose of reality for would-be surface ports on the Moon and Mars! Increasingly, larger spacecraft, including all those using fixed booms rather than winchable tethers to provide artificial gravity in cruise mode, will be forever con-fined to space, unable to make planetfall. Only zero-G space craft and shuttles will come down to the surface, plus the unique class of smaller circuit-making trader ships that are designed to separate in space into winch-tethered components for spin-up to sixthweight mode. [See the description of the aerobrake Earth-Moon ferry “Jules Verne” in “Lunar Over-flight TOURS” in MMM # 21, Dec ‘88, MMM Classics #3.]

If this is so, then the lunar spaceport may be a space depot in low-lunar-orbit, “LLO”. Here the large fixed-confi-guration cargo and passenger ships will dock, their wares taken down or brought up by “lighters”, passengers by shuttle taxis. Here in the environs of “Port Lunagate” will be the big ship-yards for big craft and their even larger successors. But, if this is only a transfer hub and not a population center, as seems the likelier eventuality (to this incorrigible planetary chauvinist) then the surface port xities that it serves will still hoard the bulk of the port-typical features discussed above.

Still, even if the really big ships never swoop down out of the starry lunar skies, the comings and goings of smaller craft will be the talk of the town. Reporters will inter-view inveterate old spacers, thirsty for the latest yarns. Newspapers will advertise the sudden manna of trader-brought goods. Restaurants will advertise the sudden availability of rare delicacies and savory delights. Port bars will be enlivened by the company of the visiting spacefarers. Art and literature in the town will mirror this opening to the larger world. And among all the settlements on the frontier, those that are port xities will be the liveliest, most colorful, most memorable.

Yet for every Yin there must be a Yang. There will always be those who prefer the quieter, more relaxed, less quick-changing “best kept secrets” of hinterland and hinter-space towns in which to live, and raise their families. **MMM**

Note: The picture painted above will fit a lunar port city that has been growing for a decade or two or more. But even the first settlement “spaceport town” will begin to resemble what we have described, bit by bit, year by year, as it grows. Early tourist visitors will get a glimpse of what is to come, and be motivated to pay a return visit a decade or two later. Expect something colorful!.

MMM # 69 September 1993

Tourist Earnings

FOR SALE: Unforgettable Experiences & Unequaled Opportunities

By Peter Kokh

Profits from space tourism to be plowed back into the Lunar economy, can be earned for the Moon only to the extent that the tourist operations involved are owned, operated, and equipped by settlers. If at first this seems an unlikely scenario, consider the cost of building tourist resorts in LEO [Low Earth Orbit] from materials brought up from Earth in comparison to cruder yet comparable facilities built of materials processed from lunar regolith - the twenty-fold savings in freight charges will tip the edge to companies able to supply the latter, once the necessary upfront capital investments have been made.

Initial LEO resorts prefabricated on Earth will be small, however luxurious. Ample and spacious complexes able to accommodate a much wider range of activities (read zero-G sports and recreation) will have to await the breakthrough in construction costs promised by NTMs — Non-Terrestrial Materials. Compare 50s era Las Vegas resorts with those of today and multiply the difference by a hefty factor!

That said, earnings from the use of lunar materials to support expanded tourist opportunities in space will only flow into lunar accounts to the extent that the building materials manufacturers and construction companies involved are settler-owned and/or settlement-taxed. Unfortunately, there are ample past models for exploitative colonialist rape-theft of foreign resources to give us ample warning that without the proper legal-political-economic regime in place, space frontier settlers could well end up not seeing a penny of the profits. Indeed, some of these unsavory practices have been at least implicitly advocated in development schemes put forward by some space advocates emotionally opposed to surface settlement by "planetary chauvinists".

Assuming that we set things up right however, the construction, outfitting, and servicing of tourist facilities in LEO should provide a major market for the lunar economy. After all, tourists are the one thing it is far more profitable to source from Earth than from off-planet! And LEO is their handiest, least expensive "off shore" destination.

"Build it and they will come" — for the rocket-thrust experience of liftoff, for the sensation of weightlessness, and for the angelic, olympian views. Those not plagued by space-sickness will get "the experience of a lifetime" promised by the hype ads. As ticket prices moderate and demand increases it will become profitable to offer "enhanced" orbital vacations.

Exercise, sport, and even dance classes and events will exploit the opportunities of weightlessness. To make the most of the unparalleled views, there will be both "heads-up" view-plate display aids and experienced human guides to help sightseers identify and understand the geographical, geolo-gical, ecological and environmental, geoeconomic, and meteorological clues in the brilliantly sunlit panoramas below.

Picking out major and minor cities by their night lights will be a popular pastime. For astronomy buffs, the twinkle-free brilliance of the quickly shifting starscapes will bring a foretaste of heaven.

The leap from Earth Orbit tours to deep space excursions such as lunar swingbys is relatively easy. [MMM # 21 Dec. '88 pp 2-5 "Lunar Overflight Tours" pages 18-22 above.] If part of the vehicle's (and its outfitting) involved is "Made on Luna", some of the revenues from this extension business will help boost the lunar economy. Better yet if the companies serving this trade are settler-owned.

Tours to the L4 and L5 Earth-Moon co-orbital fields, which may be the site of considerable construction and manufacturing activity and boast settlements of their own, will also become popular early extensions of LEO tour stays. From these twin vantage points, Earth and Moon can be seen both together, 60° apart, and in similar phases (new, half, full, etc.). Excursions still further out may also be available.

As to "land excursions" on the Moon, in the early days when the preoccupation will be with building and establishing the first settlements and coaxing them toward some degree of self-sufficiency, it may not be possible to "visit" the Moon except on "working tours" as part of construction or prospecting crews, much as people now pay to go on archeological "digs". Eventually, traditional "pampered tourist" type vacations will be introduced.

Such offerings will probably await the day when any and all new pressurized habitable space on the Moon is constructed of materials processed from the local regolith soils. Until then, the per square foot cost of habitat prefabricated on Earth will be much too high to squander on tourist activity for anyone other than the obscenely well-to-do.

For sightseeing surface excursions, pressurized cabins retired from Earth-Moon ferries and fitted with wheeled chassis and suitable motor units ["toads", cf. "Lunar Hostels: Part I: Amphibious Vehicles – See pages 27-29 above.] They might be brightly colored ("Tangerine Toads"?) for safe visibility in the overly gray setting, operated by a commercial distant cousin of Greyhound ("Grayroamer"?).

As for touring Mars, that is an altogether different set of ifs. It is unlikely there will be any sort of tourist activity out that far until tested and proven second generation nuclear rockets are available that can significantly reduce travel times and total cosmic and solar radiation exposures. First to become available will be tours to Phobos and Deimos, Mars' two close-in moonlets. These tours will feature extended observation of Mars from relatively high orbit (3,700 and 12,500 miles over the Martian surface, respectively).

However, much closer fleeting glimpses of the day-lit side approaching and coming out of the aerobraking maneuver that ends the "cruise" out from Earth and puts the craft on a trajectory for either of the moons. Excursions to Mars surface itself may follow the lunar pattern, working tours first.

Is there a Lunar part in all this? Yes, to the extent that some of the vehicles, equipment, and provisions are lunar built, modifications of items first designed to bootstrap the unfolding of lunar settlement itself along with Earth-Moon trade. One thing builds upon the other — if we play our cards right, leveraging the most from every advantage. **MMM**

7 WONDERS of the Moon

Top Picks for Tourists

The Seven Wonders of the Moon: An "Armchair Pick"

By Peter Kokh

From orbit, as through any modest telescope, it will be quickly apparent that the Moon offers an unexpectedly diverse landscape. Eye-catching paintings of over-imaginative artists aside, (there are no craggy peaks untouched by erosion and few if any rough edges — all terrain features having been inexorably softened by the eons-long rain of micro-meteorites) this world does have some striking features all the same.

On Earth the rugged awesomeness of crustal rock outcrops and other features forged by a contest between brute geological forces and the relentless onslaughts of an ever active weather system are set in contrast to the beauty of vegetation in wild strobe-like stasis of species competing for niche space. On the sterile and barren Moon there is no such counterplay between geological awe and botanical beauty. Moonscapes, however otherwise dramatic or boring in feature, are all of one canvas in being displays of "magnificent desolation" (Buzz Aldrin, Apollo 11 landing crew, 7/20/'69).

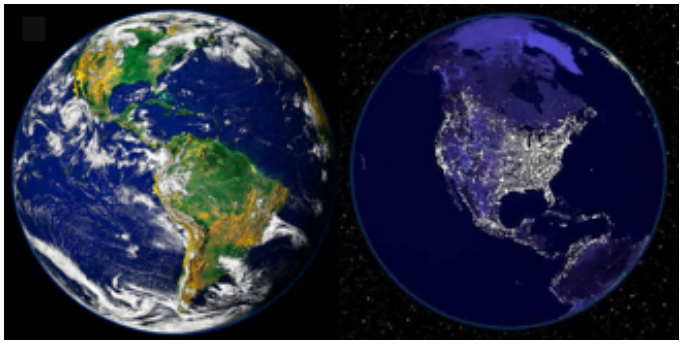
Many humans are quite insensitive to natural beauty (e.g. "when you've seen one waterfall, mountain etc., you've seen them all.") and will react to the Moon in character: "when you've seen one crater, you've seen them all". To those of us with an eye for differences and especially to those of us with an appreciation of untamed geological drama, the Moon, boring only to the boring, boasts a wealth of spectacular vistas.

As on Earth, the most spectacular views of the terrain itself will be had from the unobstructed vantage points of high ground — from crater and ridge tops, mountain peaks, rille edges, and promontory points. These overlook craters and walled plains, the frozen lava seas of the maria, straight and sinuous valleys, rolling, cratered, and chaotic terrain etc. As on Earth, there will be sights that merit only local or regional fame, and those that deserve a place on the global honors list.

Here is an armchair selection of nominees for a place on the "Seven Wonders of the Moon" list, the pick of one Earth-bound, telescope-, moonglobe-, and lunar photographic atlas-equipped student of the surface of "Earth's significant other". Five of the Wonders on the list are surface features. Two spots are extra special treats in the lunar heavens.

Five Nearside Wonders of the Moon

1. Earth itself, an apparition in lunar nearside heavens with 3 1/2 times the breadth, blocking out 13 times as much of the starry skies, and shining with 60 times as much glaring brilliance as does the Moon as seen from Earth — all in a spinning ever changing marbleized riot of blues, greens, browns, and whites. It goes through the same series of sunlit, night-darkened phases as does the Moon in our skies — with spectacular differences. "New Earth" when eclipsing the Sun during what we interpret as a Lunar Eclipse is a dark circle in the heavens crowned with the fiery ring of the sunset-sunrise line as sunlight scatters in the dust of the atmosphere. The night-darkened portion of the globe is in the last century increasingly "star-studded" with the city lights of burgeoning urban areas and oil and gas field burnoffs of "waste" natural gas and hydrogen. Meanwhile the frequent reflection of the Sun off ocean and ice accentuates the sunlit portions.



Full Earth illuminates moonscapes with sixty-some times as much brilliance as Full Moon brightens Earthscapes. This will be handy for getting about during the long lunar nights. But without a dust and water vapor laden atmosphere on the Moon, Earthshine shadows are inky black and impene-trable, and starlight is not drowned out. However, for the eye's pupils to open enough to appreciate the starry vistas, the brilliance of Earth must be baffled out of one's field of vision.

While Earthbound students can patiently study a seemingly eternally changeless Moon, lunar settlers and visitors who turn their gaze upon the Earth will have an unending drama of spectacular kaleidoscopic change to admire and study. It will be a treat without the distraction of flora and fauna and weather in the foreground, a Van Goghish canvas of color understatingly matted by black sky and gray regolith.

Astronomical painters such as Bonestell have tried to help us envision what it will be like to look upon Mars and the various other planets from the surfaces of their natural satellites. But the view from the Moon need take second place to none. Yet not all lunar settlers and visitors will be able to appreciate it with equal ease.

"All the Moon can be divided into four parts"

To paraphrase the opening sentence in Caesar's report on the Gallic Wars, "Omnis Luna in quattuor partibus divisa est": "All the Moon can be divided into four parts".

"The Crooknecks" include the central part of the Nearside hemisphere, Earth is either directly overhead or at a very uncomfortably high angle above the horizon. Settlers might aptly nickname these central regions **"the Crooknecks"**. Included is most of Mare Imbrium, Mare Nectaris, Mare Serenitatis, Mare Tranquilitatis, Mare Nectaris, Mare Vaporum, etc.

"The Postcardlands" are the peripheral portions of nearside, regions in which the Earth hovers perpetually a comfortable 5-40° above the horizon.

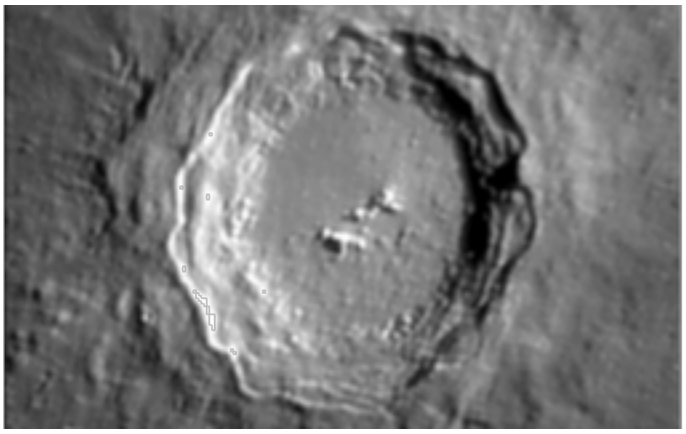
"the Peek-a-boos" are adjacent to these, straddling the "limb" of the lunar globe that forever keeps the same side turned towards Earth. Because the Moon's axis is not perpendicular to its orbit around the Earth and because that orbit is somewhat eccentric and the Moon travels faster when nearer Earth and slower when further away, all the while rotating at a fixed rate, about 7° to either side of the 90° East and 90° West lines are alternately turned towards Earth and away from Earth. Taken together, the above three regions cover nearly 60% of the lunar surface.

"the Peek-a-boos" include the remaining 40+% is in, the Farside heartland from which Earth is never visible. "Out of sight, out of mind" as they say. This sets the scene for the last two Wonders on our list.

2. Copernicus. Nearside has many striking large craters. Any amateur astronomer who studies the Moon through a backyard telescope will recognize a couple dozen by location, appearance, and name. And each will have his/her favorites.

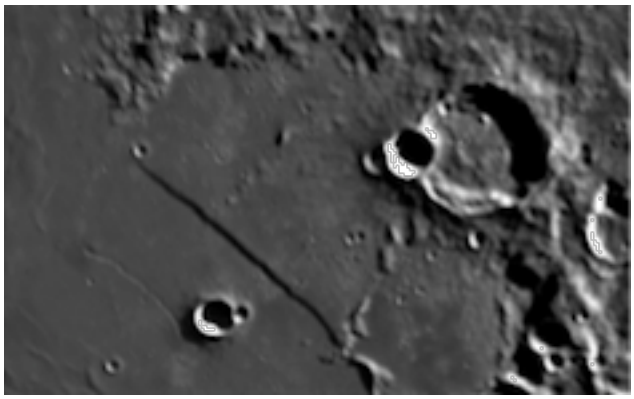
Even to the naked eye a few craters stand out a quarter million miles away. During Full Moon, **Tycho** in the mid-south is the radiant point of bright streaks of lighter regolith splash-out that stretch for thousands of miles. Smaller **Aristarchus** catches one's attention with the superimposed brilliance of Venus. **Plato's** dark floor (Academy Plain?) can be picked out just north of Mare Imbrium, the Sea of Rains.

Through the binoculars even more can be recognized. But even though there are sixty-some other nearside craters as large or larger, easily the most striking of all, from Earth, is **Copernicus**. With its extensive debris slopes, it sits alone in southern Oceanus Procellarum, the Ocean of Storms, without neighboring rivals. **Mount Nicolaus*** at its center reveals a glory of detail. [* The author has published his suggestion that crater central peaks be known by the first name of the famous person after whom the host crater is named. They are otherwise known only as "central peak of ..."] A stunning low angle photo-mosaic of Copernicus taken by Lunar Orbiter 2 in late '66 was billed by the media as the "Photo of the Century". Indeed its psychological impact was without precedent.



Early settlers will have as favorites prominent craters that lie in easy excursion reach of their settlement. It will be these that are first offered on itineraries of tourists from Earth. As tourist support infrastructure grows, however, those sights with world-class splendor will be offered. If Copernicus is not handy to the initial settlement site(s), it will soon be reached "by beaten path" nonetheless. In low gravity "sixth-weight" it should be easy enough to build an elevator-equipped observation room-capped tourist tower 2 miles (10,000 ft. 3 km) high atop Copernicus north rim to showcase the scene.

3. The Straight Wall. In southern Mare Nubium, the Sea of Clouds, lies a 90 mile long escarpment or cliff known as "The Straight Wall". Because it runs north and south, it is cast into high relief by the rising Sun and is very prominent in even a low-power scope a day after first quarter (first Half Moon).



While the "wall" is not really that high, this sunrise shadow play can be appreciated from surface viewpoints as well, especially those above the average elevation of the plain to the east [a mischievous use canonized by astronomers. The thought never crossed their ivory tower minds that the orientation of people on the surface might someday matter. What is the "eastern" hemisphere of the Moon as seen from Earth is really the "western" hemisphere from a lunar point of view as determined by the progress of sunrise and sunset.]. This feature probably does not deserve a thousand mile detour, but it is unique and special enough to be on the itinerary if established trade and travel routes pass nearby.

4. The Alpine Valley. Running like a canal through the mountainous terrain between Mare Imbrium and Mare Frigoris a couple of hundred miles east of Plato is an arrow-straight cut or trench, probably made by a massive piece of ejecta from the impact explosion that carved out the Imbrium basin. About a hundred miles long, it is sure to be a mainline route for traffic and utility lines between these two mare areas. All along the route there are high points to either side which must offer quite a vista. Some of these may one day host tourist lookouts, rest stops, and hotels.

5. The lavatubes. While we have strong evidence such features exist and in what kind of lunar terrain we are likely to find them, we have yet to actually map, much less explore, even one. These cavernous wormholes made by subterranean rivers in the still cooling lava floods that, layer upon layer filled most of the Moon's larger impact basins over three and a half billion years ago. Some near surface tubes have partially or wholly collapsed to form broken or continuous sinuous rille valleys. But many others must lie intact, invaluable geological preserves as well as handy shelter for the more volume-hungry needs of lunar settlement and industry. Lavatube exploration is sure to be an honored lunar "outlocks" activity.

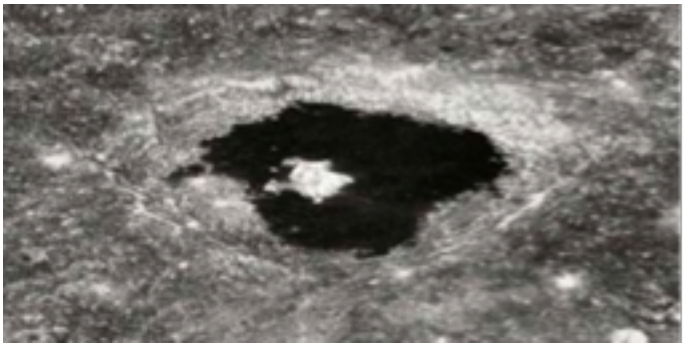
Two Farside Wonders of the Moon

6. The Milky Way. One of the lesser-recognized ways in which we are allowing our terrestrial environment to continue to degrade is urban nocturnal light pollution. Today there are millions of youth who have never seen the Milky Way. For those of us fortunate to live in or visit at least occasionally, countryside areas well outside built-up populated areas, the sight of the Milky Way in dark star-bedazzled skies is unforgettable. But we glimpse it at the bottom of an wet and dusty atmospheric ocean. Even in mid-desert where on cold crisp nights the seeing is best, we are somewhat handicapped.

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

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

7. Tsiolkovsky. The standard approach and landing trajectory that ships bearing settlers, tourists, and visitors will take to surface settlements will bring them in on a descent swing around Farside. Mare Orientalis, the dramatic bullseye-shaped Eastern Sea (misnamed because it is in the western Peekaboos) will be the feature most watched for, if, of course, it be sunlit at the moment. But deep in Farside, again depending on the time of sunth, another spectacle awaits them, to this writer's eye the most dramatic crater on the Moon — Tsiolkovsky, aptly named after he who taught us that Earth is but our cradle, and that it was our destiny to move up, out, and beyond.



Like Plato and Grimaldi on Nearside, Tsiolkovsky's basin is flooded with mare-like deposits — in its case some of the darkest mare regolith to be found anywhere on the Moon. This only serves to set off even more strikingly the **Mount Konstantin** massif that dominates Tsiolkovsky's interior. What a perch for a monastery or shangrila!

If the day comes when human settlements in the solar system organize in some politically cooperative way, what better site for a capital or headquarters than on Tsiolkovsky's dark flat floor south of the Konstantin massif. It is handy enough to Earth where most of humanity will continue to live for a long time to come. Yet its horizons face away from the hidden cradle world out upon a Milky Way crowned universe of unlimited opportunity. And who could pick a better name? It's frosting on the cake that those approaching from space could pick it out instantly by naked eye a half million miles out

National Parks and other Preserves

Any discussion of great natural wonders would be incomplete without considering what we might to do preserve such heritage. **Scenic Preserves** would establish regulations restricting buildings, road placement, and other developments in the foreground or background visible from scenic overlook sites. **Geological Preserves** would go further, protecting not only specific viewpoints but the physical feature itself from development, some types of mining, etc. Designation as a **National Park** would signify the intention to develop tourist and other recreational use facilities nearby so that the feature could be popularly enjoyed in a controlled fashion, as well as preserved from other types of development.

There is the added question of preservation of scenic orbital perspectives, i.e. of preventing developments that might be defacing on a large scale. Given the impotency of efforts to control forest clear-cutting in the Pacific Northwest where ugly scars that seem to grow cancerously insult anyone peering out an airplane window, lunar authorities will have to insulate themselves from the palm-grease of developers if they are to have any luck. But solving the future's problems is the chore of those alive at the time. We can but warn.

MMM

"A Budget Trip to Mars?" - Note: Not added to the list above is a "sight" that is sure to be on the Tourist top 3 list: **anywhere on the Moon's nearside during what from Earth is a total eclipse of the Moon**, with the Moon passing through Earth's shadow. During this time, the Moon's surface will look a lot like that of **Mars during twilight!**

MMM # 78 September 1994

"Tourism in Earth Orbit — and Beyond"

A 3-Breakout Workshop, May 28th, 1994, ISDC '94, Toronto, Ontario

Led by Peter Kokh, Mark Kaehny, George French

Breakout 1: A Space-going Tourist: The First Flights

Mark Kaehny, President: LRS, Editor MMR (discussion leader and secretary)

Team: Ronnie Lajoie, Ruth Petra, Morrie Schneiderman, Mark Kaehny

Tourism is perhaps the largest "industry" in the world at present. People like to see new sights, try new things, be thrilled, and of course show off their wealth and status. If we are to expand our human experience off the Earth we will also have some of the most exciting, spiritually uplifting, and expensive experiences accessible to those who want to try them.

In this workshop exercise we tried to explore what the first steps in Space tourism might look like. We defined space as in the IAU definition of 100 km (not 50 miles like the US Air Force). Thus the "space" part of space tourism means going at least 100 km (62 miles) up for some period of time. The group considered a time of a few minutes to a few hours as the period in space. "Tourism" generally means going somewhere or doing something for personal enjoyment and the experience.

The Current "Space Tourist" Options

Currently there is only one possible Space Tourism opportunity - the Russian Space Program if you have enough cash (say $10 million). This is not guaranteed but it currently is the only game in town.

There are several other opportunities at present for the adventurer, that have some relation to space. They may go to Space Camp™ in Huntsville, Alabama and work through a simulated shuttle mission. They may experience micro-gravity in several places for a period of time longer than the nearest roller coaster - aerospace companies or organizations off parabolic flights with several minutes of weightlessness in Russia and commercially in Idaho. If you can fake being "useful" (remember we are talking about a tourist here!) you may even get on NASA's micro-gravity plane. These experiences cost from several to many thousands of dollars.

The only truly commercial one of these enterprises is Weaver Aerospace in Idaho. Commercial in this case meaning that the Company is not just scrounging equipment built for other purposes and making extra money, but rather that this is their business and the proceeds are put back in to the company. Actually Interglobal Space Lines, Inc. (307-739-1296) provides the flight opportunities through Weaver to Tourists.

The closest the "average" millionaire can get to space now is to get a ride in a Mig 25 up to 15 kilometers or more. At this level one must wear a pressure suit, sees the stars with the eye in sunlight, and sees clearly the Earth's curvature. This kind of experience costs tens of

thousands of dollars. (If you don't already live in Russia.) There is a steady supply of people doing this. So where do we go from here?

The Next Generation

What can a tourist look forward to in the next 10 to 15 years and what kind of market will there be at various price levels? Our group concluded that tourism could actually be a driving factor for development of maneuverable suborbital spacecraft designs and also for orbital designs.

For true "space tourism" we assume that one or several of the Single Stage to Orbit designs works. The "sortie" cost of a flight has to be brought down to between $100,000 to $1,000,000 depending on the number of passengers. This would seem to be a necessary prerequisite for space tourism. This market segment includes those people who do the activities described in the previous section and people that go to the Antarctic, who make scuba trips, who take helicopters to ski down Greenland slopes, etc. The common denominators are a willingness to take a chance to get a unique experience, and the ability to pay for it. A "space experience" including a suborbital flight (or depending on launch prices a few-orbit-flight) was assumed to cost $50,000 or so. This was just taken as a figure out of the blue - launch costs have to come down by an order of magnitude for something like this to be possible. No market surveys were done at this point. The group decided to concentrate on fleshing out what a tourist would be buying when they bought a "space package", what kinds of equipment would be needed, and a 'walk through' of what the experience might be like. Sooner than one might think, people will routinely fly into space, just for kicks.

What a Ticket Might Buy

Suppose Jane Doe buys a ticket from Space Tours Inc. What is she going to get? Certainly not just a quick one hour flight for her $50,000 dollar ticket! The experience should be a combination of Space Camp, Emergency Rescue training, and an American Museum of Natural History Cruise. Jane would pick a 2 week period for her trip. She would come, have a flight physical to qualify her (before paying, of course), and spend about a week in orientation that may include a micro-gravity flight in a plane. Also for some types of suborbital flights she may need to worry about high-G stresses. The orientation would consist in getting familiar with the cabin environment, and if Space Suits are to be used, with her suit and how it works.

Since the tourist company would want to maximize throughput of people, part of the orientation would be given by someone who have already been on a flight. This allows for socializing, and for letting the "experienced" show off a little. Depending on the kind of flight, different things would be emphasized. As with things like Space Camp, all persons would have a personal video of how they trained, and how they taught.

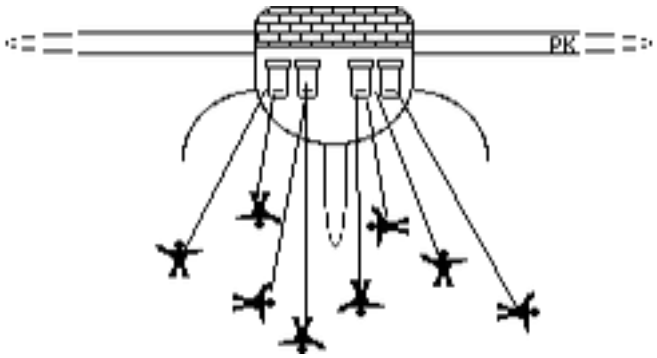
For a suborbital flight lasting on the order of Alan Sheppard's flight [i.e. about 15 minutes] it would be nice if the craft could return to the point of origin. This means cross range and some kind of maneuverability in the vehicle. There would be at least 10 minutes of weightlessness. Flight problems that would have to be dealt with are sickness, panic, normal bodily functions ... and room. To deal with these there would have to be "caretakers", more than just stewards and stewardesses, along. These people would have to be able to deal with unforeseen problems. Diapers [chux] of some kind or a similar system could be used for as short a flight as this. Room is certainly important.

If you are crammed in a little space with no window you won't even notice you flew! Large windows and some room, perhaps as much as is given in a railway seat (bigger than an airplane seat), would be nice [although such generosity would surely increase ticket prices - Ed.]. The spacesuit option discussed below is probably impractical for this short a flight. Either everyone will have their video equipment or cameras, or overall video would be provided. The flight schedule should be such that either a sunrise or sunset would be visible to the passengers. A little night Earth viewing would be nice.

Orbital Flights

For an orbital flight, with more than an hour of micro-gravity more problems (and more fun) are possible. This could be a LOT more expensive than suborbital flights.

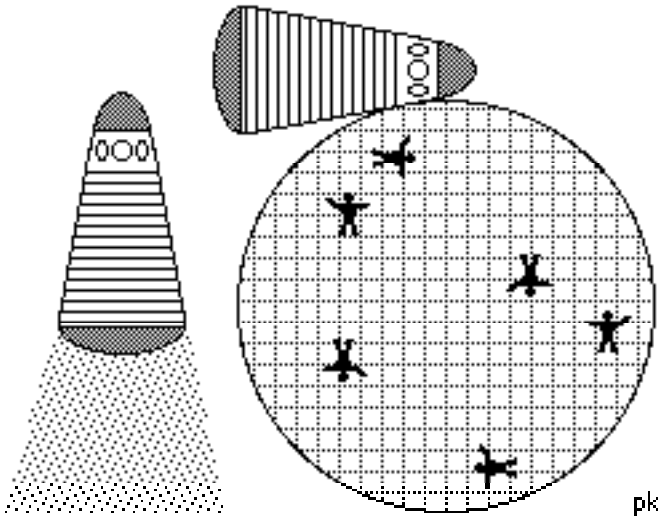
One option discussed was the idea that each passenger wear a space suit, and that the cabin be opened up so that each ticket-purchaser could float in space, for a true "in-space" experience.



Points to consider would be the design and manufacture of relatively inexpensive space suits, and the probable need for extra personnel to deal with people getting sick in their suits, etc. One could just have the top of the cargo area open up above the people, people would be hooked to their seats by short lines so they wouldn't get tangled up, but they could mess around. Another way is to have the people exit a hatch on some kind of control structure.

Tether-restrained "free" floating Space Shuttle type Payload Bay Passenger Cabin Orbiter

Finally, there was the suggestion that a strong but practically invisible net be cast out as the cabin doors or roof opened, so that each passenger could float truly free, without tethers and tether entanglement problems. But then how would you round everyone up? Sooner or later the romp must end so as to start making preparations for a descent out of orbit.



"Truly free" floating within "invisible" net - Delta Clipper type Passenger Orbiter shown

With Spacesuits would come the need for radio communications. What if somebody becomes disoriented and starts screaming? The caretakers should be able to cut off people from the general circuit. Depending on the number of passengers, there may be several circuits for people to use. Spacesuits or helmets would be uniquely labeled, different colors, etc., for easy identification. Depending on cost, the passengers could have the option of keeping them. Problems with the spacesuit approach are obvious and the danger would be greater, but what an experience!

Other possibilities for orbital flights would be the ability to call friends and relatives on the ground from orbit, and all the viewing described above. With orbital fight, everyone will get

to see at least one sunrise and one sunset. The craft should also return to the departure point for more centralized operations.

Note that this is the report on an "idea generating" exercise in thinking about this type of tourism. The problems were not dealt with in detail; rather the idea was to get some feel for the experience. It would be dangerous, some people would die, but people die every year scuba diving. The people to whom space tourism would appeal would not be risk averse.

Space tourism of the sort envisioned is dangerous but perhaps not as physically demanding - an older person (>65) in the group was quite interested. The existence of groups like Weaver Aerospace and Interglobal Space Lines makes us hopeful that this kind of thing will come about, and point the way for what kind of space research NASA could be doing -- developing the engines, designs and test vehicles, so that the type of spacecraft needed for these flights would be available! **MRK**

Few men during their lifetime comes anywhere near exhausting the resources dwelling within them. There are deep wells of strength that are never used.
- Admiral Richard E. Byrd

MMM # 79 October 1994

Space Tourism Workshop Part 2: The first Space "Hotel":
Aiming at a ready-made market

Discussion Leader George D. French, Jr. President: Wisconsin Space Business Roundtable.
TEAM: Richard Richardson, Edward T. Reber, Kyle Smith, George French (team secretary)

While the suggested "Mission" of our group was to "assume an operational Earth-to-Orbit Passenger Vehicle of some type and design an independently orbiting minimal tourist hotel not attached to a Space Station and suitable for stays of a few days ..." we decided on a much more conservative and practical project. Our reasoning was that business and industry travelers to the station would form the first hotel market, not private individuals going up for personal pleasure.

Accordingly we endeavored to define this ice-breaking market niche, and then define just what kind of a facility, attached to a space station, might fill their needs.

At the time of the Toronto ISDC last May, the future of "Ralpha", the proposed joint Russian-American Mir II based station was still in doubt. Its proposed inclination of 51° to the equator, fine for Earth observation of temperate latitudes seemed to us less than ideal in that it made access from U.S. spaceports (European, Japanese, Chinese too) more difficult and expensive. The scenario we were working with was a multi-government built station in a 28° to 32° orbit, a compromise between accessibility from most international spaceports and the range of observable latitudes.

Attachment to an oft' proposed commercial orbital facility seems another option. If both types of facilities exist, cooperation between them is likely, depending on their mutual proximity in orbit If Ralpha is built as proposed, the appeal of and incentives for a second commercial station in a much less highly inclined orbit (better as a staging point for deep space operations of any sort) would grow stronger.

The advantages of attachment to an existing station, government-run or commercial are these:

✓ **A ready-made market for housing commercial, industrial, and official visitors** to any existing station engaged in orbital research and/or manufacturing.

✓ **Power, communications, and attitude control, and orbital altitude maintenance** would be already provided for by the host facility, making the hotel more of an "incremental" expense, much more feasible to amortize with (company or government-paid) guest registrations and thereby more apt to earn a profit. We think it makes more sense that any such facility, even attached to a multi-government international facility like the defunct Freedom or current Ralpha station, be both commercially owned and commercially operated.

What is the market? Activities likely to be supported in orbit by both governmental agencies and commercial/ industrial projects are:

✓ Astronomy

✓ Life Sciences

✓ Experimental agriculture (centrifuge hosted-hydroponics)

✓ Zero-G or micro-gravity research and processing.

✓ Manufacturing feasibility research and manufacturing:

Those (in addition to the station's regular crew with their own habitat module(s)) coming either to work or to tour and visit will need the following:

✓ Zero-G-proof facilities with locomotion and position-keeping aids and adaptation assists

✓ Exercise facilities

✓ Work stations

✓ Other research and study facilities

✓ An observation cupola or viewport, inspection port

✓ Additional communications facilities

* Press interviews
* Conference calls
* Family calls
* Program origination broadcasting facilities

✓ Assembly lounge facility (= dining, entertainment center)
(Nb. meals could be taken with regular station crew)

✓ Games, entertainment center, audiovisual library

✓ Half as many berths as design guest capacity, on a time-share shift-assigned basis. This provides for more efficient 24-hour use of work, recreation, and sleeping facilities alike — no underutilized space. Six berths seems a reasonable initial size to support the early market. An upgrade would be a dozen berth cores with movable partitions between them to provide elbow room when occupied.

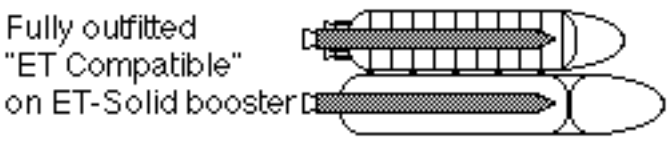
✓ Toilets, showers - hygiene facilities in general.

✓ One "permanent" staff member with medical and other training appropriate to serve as host and decision maker.

Two "prefab" hotel design architectures seem plausible:

1) A very spacious in-orbit modified Shuttle External Tank with a docking port in an Aft-Cargo-Compartment (ACC) for real "growth potential".

2) An option would be to boost to orbit a ready to use ET-based facility, sent up dry attached to a fueled ET and double booster pack, in the proposed shuttle-C configuration.



✓ A functional mockup of the proposed Mars Habitat Module in Bob Zubrin's "Mars Direct" mission proposal: [see MMM # 42, p. 3, FEB '91] a cylindrical pod 27.5 ft in diameter (same as the ET), two floors (16 ft.) high with nearly 600 square feet per floor. It could be attached to the station by NASA, to test its flight worthiness and debug its systems in an extreme environment closer to home. This choice, more in scale with the proposed station, kills two birds with one stone, providing a small but functional commer-cially-run orbital hotel and preparing for Mars exploration (perhaps earning it a hefty NASA subsidy.)

ABOVE: Artist sketch of the TransHab Habitat Module attached to the Space Station.

For station hotel use, the "cargo floor" could contain science and/or utility systems equipment or additional private berths and common space.

While usually "tourists" need only minimal special "preparation" for their tour or expedition, it seems prudent that all visitors to the station hotel in this early phase undergo some qualification process with some subsequent training. There will be physical qualifications and others requirements.

The amount of training tourists or would-be hotel guests will need will depend on relevant past experience, from as little as 2 weeks to as much as 6 months. A certification process (and certification maintenance program) are likely.

While the early market may be dominated and pump-primed by official visitors and commercial/industrial visitors, there will occasionally be upcoming vacancies that can be filled by lottery winners, affluent globe-trotters, press persons on assignment, etc. Beginnings are always humble. **GDF**

MMM # 80 November 1994

Space Tourism Workshop Part 3:
An Expandable Luxury Earth Orbit Hotel-Resort: Beyond Motel 6

Peter Kokh, discussion leader

TEAM: James McEnanly, Goana Milosevic, Murray Wilson, Janet Jones Smith, Hugh Dietrich, Dennis Pearer, Bill Bogen

MISSION: Assumption: Market demand i.e. ticket prices now make it possible to build a luxury hotel in orbit. It will have artificial gravity sections at Earth-normal, Moon-normal (1/6 G), and Mars-normal (3/8 G). There should be 50-150 guest rooms with at least double occupancy. They will be compact but comfortable (more akin to Amtrak than cruise ship models). The hotel should, however, have generous exercise room in a non-rotating zero-G hub.

Take time to consider what other amenities are worth the cost to guarantee a "thrill of a lifetime stay" and how little/much room they merit. There should be generous Earth-viewing and watching lounge areas. How about a "screened in" "outvac" sports area to frolic in with untethered space suits?

Design a facility that is both easy to construct and finance. Assume that only Earth-sourced components are available at this time. You should probably work with prefabricated modular elements like ET-Compatibles, outfitted on Earth and boosted dry (in place of an Orbiter) or more compact modules, rather than design some stunning megastructure that will require extensive on orbit labor to assemble. There should be two or more docking ports at a minimum. You will want to keep total per capita (guest & staff) weight (and number of launch loads) to a minimum.

It is important that the design not be fixed in size but able to support continuing hotel expansion as tourist demand warrants. The special constraints imposed by artificial gravity are to be considered here. If you have time, show phase by phase expansion and what might be added: rooms, suites, conference areas, shops, other tourist- and business-oriented activity areas.

Your purpose in all this is to expand on your own thoughts and help illustrate to others some of the logical possibilities.

WORKSHOP RESULTS:

The way this group worked, various ideas and trial balloons would be put forth by each of us as they came to mind no matter which heading they came under: guest facilities, guest activities, recreation, food, services, structure, future expansion — if this free-form process seems unruly, it is exactly what is needed. For, after all, everything bears on everything else and to tackle each heading in sequential isola-tion is to guarantee our missing important definition and design opportunities.

The moderator's job is to help others flesh out their ideas, suggest repercussions and enhance-ments, and get the discussion back to unfinished business. A synthesis of our brainstorming follows.

What Hotel Guests Will Want

The View:

Individual Quarters, or at least Premium Class ones, should have shutterable portholes from which to gaze on the planet below: landforms, mountain ranges, rivers, coastlines, seas, clouds; and, on the nightside pass, the ballet of lightning flashes and metropolitan city lights. Common areas such as a combo Dining/Lounge/Library/Assembly hall should also provide generous Earth views.

Floating Free:

For those able to adapt to it without space sickness (about half of the general population), the ambient zero-G will be something to enjoy. There should be some assists, however: velcro shoe soles with convenient attach points here and there, handrails, visual cues, possibly color coded to help maintain orientation. There needs to be a zero-G gym with exercise equipment and a room for supervised structured activity: aerobatics and dance.

One permanent staff position may be **zero-G choreographer/dance instructor:** someone who is as at home in weightlessness as cosmonaut Andrei Krikalev. [Those who have seen videos of this cosmonaut at work in Mir will have been awed by the sheer Manta-like grace with which he effortlessly swims/flies around the facility with no wasted motion). Guests so inclined could schedule practice sessions several times a day and by the end of their several day-long stay may be good enough at individual, paired, or group free-fall dance to stage a show for the rest of the guests, and have it videotaped, if not televised live, to impress friends at home and preserve a unique memory. as well as to further entice those thinking about buying a similar out-of-this-world vacation.

The zero-G dance hall might be a spherical inflatable, with a post-inflation inner armor of metal applied through the vapor deposition process. Creative placement of mirror segments would enhance the experience and provide feedback to neophytes. For "gala night" show and tell, disco and strobe lighting could further theatricalize the performance.

Restaurant: granted that some will have little appetite in weightlessness, one intriguing suggestion is that culinary experimentation may yield gustatory delights that could not be created in a gravid location (on Earth, on the Moon, on Mars). This may or may not be the case and calls for "orbit-truth" demonstrations after considerable brainstorming. If the idea proves out, free fall foods and drinks may someday provide an added incentive to take an orbital vacation.

Artificial Gravity:

Why reproduce Earth-normal gravity? Are not our guests out here to experience something new? **One-sixth G** or sixthweight, the fractional gravity level of the lunar surface would be easier and less costly to reproduce: it would require only 1/6th the radius and correspondingly reduced structural mass at any given rotation per minute level. Yet this level of gravity is more than sufficient to support normal physiological processes, provide firm orientation, and guarantee freedom from space sickness. Most LEO hotel guests might welcome this chance to experience what it would be like to walk on the Moon. But more about this later.

The Lunar Section should have a dance-floor (glass see-through: stars, Earth??), also staffed by a sixthweight-adept choreographer/dance instructor. Again, by the end of stay, some may want their gala night public performance videotaped.

The Lunar Section should also have some sort of ball court in which, thanks to a succession of experiments by a succession of guests, new sport forms fun to play and watch in the Moon's lower gravity could be developed and debugged. We could start by trying racket ball and **Jai Alai**, and making trial adaptations. Eventually, the results might be good enough to make ABC's Wide World of Sports and other TV Sports Magazines.

A **swimming pool** in this section would attract **divers** who could go through fairy-tale like routines before finally hitting the water. Again likely fare for Earthbound viewers green with envy, and great promotional material for the hotel. If possible and practical, a perimeter **jogging track** of some sort would be welcomed by many.

Because artificial gravity introduces a coriolis effect on motions within its "field", both dance and sports in an orbiting hotel Lunar Section would give rise to a characteristic "english" that would not carry over to the Moon settlement itself. This "english" will be hard to learn because it will matter greatly if one is facing spinward ("east"), antispinward ("west"), to the right of spinward ("north") or to the left ("south"). Standardized **orientation color cues** on the walls, something that the subconscious mind can learn to take into account automatically, should help greatly. Of course, some will pick up on these cues faster than others.

Both zero-G and reduced gravity sections may someday support **sanitaria**, places where enhanced recuperation may be possible. This assumes, of course, that patients are not only well-heeled, but able to stand the stress of getting here in the first place.

A small museum or historical area would be logical. Guests would be amazed with displays of primitive free-fall toilets and dull meal-fare, and more gratefully appreciate what civilized improvements progress has since made possible. Of course, such facilities could also or alternately be provided at Earthside aerospaceport gateways..

Orbit may become as popular a honeymoon visit as Niagara Falls. Honeymoon aside, the idea of simply being married in space should draw more than a few. Zero-G or sixth-weight processionals could provide quite a memorable show.

Other Facilities:

The hotel should have a well-stocked audiovisual **library**, an **observatory** from which guests could peer at stars and planets in their natural atmosphere-free twinkle-not brilliance. A **communications center** should provide phone, visiphone, fax, electronic mail and internet

access. A tax-free **casino** with zero-G games could be a novelty for those not up to more aggressive pastimes.

The hotel should not only support teleconferencing but have some meeting room and conference space and a newsroom available for on site anchoring of major network newscasts. More imaginatively, a properly decorated alcove with table and chairs and Earth-view picture window backdrop could conceivably become a favorite site for ceremonial signing of important international treaties.

Stores, Pantries, Supplies:

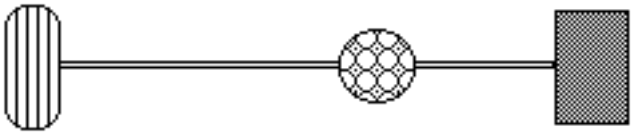
There should be emergency caches of non-perishable food preserves, water, oxygen, power, medical supplies etc. should the normal scheduling of freight resupply flights and passenger craft be interrupted for any reason. There ought to be a full time nurse and paramedic able to perform most of the more common surgical emergency routines under radio/TV guidance from the surface.

Earthside Gateways to Orbit

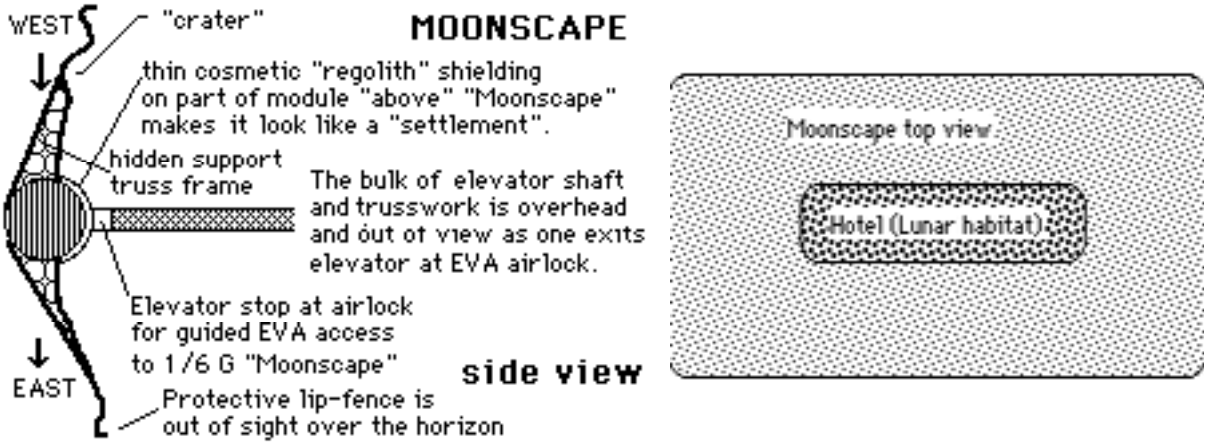
Given that the Orbitel should cater to international trade, and given the need to get 24-hour service out of all common facilities and equipment, an elegant solution would to have three near-equatorial gateways for shuttlecraft (NASP or Delta Clipper) feeding the hotel. One for the Americas (Bogota and/or Quito international airports?), one for Europe-Africa (Nairobi?), and one for East Asia/Pacific (Singapore?) This would feed a natural three shift rhythm without inflicting a jet lag handicap on anyone. The national carriers feeding those aerospaceports would logically prosper in the traffic and prestige.

Architecture and Expansion

This is fairly well determined by the decision to include both weightless and simulated lunar gravity sections in the hotel. A dumbbell arrangement would counterbalance a service, maintenance and supplies section at one end with the 1/6th G guest quarters at the other with a non-rotating hub in the middle. As with a teeter-totter, the two ends need to be neither of equal mass nor equidistant from the hub. The heavier end need only be proportionately closer to the hub , as it were a fulcrum.

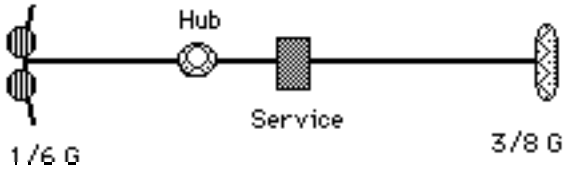


One expansion we considered was to create a simulated Moonscape, in which the Lunar Wing of the Hotel was “buried”, to give suited guests EVA access to the 1/6th G “surface”. Such a feature need only be “skin-thick” i.e. not very massive.



The "Lunar Experience" could be heightened by using only furniture and furnishings that might be duplicated on the Moon using materials that could be processed locally in the early settlement. There could even be an optional Lunar "menu".

If at the same time the Lunar Wing of the Hotel is doubled or twinned, the total excess weight could be counter-weighted with a new small Mars wing a bit more than twice the distance from the hub to provide 0.38 G.



The Service Complex can be positioned anywhere along the axis, to either side of the hub as needed to balance the Lunar and Martian Wings. The idea of an orbital amusement park was mentioned but not elaborated. *

SUGGESTED READING:

"**The Frontier Builder: An Earth-Moon Hotel Cruise Ship**"
by Doug Armstrong and Peter Kokh.
http://www.moonsociety.org/publications/mmm_papers/transitel.htm

Tourism in Space Workshop postscript

A Near Term "Terrace" on the road to a space based economy

By Peter Kokh

Orbital tourism is perhaps a generation away, lunar flyby tours following shortly. But land excursions on the Moon, and on Mars especially, are well beyond our horizon. "Virtual Reality" armchair excursions of these and other worlds, fed by orbiter and rover compiled data banks, seem to be the consolation prize we must settle for. The proposed LunaCorp mission has such an ersatz experience, available at theme park terminals, as its principal "product". It will allow viewers to "visit" Apollo 11's Tranquility Base and then trek cross mare to the Apollo 17 site in the Taurus-Littrow valley 600 km to the north northeast.

But "Virtual Reality", as amazing as it is, in its current state of realization, fools no one. The sense of being in and moving through the landscape at will is amazing. But the landscapes themselves have a cartoon like feeling, a low resolution smoothing of colors and shapes. Such "tours" will leave much to be desired.

Another near-term option is "telepresence". This puts the operator/spectator in the drivers seat "real time". You see what the rover etc. sees. While the resolution will be much better, there can be only one telecontroller, while an unlimited number of others can join in "for the ride" as if on a guided tour coach. Unlike the telecontroller experience which has to be "live", the guided tour experience can be canned and replayed for others at any time.

Surface teletours of the Moon could be arranged before the turn of the millennium. They could even "visit" outposts in the form of landed scale models, to get beyond the sterile

barrenness of an unending succession of unrelieved raw landscapes of rock and sand. Such fare would all too quickly satisfy the appetite of the most eagerly anticipating participant – "when you've seen one crater (or mountain or rille, etc.), you've seen them all".

Mars, it would seem, is too far for any sort of telepresence. But let's back up. Flyby and orbital teletours of the Moon might come first. And what about Earth orbit?

A satellite hooked to telepresence receivers could offer real time surround-vision experience of skimming over the Earth a couple of hundred miles up. Again, there could be only one telecontroller (steering or aiming the field of view) at a time – and again, an unlimited number of spectators could get a front row seat guided tour. And why not "guided" in the full sense of the word, with a voice describing notable features as they come into view, on the Moon or on Earth from orbit, as the case may be.

Such tours will require expensive equipment and so are a natural for theme park investment. There, the number of people using, and hence paying for the equipment will be large. In such a setting, it may even be possible to add to the illusion by simulating weightlessness. That is, telepresence could conceivably be enjoyed by a properly-suited person in a neutral buoyancy tank.

But less expensive productions using telepresence equipment can be arranged right here on Earth. By this means anyone can tour remote areas and extreme environments on Earth: Antarctica, the Barrier Reefs, etc. Theme Park profits might be plugged back into more terminals, more rovers, etc. As word of the experience spreads, the whole scale of operations could be increased.

Looking for an entrepreneurial gold mine? One that will both make you money and help increase the pace of the new Lunar Reopening? Why not put together some capital and form Teletours, Inc.

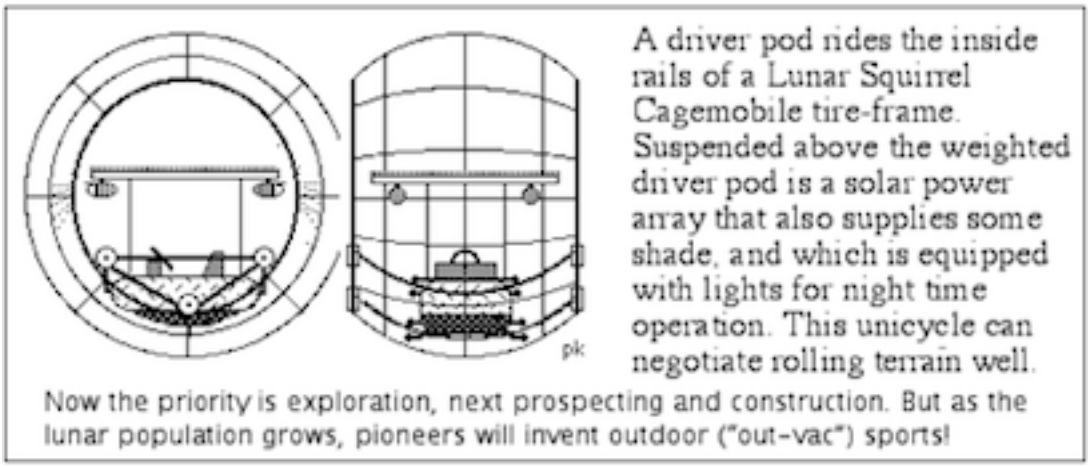
[No, we won't claim the name is taken or ask for a royalty. The name is free for the taking. First come, first served!]

There's definitely a market out there, and you might get rich catering to it (rich enough, we hope, to invest in real space touring opportunities!). **MMM**

MMM # 81 December 1994

Lunar "surrey with the fringe on top"

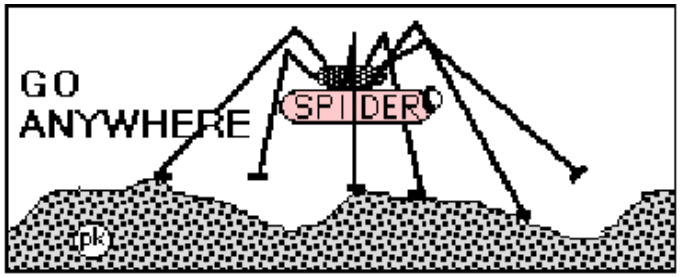
Watched "American Gladiators" lately? Have you seen the "Atlasball" segment? Next time picture space suited lunar thrill-seekers working their geodesic cages along a rally course of craterlets etc. Might be fun if the sweat of exertion and the overheating inside one's space suit could be handled!



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

Your 

ticket!



GO ANYWHERE SPIDER VEHICLE
By Peter Kokh

One model from nature of a creature that can go just about anywhere is the spider. I have in mind particularly the mobility architecture of the "Daddy Longlegs", in some places known as the "Harvestman". Might not a lunar (or Martian) traveling conveyance of similar articulation and ability become an indispensable asset in opening up the more difficult reaches of both frontier worlds?

The Spider's "body" would consist of two separable components: the "trunk" would contain the "hips" for the six legs and associated "musculature", and the power, fuel, and motive plants. Underslung by a "dead man's winch" would be the crew cabin. This position gives it shielding protection from the locomotive complex above as well as an unobstructed view of the terrain below. If power should fail, the crew cabin would automatically winch to the surface in a controlled descent. This deployment could be overridden, if there was any reason to remain aloft.

The scale of such a contraption could be rather large, in fact the larger the better within practical limits. The legs could be long enough to elevate the central pod complex some dozens of meters above terrain obstacles below. This height would also be of great advantage in scouting a pathway ahead.

The spider gait could bionically mimic that of real spiders and include a cautious grope as well as a trot of sorts when the going permits. All it takes is a computer program.

The feet, the knees and hips as well, could be sensor laden, feeding back first to neighboring and partner legs, then to the central nerve center. In this respect the model might rather be the loosely decentralized manner of the octopus. [See MMM # 45 MAY '91 "ROBO ANTS" pp. 2-5 - republished in MMM Classics #5 - a free pdf download from: http://www.moonsociety.org/publications/mmm_classics/]

Difficult Terrain Exploration

In the saturation bombardment craterland of the lunar "highlands", it is in general possible to make one's way by sticking to "intercrater" plains, ridges, and shoulders, avoiding steep inclines. But what if we want to visit the central peak of a debris- and boulder-strewn crater such as Tycho?

On the maria, the darkish solidified lava sheet “seas”, the going is generally easier, craters of size being fewer and further in between. But even the flatish maria are laden with obstacles such as sinuous rilles (relics of large collapsed near-surface lavatubes), lava sheet flow front escarpments, “reefs” of incompletely buried pre-flood “ghost” craters, and of course the ramparts of “coastal” impact-upthrust mountain ranges. Such obstacles could make circuitous detours the norm rather than logical straight line routing - that is, if we are traveling by vehicle with limited ability to negotiate rough terrain.

On Mars there are similar relatively smooth and relatively rough areas, and similar obstacles. To be added in the mix are difficult landforms unknown on the Moon: crevasse-ridden layered polar ice caps, eroded slopes of the great shield volcanoes, dendritic tributary and distributary channels of ancient river and flood courses, chaotic labyrinths and canyon-lands. Many of the geologically and/or mineralogically (thus economically) more interesting spots on Mars lie smack in the midst of such harder to reach places.

Cache Emplacement

A go-anywhere spider vehicle could do preliminary geochemical assessments along its route, and emplace seismic monitor stations. Where such dust and rock samplings warrant, it could then put in place handy base camp supply caches for follow-up field expeditions and prospecting efforts.

C**onstruction Crane Workhorse, Webspinner**

A heavy-duty version of such a straddle-anything pick-its-way-anywhere vehicle could serve as a crane. As such it could do yeoman work in relatively urban settlement sites as well as in remote construction locations, becoming in this version the workhorse of lunar development, as well as scout. Specialized versions could spin arrays of cables across craters to make radio telescope dishes and space-solar-power rectennas. They could spin cables across rilles houlder to shoulder for bridges or to support habitat meta-structure roofs. It is hard to see how we could long manage without one. **MMM**

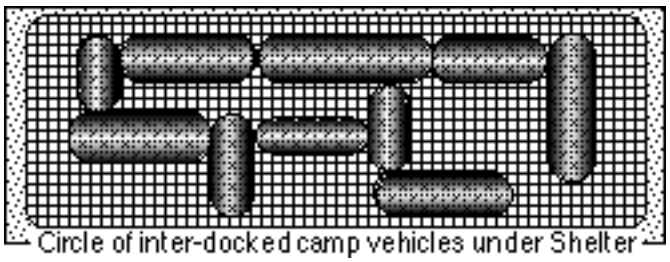
[Shelterless travel]

Roughing it for real!

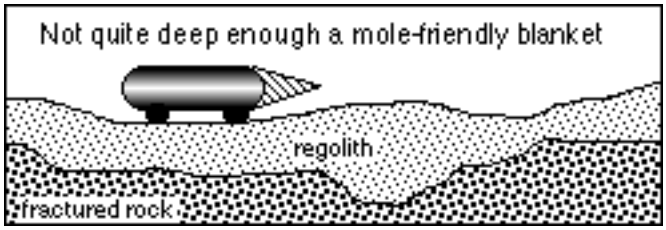
By Doug Armstrong and Peter Kokh, CCC

Off-road vehicles will not only ply trackless terrain but range far from convenient roadside flare sheds or wayplexes [see the articles on these topics in the October issue]. Short round trips can be ventured without provision for significant radiation shielding. But in times of Solar unrest especially, in Flare Season so to speak, off road vehicles must be prepared to “dig in” one way or the other.

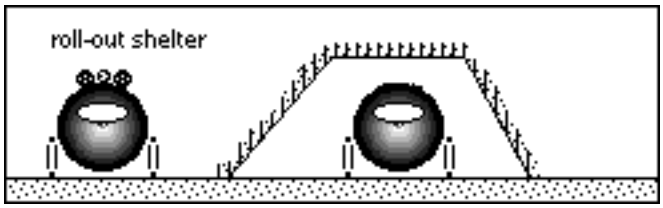
This need is critical for remote construction site camps as well, whether engaged in building new outposts, mining operations, or road work. For the latter some sort of semi-permanent storm shelter would seem to be an immediate priority of setting up camp. Camp vehicles would normally park in an inter-docking array under the shelter. But here we are concerned rather with the situation for vehicles en route.



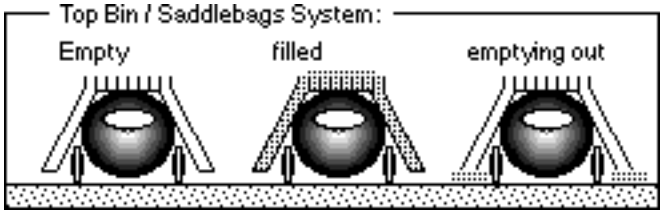
Copernicus Construction Company [CCC], the for-fun design and brainstorming activity group of LRS, has given some thought to how sudden shelter can be provided. One idea, coming straight out of a comic book read four or more decades ago, is to have a giant screw on one end of the vehicle so it can literally bore its way forward or backward into the powdery regolith. The problem here is that the regolith layer is in some places only a meter or two thick, not quite deep enough.



Another possibility is to carry along a collapsed, easily erectable space frame shelter and unrollable fiberglass canvas cover over which a scoop/conveyor system could blow regolith dust. Once deployed, such a shelter could be left in place permanently, its site marked on official maps for the convenience of others in the future. That leaves the vehicle, however, without protection if another storm should rise later at a point further along the route. Devising a way to "empty" the space frame/canvas shelter of its regolith overburden so that it can be packed up and stored on the vehicle rooftop or side for future use is an interesting engineering challenge.



Another system we thought of is an emptiable rooftop bin system with emptiable side mounted "saddlebags". A scoop/conveyor could fill the bins and bags as needed. The bins and bags could be mechanically opened and the dust would pour out as the vehicle moved out of its parking spot.



Actually, in latitudes some distance north or south of the lunar equator, the problem becomes easier. All that's needed is a sloping shed facing Sunwards (recall that the Sun creeps slowly across the lunar sky at only 1/28th the pace we are used to on Earth). A Solar Windbreak will be easier both to deploy and fill and to empty and return to rooftop standby storage.

Even small open rover type buggies, should they venture much beyond the point of easy swift return will have to be equipped with some "KD" (easy erect, easy "knockdown") system of flare storm protection. All vehicles of any kind, when parking at a site along the route for a few days would be advised to deploy their shelter system as a matter of prudence. In the meantime, even under calm Sun "weather", the voyagers will be at reduced accumulative exposure to the weaker but incessant cosmic rays coming from all sky vectors.

At the heart of the matter is the functional analogy between the protective high-pressure atmosphere of Earth and the regolith blanket which can serve as a condensed solidified atmosphere for the same protective purposes. **MMM**

MMM # 87 July 1995

THE BRASS SPITTOON

Some of us will need a place to let our hair down before we can call a new world home

By Peter Kokh

Bars and taverns have always been prominent in science fiction, providing the setting for rendezvous, intrigue, trade and smuggling deals, shanghaiing hapless unwilling ship hands, or just providing comic relief. Many of those in media science fiction have become classic: the cantina on Tatooine where young Luke Skywalker and Obi Wan Kenobi gained the services of Han Solo, Chewbacca, and the Millennium Falcon; Ten Forward on the Enterprise D; Quark's on Deep Space 9.

Yes, bars are also places where alcohol is abused, drug deals made, partners picked up for one night stands, prostitutes engaged, and drunk drivers set loose etc. But the shady side of the bar scene can never discredit the legitimate and useful relief valve functions such places serve. Those uncomfortable with the subject because of tragic family situations need not read on.

The bar for many serves a useful function, on an occasional if not a regular basis. It is a "neutral" scene removed from the stresses of workplace and home. When not abused, alcohol is a tension and stress reliever, and often just as importantly, an inhibition and shyness relaxer. The watering hole is a place where one can go "to talk it out", "get things off the chest". Here one can hope to be listened to, however noncommittally. Here one can tell and trade stories, make plans and launch joint endeavors, think bold and uninhibited thoughts. Here one can socialize, mix, make new acquaintances beyond the small circle provided by the workplace or neighborhood.

One comes here to dance perhaps, or at least to flirt or be titillated by a flirtation; to see and be seen. One can find others with which to share a game of dice, of darts, of pool, maybe even of chess. A lunar bar might boast a wide stock of imported games, electronic, and classical, that most settlers might not be able to afford for themselves. And juke boxes!

Besides coin-metered canned music, where else can one go and listen to live music, enjoying entertainment, skits, comedy, song, even staged bar room brawls — for free or for a modest cover charge? Here to settlers and those on assignment can come to dance, enjoying the freedom of one-sixth gravity.

Here amateurs and others can try their hand (or mouth) at expensive establishment-owned terrestrial musical instruments such as the harmonica, flute, guitar, piano, synthesizer. But many securing a gig at the local pub will bring their own home grown lunar musical instruments: steel (pan) drums made from steel shipping barrel ends, bells, cymbals, "saws". xylophones and marimbas - none of them using wood, copper, or brass which would have to be expensively withdrawn from the settlement biosphere or imported.

The Lunar tavern will be a place where one can come to watch special (sports) telecasts from Earth in the company of other rabid fans. On the other end, bar-sponsored teams could play a major role in the development, refinement, and popularization of uniquely lunar team sports, just as some bars nourish local talent in song, dance, music, comedy and acting.

The first bars beyond Low Earth Orbit will be on board on cruise excursion ships looping the Moon and Earth-Moon Ferries. Once an outpost is established, the first bar on the Moon will be little more than a small liquor cabinet in the ward room. But ultimately real private establishments open to public will appear as the population on the Moon mounts to the point where such enterprise is worth a try.

What will a lunar bar do for atmosphere (not that many terrestrial bars give it more than a passing thought!)? Lunar bar decor will not, save as the exception that proves the rule, sport rich woodwork or paneling, wooden floors, bar tops, tables, stools etc. Nor will plastics and other synthetics be much in evidence. Economics will make lunar-processed materials the standby: iron and steel, aluminum, cast basalt and ceramic, glass, stained glass, Glax™ (fiberglass-glass matrix composite), concrete and lunacrete, etc. Working with this suite of materials will provide ample and rewarding challenges for lunar interior architects and designers.

The decor of most bars is just thrown together, of course, and there is no reason to expect a higher score for lunan tavern keepers. But somehow I think that at least the first few will have enough sense of history to try to make their places of business truly distinctive and at the same time pioneer rather than follow decorating trends with the new materials. To organize the setting, there may be a focal point provided by some memento or heirloom from back on old Earth, perhaps even supplying the place with its name: a brass spittoon; a large stein; a shark jaw; a stuffed moose head; a nice quilt; the empty shell of a vintage juke box; a ship porthole — the possibilities are endless.

Or a lunar tavern might have on display an interesting item salvaged from an abandoned or crash-landed spacecraft or settler ferry. Or some other surplus frontier museum-ware item like a zero-G toilet.

Not all bars will take their names from such prized possessions. There will be simply Ted's Place, and Cal & Sally's. Other taverns will be named after local geographical features (Crater Rim Bar) or allusions to the dayspan/nightspan cycle (The Long Dawn), shielding (Six Feet Under Bar), or typical lunar occupations (Prospector Pete's, The Dusty Boot). Of course, some bar names may make allusion to missed aspects of the terrestrial experience or to spacefaring lore.

Bars in principal lunar (space) port cities will have a different flavor than those at scenic concessions or at sleepy backwater outposts. [see "Harbor & Town" pp. 40-42 above.]

What to drink? Well that's the subject of another article. You might not find your favorite brand or brew but imports or no, people have always found a way to provide! Like schools and churches and other familiar institutions, the tavern too will survive lunar transplantation. **MMM**

MMM # 92 February 1995

Pioneer Holidays & other Festivities

By Peter Kokh

While "new traditions" (as oxymoronic as it sounds) are being made all the time, there is little doubt that those that command our observance most deeply are those which are oldest, rooted in our collective gitgo times. So it is with Holidays: Christmas, Easter, New Years go back millennia (two at least). Thanksgiving goes back nearly four centuries. The 4th of July will be 220 years old next time around.

We can expect that as the lunar frontier becomes fully established with the coming of age of the first native-born generation of Lunans, the holidays and festivals they will most cherish will include those observed by those establishing the first beachhead.

The Apollo 11 landing (July 20th) is sure to be observed, as is the "infamous" day of retreat, the liftoff of the Apollo 17 crew (December 10th). But neither of these "trivia" dates will rival the enthused celebration of the **"Day of the Return"** when humans come back to the Moon intent on setting up an open-ended "permanent" presence leading to genuine settlement.

The first crew may only set up camp and then return to Earth, to be followed by the first crew intent on staying a full day-night cycle (the lunar "sunth") or more. So closely connected with the observance of the Day of the Return will be the celebration of that first successful "overnighting" and the greeting of that first "sunrise" - **"First Night's End"**.

Finally, **"Ever Since Day"** will mark commencement of uninterrupted human presence on the Moon. If I were to put a friendly wager on which of these will be the most honored in Lunan settlement tradition, it would be on "First Night's End". There will be a special flavor to this holiday, the shared mutual congratulations at having survived this "initiation" imposed by the Moon itself. And for all non-native born Lunans, there will be a special personal resonance with memories of their very own "First Night" and "First Night's End".

Other history-rooted anniversaries may mark the birth of the **first native born** Lunan. And later, the first native born grandchild (i.e. second generation, whose health will be the final test of whether or not humans can stay on the Moon indefinitely) [See "Native Born" pp.]

Not all Lunan Holidays and festivities will take root in such historic occurrences. Some are sure to be bound up with the **Moon's natural rhythms**, much as a growing minority of us terrestrials observe the equinoxes and solstices. Local **sunset** and local **sunrise** will be big deals, something to mark with a special meal or wine or friends - simply because they occur on a 28+ day cycle, not a 24 hour one.

If a particularly appropriate **Lunan Calendar** is adopted [see "Moon Calendar" pp. 8-9 above.], with "sunths" of 28.5 (24 hr.) days instead of 30.5 day calendar months, with the discrepancy with Earth reckoning made up with occasional "leap" ("intercalary") "sunths" or weeks, Lunar New Years may only approximate the fall of New Years on Earth.

In such a case, the observance of religious feasts and holy days may also vary with that on Earth, without spiritual harm to those who honor them. This will be much to the chagrin and

resistance of religious fundamentalists (those who give major importance to the minor, and minor importance to what really matters, and call every one else heretic and infidel.]

Solar Eclipses on the Moon are the flip side of Lunar Eclipses on Earth. They will be much more of an experience for Lunan pioneers and settlers than any eclipse on Earth (even total Solar). They will last several hours locally, and possibly may occasion the morning or afternoon "off" (work or school) as the case may be. And it will be the most favorable time for looking for city lights on Earth's nighttime face.

In time, other **"political" milestones** will come to be honored in settlement tradition - the day when home rule is won, or independence declared, for example.

Historic and festive holidays will not be the only early-rooted traditions. **Pioneering songs and ballads**, even candidate settlement **anthems**, are sure to be written, sung, performed, and loved.

There may arise too special **festive foods** with historic significance. We have pretzels and crossover buns associated with Lent, unleavened bread associated with Passover. Eggnog, Christmas cookies, Easter Eggs, Pumpkin Pie are among many foods especially popular at specific festive times.

On the Moon, many long-loved foods and recipe delights will not be available early on. Special early frontier substitute food and menu items, beverages too, even if in time the need to make such substitutions eases, may be prepared and consumed with relish on commemorative occasions. Associated with such holiday tradition meals may be time-revered toasts, blessings, and mutual greetings.

Certain **plants** are associated with various observances on Earth; poinsettias and mistletoe with Christmas, for example. And plants grown successfully in the early outpost days, may come to be associated with various Lunan observances in like fashion.

The first humans to return to the Moon may think that all they are doing is erecting, deploying, setting up, demonstrating, testing, etc. But even the little incidental things they do, may in time take on special meaning and color not at all obvious at first, to become ritually repeated. This will all occur sometimes spontaneously, other times with alertness, if not deliberateness, as a part of fulfilling the very human need to impose on nature's own rhythms, a festive and commemorative **cultural rhythm** of our own.

Such cultural rhythms are a major element of the **social glue** that binds generations together. In this way they will bind future Lunan generations, much as similar traditions have always served in terrestrial communities throughout the globe, and throughout historic and prehistoric. **MMM**

MMM # 94 April 1995

The Cultural Implications of the Moon's 1/6th G

This month, we return to our essay series on the early days of a permanent human community on the Moon, as we consider the **"Lunar Condition"**, the defining set of parameters that go with the territory and will leave an indelible mark on early Lunan culture and civilization. The Moon is a world dramatically different from Earth. One way this was brought home to hundreds of millions was the sight of our astronauts and their moon buggies bounding and bouncing about in the lower gravity. The effects of "sixthweight" will be more than anecdotal. For the impact of the Moon's environment on pioneers, see below.

The Primitive Roots of "Lunan" Culture

By Peter Kokh

This month we return to our series of essays on the very early lunar frontier. It may at first seem that a particularly “Lunan” culture will be a development a long time arriving. On Earth we are used to considerable cultural diversity, both from place to place and through the generations. It may seem outrageous to forecast the day when we will see revealed the considerable family resemblances all terrestrial cultures bear to one another. But there are certain time-and-place-transcending aspects of Earth that insert themselves in every human culture to date. For whatever the differences we love to exaggerate, we all share one very friendly planet, one encradling biosphere, the same gravity, the same protective envelope of sweetened air in which we work and play under wide open blue skies.

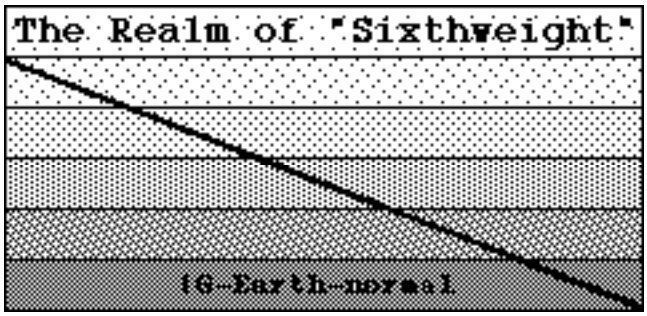
The unique equally transcendent wellsprings that will eventually make “Lunan” culture distinctive from all terrestrial cultures, making it in effect the first culture of a new family, will be present from the outset, intensely felt already by the first crew to take the plunge and “overnight” on the Moon.

The Moon is a world dramatically different from Earth. It’s gravity is only one-sixth “normal”. It is without atmosphere of any practical consequence. Its surface lies naked, exposed to the weather of space. It offers no life supporting biosphere of its own. These constraints will make life-as-we-are-used-to-living-it a memory-myth early left behind. As we deal with these facts and their consequences with a swim-or-sink urgency, and as we find successful ways to accommodate them, we will be forthwith face-slapped out of any romantic reveries we may have had. — this month’s topics.

So much for day one! Hardly will we have begun to cope and neutralize these brutalities and two other facts about the Moon will carve nascent Lunan culture even more deeply. The Moon is very dry. And its mineral assets lack some of the industrially strategic elements Earth’s more generous endowment has lulled us into taking for granted. — next month.

We have touched on each of these topics before in sundry articles. We do so again, all in one place, from the eye of the future historian and anthropologist interested in the very early beginnings of what is sure to develop into a uniquely Lunan culture and civilization.

There will, of course be many other things that add color to lunan culture. The sports that arise, for one thing: indoor, middoor, and outvac. Trade relationships and particulars with other off-Earth pockets of humanity throughout the Solar System: political events; Art and Literature; the performing arts and media. And, of course, the indelible mark of powerful and influential personalities. But all these things will but add flesh to a cultural infrastructure grounded in the physical nature of our host adopted world, the Moon. And this infrastructure will fall into place almost immediately. **MMM**



THE REALM OF “SIXTHWEIGHT”

By Peter Kokh

For the hundreds of millions who watched the first Apollo Moon landing, next to the black sky and the spacesuits the astronauts wore (eloquent joint testimony to the absence of appreciable atmosphere), the most visually striking thing we noticed is how our scouts bounded

about the surface. Despite heavy backpacks that would have all but immobilized them on Earth, their gross weight was quite a bit lower than their muscles were used to handling. The surface gravity on this significantly smaller world is only one sixth that of Earth's.

Operating in "sixthweight" will make for more than an anecdotal, temporarily amusing difference. It will affect almost everything visiting crews and eventual pioneers do:

BIOLOGICAL EFFECTS

Bodily Functions - That the human body is adversely affected by long stays in low Earth orbit, is well known. Blood circulation, digestion and excretion, muscle tone and muscle mass, heart rate, etc. all are affected. It seems as if our bodies were designed to operate with a gravitational "assist". After all, gravity is a transcendental parameter of our home world.

The medical evidence from zero-G ("micro-gravity" is the preferred physiologically irrelevant semantic micro-correction currently used to self-distinguish the 'in crowd') has led many to jump to the conclusion that nothing short of Earth-normal gravity will allow the body's several systems to perform satisfactorily. At least as far as gravitationally assisted blood circulation is concerned, they may be partially right. Gravity helps overcome friction within vessels and arteries, and the "mini"-gravity we will find on asteroids even as large as Ceres (1/30th Earth normal) may well be functionally zero.

It is an enormous and unsupported jump from that recognition to the faith-tenet of some that therefore long, term exposure to the one-sixth gravity of the Moon will also mean unacceptable physiological decline. One-sixth is infinitely larger than zero. No one, thanks to NASA's timidity when it comes to experimentation with artificial gravity, has been exposed to "sixthweight" for more than a few days - that hardly qualifies as a bona fide experiment!

Only long-term exposure to sixthweight either on the Moon itself or in a rotating structure in space, will confirm the more probable expectation that several physiological functions will decline but then plateau out at an acceptable level.

Cardiovascular health is not the only thing at stake. The final health seal of approval will require evidence from a fair sample of on-the-Moon pregnancies and subsequent fetal development, pediatric evidence from born-on-luna children and youth, the fertility rate of the first native born generation of adult men and women, and geriatric evidence from those living out the full term of their natural lives on the Moon.

Some would have us wait until the evidence is in before we commit to settlement. But that is preposterous, since we can only gather the evidence if we take the plunge, and the sooner we do it, the sooner we will know.

Physical Activities - the obvious things: walking, running, climbing steps, sitting, standing, and posture in general - even sleeping - and other bed-scene activities will be translated into the differently expressive tongue of sixthweight. Here is an area where we have no evidence at all. No one has ever walked on the Moon - not without a cumbersome space suit, except for a step or two inside the lunar modules, from which you can tell nothing. No one has tried to climb steps on the Moon under what would be normal conditions. No one has slept in a real bed on the Moon. There has been some pretty interesting speculation about sitting posture and about steps. We'll have to distinguish what comes natural to those coming from Earth and "just off the ship" versus, on the opposite end of the spectrum, those eventually born on the Moon.

Sports - gravity is less but momentum stays the same because it depends on body mass, not weight. You can be weightless but the only "massless" people are ghosts etc. Because traction and "purchasing power" will scale with the gravity level while momentum remains Earth-normal, it will be much harder to start, to accelerate, to maneuver, and to stop - this will apply to individuals and to vehicles alike.

It is interesting to speculate how we might make ourselves at home in such an environment. Will we kiss the traditional flat-floored court and field goodbye in favor of banked sports fields? And/or will playing areas have cushioned sidewalls that we can throw ourselves against to help change the direction of our momentum? Will we use fellow players in both friendly and hostile bumping maneuvers, much as "jammers" do in roller derbies?

Dancing will also be affected. One can picture almost ethereal movements in Lunan ballet. But while dancers will experience considerably more air time (cellular phone users will be jealous), they too will have to accommodate the greater difficulty in starting, accelerating, maneuvering, and stopping. Perhaps both in ballet and modern dance and the night spot public dance floor, we will see a return to couples dancing in physical linkage, not just loosely opposite one another. This will allow partners to transfer momentum and direction to one another, as in the days of swing and ballroom dancing.

Exercise programs may well emphasize isometrics, in which one part of the body pushes against another. Some will want to maintain "earth tone" so they can more easily handle a return to Earth with its sixfold greater gravity (we think few acclimatized or native born Lunans will seriously entertain the possibility of gladly weighing six times more - that's too big a jump). They will want to exercise in centrifuge gyms.

Children's gym sets will likewise show interesting characteristic differences from those on Earth. The kids will pioneer a characteristically different lunar-style gymnastics.

Trans-generational Effects - If you will, a couple of definitions. A genotype is the shape a living creature assumes as it matures from egg or seed insofar as it is determined by its genes. A phenotype is the shape it assumes insofar as it is determined by the environment. Take twin tree seeds, plant one in its normal habitat, the other up near the tree line on a mountain slope, and you would never guess that they belonged to the same species. Native born Lunans may look like a different race from their parents. On average, they might grow significantly taller and more lithe, and generally leptomorphic. Add in a couple of generations and they may not fit well in the habitats built by their earth-born ancestors. They will walk differently, sit differently, climb steps differently, dance different, play differently. These differences may dwarf those experienced in this country and elsewhere in the average height and weight of adults - coming from better modern nutrition.

Farming and Gardening - agricultural and horticultural implications of sixthweight include especially those gravity-assisted processes like hydroponic and other drip irrigation and nutrient delivery systems - requiring some minor and perhaps some major modifications, as well as soil and plant bed drainage. If the soil is too fine, a bed that may have drained fine on Earth could become water-logged on the Moon.

Will plants grow taller? Will they boast larger blooms and fruit? Or spindlier stems? Will these differences be subtle or striking? Science fiction writers have speculated about flower gardens of forest proportions in lunar greenhouses. Will we have a settling out into garden floor and garden "canopy" flowering species? Will such gardens be a major must see on tourist itineraries, and host many a wedding portrait session?

More important are the implications of phenotype change for food production and harvesting methods. Conveyors and chutes and other gravity-assist produce-moving equipment may need subtle changes. Again, the sooner we get our feet wet, even if its just in artificial sixthweight, the better.

Food Preparation - some cooking methods (boiling, at least), and the mixing and blending and separation by density of ingredients will surely be affected by transposition to the lunar gravity environment. Vinegar and oil, for example, will not be so quick to separate.

NON-BIOLOGICAL EFFECTS

Tool Use - Most of us are familiar with the major redesign of hand tools meant to be used in orbit that has been necessary to accommodate to weightlessness. The lack of gravity-assisted purchasing power, combined with the equal reaction laws of nature requires anti-torque compensation and other major changes. On the Moon, we will have gravity-assist to enable us to lean into our tools, but it will be less than that we are used to on Earth. Some of the modifications meant for tools used in orbit and outside space vehicle repairs may survive in some form on tools designed for lunar use. However, many tools unmodified from their common terrestrial form should do well enough for general use.

Operation of Machinery – Material handling equipment systems that rely on gravity assist may need some modification. This will be true both for solids and liquids. Some pieces of equipment, especially mobile units, may need to be redesigned for a lower center of gravity as on the Moon, tip-overs will be much more common, if compensation is not made. mass distribution

Vehicles – What applies to people, applies in exaggerated form to vehicles. It'll be harder to start, accelerate, maneuver, and stop on the Moon – simply because traction is reduced along with gravity, while momentum is not. Personal vehicles from indoor bikes to outdoor trikes to jeep equivalents, trans-port vehicles like trucks and coaches, "'lith-moving" (road building and surface mining and gas scavenging) and construction vehicles, and sport vehicles will all need to be radically designed for sixthweight. At stake is stability in turning and banking, and overall safety.

As the years go by and native-born Lunans start taking over, vehicle cabins may need appreciable redesign or resizing to accommodate their possibly taller average stature.

Furniture Design – because of both reduced weight and lower friction, furniture pieces will be a lot easy to move unintentionally by just bumping into or grazing them, an easy thing for non-adepts "fresh off the ship" yet to find their "moon legs". Thus furniture too may be built bottom heavy. Sofas and chairs may need a lot less cushioning, relying more on contoured seat areas – a good thing, because upholstery fiber would be an expensive item. We can expect more built-in furniture, not just cabinetry, but also bench seating, even beds – all for the reasons above. Provision for foot traffic aisles and walk ways may be more generous to accommodate a higher incidence of at least temporary clumsiness. Standard counter and table heights may also grow to suit taller Lunans.

Product Design – Bottom heavy design may extend to glassware, bottles, mugs, vases and other objects. Here we are ready to go with an ample suite of such things already designed for boat and recreational vehicle use.

Architectural Standards – Over time, as Lunans grow naturally taller, ceiling heights and door clearance heights will grow. Lunar habitat ceilings may be see a return to 9 ft. and 7.5 ft standards formerly common. Some expect "bounding ramps to replace stairs. But we will always need to accom-modate the aging, the infirm, and those just off the ship. Paradoxically, it may be the latter, with their Earth-tuned musculature, who'll opt for bounding platforms. Those long acclimatized to sixth weight may need traditional stair sets.

Construction Methods – The lower gravity will allow easier lifting, and the suspension of more massive loads from ceilings and walls. There will be other subtle changes.

Power Generation and Storage – strange as it may seem, hydroelectric nightspan power in closed loop recycling water reservoir systems is a distinct possibility on this ultra-dry world. Water reserves could be pumped up crater walls and mountain slopes by solar power during dayspan, UV-sterilized under quartz panes, and then allowed to fall through generators during nightspan. Head heights will more than compensate for the reduced gravity. **MMM**

Making do without the "Outdoors"

By Peter Kokh

If the principal theaters of lunar life and activity will be subterranean (in lavatubes) or sub'lithic (under the [rego] lith blanket), the supporting roles will be "out on" the surface. Using the Australian experience as a model of sorts, in which their great relatively barren continental "back yard" is known as the "outback", we've coined the phrase **"out-vac"** for the lunar surface. The out-vac will be a place visited and a medium of passage rather than a place lived in. Most Lunans will never don a spacesuit except in "decompression drills" reminiscent of our fire drills. Vehicle to vehicle and vehicle to habitat "dock-locks" will allow people to travel anywhere on the Moon in "shirtsleeve environments". There will be the geologists or selenologists, the prospectors and explorers, and the overland truckers and others whose jobs keep them in the out-vac for long periods. And there will be the self-elevated rugged individualists who throw themselves into various out-vac "sports" such as out-camping, out-cycling, out-climbing, etc.

Shielded ramada canopies will offer protected **"lee vacuum"** for those with regular work duties just outside the airlocks and dock-gates of the town or outpost. In such areas only pressure suits, not hardened space suits, need be worn.

But for most Lunans, the hostility of the out-vac will threaten a wholesale forsaking of what on Earth are "outdoor" activities. Without compensation or accommodation, this loss could be demoralizing for a significant cross-section of a normal population. Some, as we've just suggested, will find ways to fashion out-vac activities that are reasonably safe and yet satisfactorily thrilling as well as liberating from the all-so-limited confines of even the most spacious and extensive of settlement mini-biospheres. The importance of such a safety valve cannot be overemphasized.

But for the greater part of the population, the answer may lay in the creation of very generous pressurized commons, nature and picnic parks and playing fields and parkways that, while sheltered from the cosmic elements, nonetheless have an airy and supportively verdant feel to them. As opposed to the more confined spaces within individual habitat homes and edifices which they will serve as interconnectors, we have called such sheltered yet open spaces the **"middoors"**. The middoors lie between the doors of private spaces and the airlocks and docking gates of the settlement proper.

The more-generous and more high-ceilinged spaces of the Lunan middoors can be offered by several architectural devices. Pressurized cylinders carrying vehicular traffic can have a radius generous enough to support green strips with hanging gardens, trees, walking and jogging paths, even meandering trout and canoe streams. Spherical or ovoid or torus structures can serve as more self-compact nonlinear park and nature space. Farming/food production areas can provide for public footpaths and picnic oases.

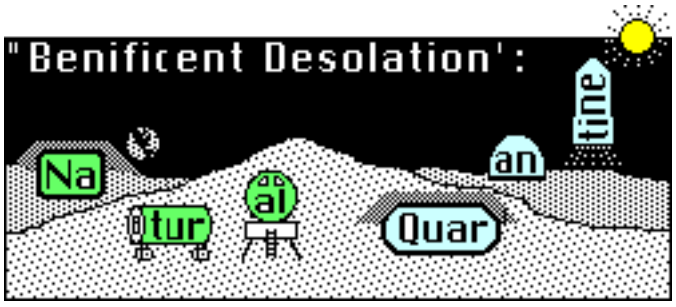
Solar access can be provided more conservatively by bent path "sundows", by optic fiber shielded "sun wells", or more radically, as Marshall Savage suggests, by water-jacketed double domes. [See the illustrations in #74 article cited above.]

Well-designed middoor spaces provided in a generous acre per citizen ratio can probably substitute for the open-air greenspaces of Earth for a large cross-section of the population. Others will need to come to personal terms with the out-vac. Still others will never be able to leave behind the green hills, the ocher deserts, the blue skies, the thick forests, or the horizon to horizon expanses of ocean deep on the only world they have collectively and individually ever known.

For while we may be able to walk and hike and bike and row and trout-fish in lunar middoor spaces, many other cherished outdoor activities will be difficult to replace: skating yes but skiing and snowmobiling no. Human-powered flight maybe, but powered flight, soaring, and skydiving no. Rowing and canoeing yes; but motor-boating, sailing and ocean cruising no. Caving or spelunking in lavatubes yes, in limestone caves no. Berry picking and trout-fishing yes, but hunting not likely.

Anyone pondering signing up for the lunar frontier must weigh his or her attachments to activities that may not be supported in lunar settlement biospheres any time soon, if ever. And those who take the plunge will owe it to themselves to be politically and civilly active in

guaranteeing that the settlement middoors is as generous and diverse and user-friendly as economically possible. Nothing less than the morale and mental health and long-term survivability of the whole settlement is at stake. **MMM**



Lack of Global Biosphere has a Silver Lining

By Peter Kokh

On Earth "the" biosphere is continuous, integral, and all-embracing. On the Moon, each settle-ment and outpost must maintain its own discrete minibiosphere, and do so very caringly. Lunans will live essentially and immediately, "downwind and downstream from themselves". No global air circulation to diffuse pollutants, no shared ocean or boundary-defying groundwater aquifers to pollute. On the Moon, the great barren sterile out-vac will maintain a virtual mutual quarantine between all the several settlements and outposts.

Locally this discontinuity can be 'postponed'. It will make no sense to have separate town center and suburban biospheres. Everyone living within feasible connection distance will seek to be interconnected. And there is virtue in this. The bigger the biosphere, the more stable and forgiving and satisfyingly rich and diverse it is likely to be, both in decorative greenery and in food and fiber producing plants. That does not mean there may not be separate political autonomies with their own little school district and zoning peculiarity fiefdoms etc. But the important thing, the biosphere, will be a shared metropolitan responsibility. There may be some few separate neighboring installations, but these will be industrial facilities where prudent separation is maintained in case of a potentially polluting accident.

The biological quarantine that will reinforce the separateness of discrete outpost and settlement biospheres will offer an important plus. We've never built / developed / grown mini / artificial biospheres before, and the risk of biological collapse through imbalance, disease, or mismanagement will be higher than we would like - certainly for several generations to come. The provident availability of quarantine through the aegis of surface vacuum and the absence of groundwater will provide distributed, rather than shared vulnerability.

If there is disease or wholesale biological collapse in any one given minibiosphere, the chances of containing it there locally are greatly enhanced by this quarantine. Infection can be carried in by travelers and visitors, of course; but the odds of prevention are clearly enhanced by this separation.

Another benefit of this natural quarantine is that the town fathers and citizenry in each case can choose their own flora and fauna combinations, their own climate and regimen of seasons. "See one lunar town, and you've seen them all?" No way! Each can have its own natural ambiance, enhanced by differences in city plan, prevalent architectural styles, etc.

This quarantine-enabled variety will not only make the Moon a more interesting place for terrestrials to visit, it will draw the visiting Earthlubbers to visit more settlements, not just the main one(s), distributing income from tourism more fairly. Towns will choose their floral and faunal mix as well as architectural styles and other elements of distinctive and alluring ambiance accordingly.

For Lunans themselves, the result will mean realistic possibilities to “get away” and experience wholesome “changes of scenery” on vacation holidays as well as in business travels. Those needing to relocate and start their lives “over”, will have the chance to do so. As on Earth, Lunans will be able to relocate for “life style” reasons.

The desolation of the out-vac is not only “magnificent”, it is truly “beneficent”! **MMM**

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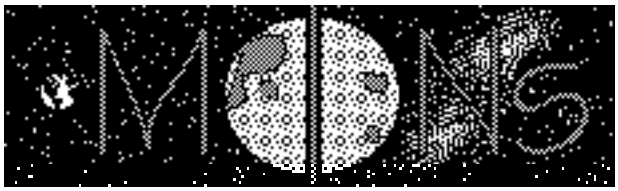
A tale of 2 Moons



Earth-facing & Earth-oblivious

By Peter Kokh

The fact that the Moon keep’s the same hemisphere forever turned toward Earth, while the other hemisphere is forever averted from Earth, may well have profound effects on Lunan culture, markedly distinguishing Nearside and Farside folk from each other. Much that applies to Nearside applies to Farside equally (mineral character of the surface, airlessness and exposure to cosmic weather, low gravity, thermal extremes, general dehydration, etc.) It is life against these constraints that will shape the Lunan character in general. But the presence or absence of Earth over the horizon will introduce profound differences in the cultural spirit of Nearsiders and Farsiders.

Nearside: Earth hangs in the black star-filled sky like some bedazzling jewel filling thirteen times the sky area with some sixty times the candlepower the Moon in our own skies, phase for phase. Its ever re-marbling blues, greens, tans, and whites will make it the prime repository of color in lunar “nature”. Paradoxically, where the Earth is at a very high angle over the horizon in central Nearside (the “Crooknecks”), it will be less obtrusive into daily consciousness than closer to the Nearside limbs where it hangs comfortably above the horizon (the “Postcardlands”). Many Nearside homes, offices, schools, hotels etc. will have windows built to frame the ever changing and ever fascinating spectacle of Earth.

It is, of course, possible to look at Earth, even study it from the Moon, just for its beauty and everchanging detail - without being reminded of the human culture on its surface, and its overwhelming dominance of the Earth/Moon economic equation. Some pioneers will be more successful than others in resisting the intimidation of the spectacle. Others, feeling Earth’s presence as overbearing, will work the harder to develop genuinely Lunan forms of culture and expression.

Again, paradoxically, the presence of the Earth may insert itself most strongly right along the limbs of Nearside where libration effects sometimes let it slip just below the horizon (the "Peekaboos"). Here in a broad 14 degree swath around the Moon from pole to pole where Earth oscillates above and below the horizon on a four week cycle, there may arise major settlements involved in the construction and maintenance of lunar solar power arrays beaming electrical power Earthwards - as well as a scattering of resorts. For the Peekaboos in general may become a favorite Lunan honeymoon destination. Here one can experience alternately, Earth kissing the horizon, and the rapture of Earthless skies.

Farside: Beyond the limbs (the "Peekaboos"), Earth is out of sight and out of mind. Lunar Farside is rather turned towards the "rest of the universe, a universe without Earth". Its skies instead are dominated by the unchallenged splendor of the Milky Way in a glory not yet fully experienced by any human (excepting brief out-the-porthole glimpses by busy Apollo astronauts circumnavigating the globe).

Not only will Earth be visually out of sight, without cable relay to Nearside, or without satellite relays, the home planet will be out of sight electronically as well. The resulting "silence" will be an invaluable asset to radio astronomers attempting to listen to the whispers of the universe in order to learn more about its structure, and whether or not it harbors other contemporary and equally curious techno-sapient species.

Terrain-wise, Farside has great impact basins just as Nearside does. But because the Farside crust is much thicker, the molten magma from the interior has had less success in reaching the surface and pooling in great sheets within these basins - to make "maria". Farside "seas" are smaller and scattered in comparison. There is no convenient "chain of seas" as on Nearside, making long excursions much more difficult. Farside terrain will be more of a challenge to builders of global highway networks.

Pioneers will come to Farside not only in the support of scientific installations like radio astronomy arrays, but for mineral resources that may conceivably occur there in richer concentrations than on Nearside. For whatever reason, over time, Earth being out of sight, out of mind, Farsider culture will evolve as more fiercely self-reliant, more willing to cut umbilical ties to Earth, more fascinated with the greater uni-verse out there, more enraptured by the siren call of the stars.

If we do someday succeed in establishing self-reliant but interdependent pockets of humanity beyond Earth orbit, to the point where some sort of "consolar" organization or association seems called for, a site on the lunar Farside might command top consideration for a headquarters or solar capital. Lunar Farside is conveniently close to Earth in travel and communications terms - and - the vast bulk of humanity will remain on Earth for the foreseeable future. Yet lunar Farside will be a place preoccupied with "the rest of the universe", a place unintimidated by Earth and its massive civilization and economy. In contrast, Earth will be very much present in the skies of Martian settlements, shining almost Venus-bright.

Any particular favorite sites? It would seem the best site for an extensive radio astronomy installation would be in Thomson crater in the north east of Mare Ingenii, the Sea of Ingenuity. A solar "capital" could piggyback on such an installation. But seen from approaching spaceships, easily the most visually striking feature of lunar Farside is the very dark mare-filled floor of the great crater Tsiolkovsky, dominated by the very bright central massif, the peaks of Konstantin. Such a site would have much romantic appeal and the symbolism of the name could not be more serendipitously propitious.

It will take time, of course, for cultural differences between longtime Nearsiders and longtime Farsiders to appear. Once they do, the differences might become the stuff of friendly rivalry. Yet the much broader shared conditions of life on the Moon will dominate both cultures in the end. **MMM**

Against the Overwhelming Barrenness of the Moonscape

A GREEN SECURITY BLANKET

By Peter Kokh

Some of us are houseplant nuts, some of us are hobby gardening enthusiasts. But perhaps most of us don't give vegetation, indoors or out, much thought. We don't have to. Given the general luxuriant feel of the outdoors, we get enough of a green-fix automatically without having to concern ourselves much about it. And that remains generally true, even in this era in which the health of the host environment is in question, and living nature under siege from selfishness, greed, and simple carelessness.

On the Moon life is not a given. There is none of that comforting green stuff maintaining itself on automatic. The outdoors is lifeless, barren, sterile - relentlessly so - assertively so - threateningly so. Greenery within the protected confines of the mini-biosphere will become a preoccupation of all but the most soulless personalities.

That a healthy abundance of plants contributes significantly and noticeably to air quality and freshness, will be a reinforcing motivation. (NASA-funded studies have shown that the right mix of houseplants can be quite effective in reducing household airborne pollutants.) But we suspect that for most Lunans, the real driver will be the need to use plant life as a security blanket, a psychological filter against the out-vac's life-quenching sterility, much as for smokers, a cigarette makes the world a friendlier place (no, I am not one).

If lunar homes and offices and schools have windows affording moonscape views, inside window box planters of houseplants will take the edge off the life=threat of that magnificent but deadly desolation. But we will find many other nooks and crannies to put plants. Greenery and foliage will become the mainstay of interior decoration. Everything else will play but a supporting role.

A much higher percentage of Lunans are likely to be home gardeners. They will be aggressive in finding opportunities to add plants. Quite possibly a solar-lit atrium space will become the organizing focus of choice in purchaser chosen home plans. Such a space will afford vegetable and herb gardens or a mini-orchard to help with the food budget and menu variety, maybe a tad of entrepreneurial canning. But it could also be devoted to purely decorative plantings of variegated foliage and flowering plants, song birds, humming-birds, and butterflies. Or it could become a more mystical place, a Japanese style sand and stone garden. For despite the general preoccupation with plant life, there will still be a big range of personal sensitivities, and of lifestyle needs.

Architects in general will look for ways to build-in planters and other cubbyholes for plants, providing also for their illumination. Vegetation will be a new design parameter.

Out in the "middoors" too, every opportunity to tuck in vegetation will be aggressively pursued by architects and users. Middoor streets and passageways, intersections and squares, are likely to become as verdant as they are busy. This can be the concern of the xity administration, or, more health-fully, of rival neighborhood, and street merchant associations, or other stretch-"adopting" clubs.

While green will be the dominant color thus inserted into settlement life (architects and decorators will be motivated to find ways to introduce ambient-lit sky blue ceilings and open space sky blue vaults), settlers may rely on plant life to provide other colors as well. The early

lunar art pallet (water-glass-based metal oxide “paints” and ceramics) will be one of generally subdued colors. As helpful as such additions will be, the thirst of the more vivid coloration of flowers (and perhaps birds and butterflies) will be strong.

It is likely that flowering plants will be staggered so that at least something is in bloom every sunth (the lunar dayspan / nightspan cycle). Will flowering plants grow taller on their own in sixthweight? Or can they be coaxed to grow taller? If so, Lunans may be able to savor the delight of floral “forests”. These would provide a must-see tourist draw.

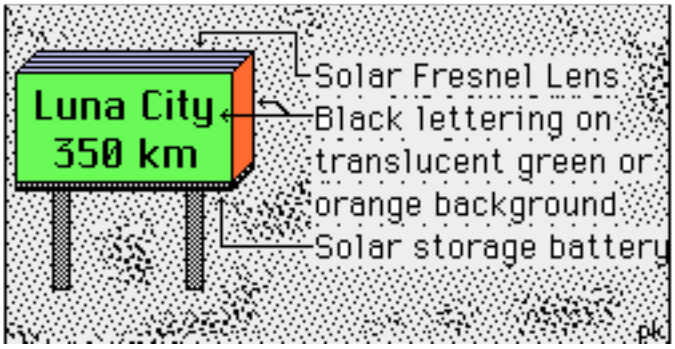
Trees are likely to be of the dwarf variety (many fruit-bearing dwarf hybrids are already marketed), more bush-like in size, at least until the cost of imported nitrogen makes economically-feasible the construction of higher-vaulted middoor spaces. In the meantime, to fill the void, individuals and clubs may take strongly to the cultivation of bonsai trees, even to the point of growing bonsai forests, again a tourist must see.

The first parks may be interim floral and grassy meadow refuges within agricultural areas. Even if the farm units are highly mechanized assemblages of trays and racks and LED lighting arrays, the sight of so much greenery (and the freshness of the air) will make any kind of food-producing area a mecca for those living or working nearby.

In the previous article, we mentioned that mini-biospheres will guarantee the reintegration of city and farm, the overdue return to farm village roots and a more nature-harmonious lifestyle-paradigm. Already in this century here on Earth, most developed cities have thinned out greatly in density, giving much more space to greenery (even if still more to pavement, in homage to the great god Auto).

Also on Earth, we have seen a general increase in urban and especially suburban wildlife, a welcome turnaround, led by post-human species, species that have learned to thrive in human-dominated environments. We can hope that Lunans will indulge in the luxury (to bean counter eyes) of urban wildlife. We’ve mentioned birds and butterflies. Surely bees, ducks, swans, flamingos, squirrels, even deer, and more.

In our cities, pockets of life are seen as a concession to nature. In the off planet xity, pockets of humanity will be the concession. Vegetation will play the host. The Xity will be an exercise in symbiosis, man and Gaia reunited. **MMM**



MMM # 97 July 1995

The Quest for Variety

By Peter Kokh

I'll never forget an experience as a fresh high school graduate of seventeen, browsing through the Hudson's Bay Company department store in Calgary, Alberta. The variety of goods seemed much greater than that at similar stores in my native Milwaukee. Here were to be found samplings of wears and wares from all the domains of the British Commonwealth, as diversified a market potluck of humanity as has ever existed.

On the Moon, shoppers are likely, at least in the early years, to have an experience just the opposite. Imported goods will be all but nonexistent and the exceptions will be prohibitively, obscenely expensive. The lunar domestic market will have to rely on its own resources primarily, other space-based markets eventually contributing their own offerings in trade.

"Small Market Syndrome" we might call it. Few people, making few products to sell to few people. How do we avoid the expected consequence: little choice, little variety?

Prohibitive imports vs. small manufacturing base

The challenge for variety (unavailable either from terrestrially made imports or from the small local labor pool) will affect almost all categories of goods: building materials, vehicles and other conveyances, home furnishings, accessories and artifacts and giftware, clothing, appliances - you name it. Not only will it be harder to find items one really likes, but it will be harder to put a distinctive custom personality on one's home, even on one's wardrobe. Such a forecast presumes that the principal entry for variety is mass produced goods from a variety of sources. But there are at lest two other avenues by which satisfying variety can be provided under these constricting circumstances.

Potluck customizing

A machine producing a product can be shut down, retooled or given a setup change, and then come back up producing a somewhat different product. Until recently, the U.S. norm for setup changes across a broad range of industries was some 9 hours of downtime. The Japanese manage to cut the average setup downtime to mere minutes. There is no reason why a given piece of equipment cannot be tooled to produce a kaleidoscopic variety using a finite number of styling elements coming into play in diverse combinations. These might be programmed-by-computer, change-outs taking negligible time, with successive production runs of differently styled products (a radio chassis, a print pattern on a fabric, a handle design on a knife, etc.)

Or the diverse style elements can be preprogrammed to come into play in random combinations, one after the other (as lottery numbers are now stamped on the inside bottom of soda cans for example) Such "kaleidoscopic variegated product machines" could cheaply supply a significant range of individually distinctive items even for small markets. The variegation in each case would be confined to a set and recognizable "family character" range (given available styling elements, materials, colorants, etc.) within domestically supportable resource and feedstock limits without regard for the size of the domestic market. It may be possible to keep track by computer of the kaleidoscopic formula or setting for each individual piece so that

patterns could effectively be saved to reproduce on request designs meeting special customer favor.

Finishing by individual artists and craftsmen

It is also possible to produce generic "unfinished" items, that can then be purchased by artists and craftsmen to finish and resell. Or an unfinished item can be purchased by the consumer and then given to an artist or craftsman of choice to be finished according to special request on commission.

While this is a slower, more labor-intensive method of introducing custom variety (than by way of the kaleido]scope machine), the results may (no guarantee) produce more artistically pleasing results, and the only way of producing non-random designs. Those who especially appreciate the hand-crafted and individually designed product may be willing to pay the extra price. But whence the artists and craftsmen?

Almost everyone will have a daytime job producing something essential for domestic or export markets, and for some time the bulk of art and craft may be executed in after hours spare time cottage industry style. Nonetheless, the demand may be so great that this need for variety in modern history's smallest market may well serve to usher in a "Golden Age" for artists and craftsmen quite without precedent.

We should also see the rise of an unprecedented number of amateur "do-it-yourself" artists and craftsmen principally finishing consumer goods for themselves, and perhaps as gifts for family and other loved ones. To serve this need, various unfinished product lines could be marketed with finishing kits, samples, suggestions, and useful tips. The enterprising factory might even have an area where customers can bring in their purchases to finish in factory supplied facilities using factory supplied materials and tools. This will be an especially economical and popular choice.

Domestic product lines it may become popular to customize are dishes (tableware), ceramic planters, furniture items, clothing items and ensembles, bed linens (in a factory furnished dying facility) and the like. Personalization and custom expression areas outside the home may include product lines that can be customized for entryways opening on pressurized streets, surface shield-roofs, and vehicles.

The multi-community lunar world

Once an initial lunar settlement is followed by a second, a third, and more of whatever size, their mutual isolation will inevitably lead to diverse paths being taken along all sorts of lines. Each having its own discrete mini-biosphere, the choices of climate, farm crop mix, and complimentary flora and fauna could be different. One of the results in addition to the obvious one of distinctive ambiances, might be different organic feedstocks to use in decorating clothing and artifacts.

But more basic than that will be differences in the suites of available inorganic materials. For the primary reason for establishment of additional outposts, at least early on, will be to exploit diversely endowed natural local environments. Thus a highland settlement will inevitably produce differently designed and styled goods from a mid-mare or coastal settlement to give one obvious example. While raw materials will certainly be traded among settlements, it would be natural for local artists and craftsman to rely primarily on locally available materials. Trade between settlements then will be as brisk in value-added artist and craftsman finished goods of locally distinctive flavor as it may be in raw materials.

Imports from other off planet communities

As strategically critical materials may well be cheaper to supply from other off-planet sources like the asteroids, Mars, and its moonlets, it will likely be a prime directive of any lunar settlement to support the opening of other off-planet outposts and markets in any way possible. Such a policy will also pro-duce a stronger interdependent off-planet economy all the less vulnerable to interruptions of support from Earth. As these other markets develop, they too may be producing consumer goods which will be a cheaper source of variety than items from out of Earth's deeper gravity well.

Stowaway imports from Earth

While items imported from Earth either on speculation or by special order will be prohibitively expensive, there are other ways of getting Made-on-Earth wears and wares to the space frontier settlements.

(a) Clothing worn by arrivals, whether new settler recruits, official visitors, or tourists: such items can be traded duty free for Made-on-Luna wears, and then made available for specialty shop resale, or for playhouse (actors') wardrobes etc.

(b) Settler immigrants might be allowed a certain token heirloom weight allowance. Such items, of diverse individually chosen sort, will remain in settler homes for the most part, but eventually end up on the market or in museums.

(c) A subsidy for the import of art/craft tools (not materials) might be a good investment for all.

(d) Earth-Moon ferries could conceivably be Earth-outfitted for the outbound journey, Moon-outfitted for the return, the Earth-made items finding their way onto the lunar market.

The happy loophole in import restrictions - Tourism

As we have pointed out, clothing that tourists wear in transit to the Moon, is not "cargo" but can be exchanged with lunar pioneers for equivalent made-on-Luna apparel items. Whether or not the authorities will look the other way on a similar fair trade, weight for weight of jewelry, made on Earth for made on Luna, is another question.

More importantly, with their appetite for variety, backed up by money, tourists will encourage diversification on the Moon in all areas: art, crafts, performing arts, sports, architecture, cuisine, etc. Vive le tourist!. **MMM**

MMM # 102 February 1997

FOOTSTEPS ON THE MOON AND OTHER LEAVINGS

Relics of the "Scouting Period" will all be preserved as a part of on site Lunar Frontier National Parks and Monuments or placed in Future Lunar Frontier Settlement Museums.

By Peter Kokh

One frequently hears complaints that we have already "trashed the Moon" referring to equipment and equipment packaging and other items left behind on the Moon by the Apollo explorers. The speaker silently assumes we will never return to establish a permanent presence on the Moon, that there can be no useful function of such leavings, that they serve only as pocks of litter. Since this set of assumptions is without justification, it does more to discredit those who parrot the chant than anyone else.

"One man's trash is another man's treasure" is an even more common tidbit of popular wisdom, however, and happily one that is definitely more applicable to the situation. "When", not "if", we someday return to the Moon "to stay" and make it "Earth's Eight Continent" and the first of many human adopted home worlds, such items, from derelict space craft stages to scientific instruments to packaging waste to footprints - these will all suddenly become invaluable. They will be priceless "hope chest" contributions to future lunar frontier museums and monuments to the watershed epoch of early human and robotic exploration of the Moon..

Even if, to our great shame and discredit as a sapient race, we fail to use our talents and resources to expand into the human hinterland of Greater Earth as we have into all the other companion continents of our native Africa, the contention that these relics of exploration constitute “trash” exposes an indefen-sible view of man as something apart from, not part of nature. Rather we should have humble pride in these leavings. They are indeed venerable and admirable relics of great achievement and of the enormous capacities with which man has been endowed.

What we have left behind on the Moon is indeed “a promise”, a promise to return, to return and stay, a humble engagement token, a sign of betrothal. Even should this future hoped for mutually adoptive relationship with the Moon not develop, these things will still stand long after the rest of human civilization on Earth has crumbled into dust, as mute testimony to the glorious design of Homo Sapiens and the Creative Agency(ies) that led to our emergence — whether or not some scouting explorers of other separately arisen intelligent populations ever stumble upon them and feel the wonder.

There has long been deep discussion of future political and economic regimes for the Moon, and on the question of property rights. However these thorny questions resolve themselves, and we have strong opinions on how they should) some very important, and arguably less controversial, legal questions are going unaddressed. Addressing them now could create a momentum of achievement that might help break the paralyzing logjam of endless debate over the other more disputed issues.

For example, we might now set up definitions, standards, and procedures for declaration of various sites and areas of the lunar surface as the lunar equivalent of national parks, national monuments, national scientific preserves etc. Procedures for nominating a site, for establishment of the special status, and for amending that status in the future are needed. At this date when evidence for a case of objection cannot be maturely prepared (e.g. unique geochemical resources of critical economic value) candidate sites could remain simply “nominees”. Protocols for the establishment of economic concessions that do not infringe on the scenic or geological rationales for the nomination, could be decided upon now, subject to revision as the on site learning experience unfolds. Might it not be unreasonable to expect that solving these “special” cases will help point the way to acceptable “general” solutions of the property question?

In addition to such special treatment of nominated areas of special scenic and/or geological interest, the historic sites of early lunar robotic and human exploration should be included. In each case, the immediate site could be handled as an easement, with use and encroachment restrictions passed on to whatever future jurisdiction or public, private, or commercial title as may come to be established.

These sites are just what we have labeled them, “hope chest” items for the future edification and education of lunar pioneers, settlers, and visitors to come. They need to be treated, individually and as a class, with honor, respect, and awe. Popular, if not universal, contempt should be approached as an opportunity for education and public outreach. When and where attitudes cannot be changed, we must sadly learn to dismiss them: “consider the source.” These things will become the foundation of lore and legend. They will live on, their thoughtless denigrators passing from the scene into oblivion.

As human sites, the Apollo sites need special protection and handling. But even robotic sites are instances of virtual human presence and need attention too. It is not too early to discuss proposals for proper preservation and protection. Some of these sites will become enucleating centers of future human settlement. Others will affect the routing of future highways. Their places on the map are more than footnotes to be sure.

MMM

The Luna City

Visitors' Guide – 2097

Musings by Peter Kokh from a visit to the Milwaukee Public Museum, while on Jury Duty lunch break 9/13/'96

The Function of Museums

For many people, museums are dusty, musty old places filled with assorted collections of useless items with no relevance for daily life. Their loss. Museums are meant to be, and are indeed for those in on the secret, well springs of inspiration in dealing with the world of today and everyday.

People who visit them, even "once in a blue moon", can scarcely avoid leaving their halls without a sense of being enriched with a greater insight into the present as well as a heightened appreciation for the past, and even – here is the punch line – with a more well-founded and cautious optimism about the future.

The Natural History exhibits help correct our sense of place in the cosmic scheme of things and events, infecting us with deeper respect for our birth planet and its features, and with a greater sense of connection with our plant and animal kingdom fellow travelers in this biosphere of tightly inter-woven interdependencies. We see illustrated our calling to serve as stewards for what we have inherited.

The cultural exhibits give us new awareness of the contributions to the material and artistic and scientific wealth we all enjoy today – contributions made by those who have gone before. Exhibits of foreign and of primitive cultures teach us that our solutions are not the only ones, and that resourceful coming to grips with local environments and assets is a universal manifestation of the human spirit, its problem solving powers, and its hardship and disaster meeting resilience.

The Function of a Museum on the Moon

What might a Future Lunar Pioneer Museum display? Two classes of deposit materials are already on hand and need not be shipped to the Moon. Soil ["regolith:" the meteorite-pulverized blanket layer that covers the lunar surface] and rock and meteorite samples can be collected from the various representative types of lunar terrain. These can be exhibited in diorama contexts to acquaint museum visitors with the makeup of the lunar landscape both locally and in other, perhaps quite different regions. Other dioramas will bring to light what it is like within the eternally dark lunar lavatubes. The Moon's geological Past, Present, and Future will be unfolded.

Second, there is the now the decades-old relics of the half dozen human scouting expeditions of the Apollo Program, as well as relics of robotic missions from before, and since — the museum "hope chest" that some shallow-thinking people call "trash".

The purpose of a museum is to visually remember and appreciate the Past in the Present through samples and representations displayed in context. In this manner the roots of local culture and civilization are illuminated, and those who come to study these displays gain a cross fertilization of ideas, inspiration in current challenges to resource-fullness, and confidence that we can always find ways to adapt to current conditions as have all past populations. Visitors come to appreciate the ever-surprising adaptability of life and man, the viability and poly-expressiveness of life. Collections and collectibles illustrate the enormous variety of nature, as of human possibilities. We learn about the relationships of living ecosystems (natural, and post-human alike; of Earth's planetary Biosphere, and in working (or struggling) off-planet mini-biospheres. The dependence of human life on nature, both

geologically and biologically is brought home. Relationships, progress, evolution, revolution, etc. – the never-ending epic of nature, life, and man are

The Luna City Museum of 2097 should be no different. Starting with the two classes of natural and human artifacts already on hand,

The museum's job will be to successfully chronicle the unfolding of the human frontier.

The visitor of 2097, be he or she a visitor from Earth or a native born 4th generation Lunan, will learn how those who have gone before have built up the lunar civilization of the day, bit by bit, resourcefully and without discouragement through an endless list of challenges, hardships and sacrifices, setbacks and temporary tragedies.

Early products of the frontier settlements and their slow steady diversification and growing sophistication and level of attainment will be on display. Arts and crafts, apparel, games, furniture, furnishings, homes, meals, shops and shopping, occupations, amusements, hair fashions, festival trap-pings, hobbies, schools, musical instruments, street scenes, sports, frontier lifestyles and hardships – these will all be on display in variety, joining displays of the products of heavier and more mundane pioneer lunar industries.

The special contributions of immigrants from various terrestrial nations and ethnic backgrounds will also be displayed, their diversity being most strong in arts and crafts contributions. One "wing" of the museum might be occupied by the "Streets of Old Luna City" exhibit. In 2097, native-born Lunans may have come to take their culture and now successful and thriving civilization for granted. It will be the museum that will get across to them, how precarious and problematic life was for their ancestors. Humility, inspiration, encouragement, and determination to do the past and one's forbearers proud should be among the fruits of the visit. For museum visitors from Earth, any feelings of superiority and condescension towards the unsophisticated and boorish Lunan rustics should be dissolved. They will be left to wonder if they could have survived the challenges clearly bested by the lunar frontier folk.

Periods of Frontier Development

Visitors will learn clearly the relationship of various intermediate periods of lunar history, and of the arts, crafts, fashions, customs, and products they produced. They will learn of the first crude faltering lunar outpost and settlement biospheres, and come to appreciate what it takes to make them and the utility systems that work with them function to guarantee continued Lunan existence.

Showcasing unsuspected diversity

"When you've seen one Lunan town, you'll have seen them all!" Anyone who says something like this will say more about his or her own shallow lack of perception than about the Lunar frontier. The discrete and all but mutually quarantined lunar settlement biospheres will sport considerable diversity, as will the architectural solutions employed within, the local "middoor" climates, and local arts and crafts traditions. Sure there will be telltale common threads. But vive la difference! To boot, the lunar frontier environment will have fostered a great number of social and cultural experiments and a number of "intentional communities" will have been launched. Of these many way be still-born, many to falter sooner or later, some to survive only by going "mainstream", but some few making their dream a reality, if not quite in the shape and form envisioned by their inspired founders. All this will be material for the Luna City Museum curators.

Frontier flora and fauna vs. that of Earth

Illustrated as well will be the life cycles of plants and animals successfully transplanted into and thriving in Lunan mini-biospheres, no two of these quite alike. But it won't be all about Luna and the Lunar Frontier Republic.

The Luna City Museum will want to gradually build up its collections that will paint an ever fuller picture of what the settlers have left behind. From nature their will be sweeping diorama vistas of terrestrial habitats: seashores and river valleys and deserts and mountains and waterfalls and forests and prairies and jungles and swamps and tundras; plant and animal

collections in great diversity, each in ecosystem context. Given the cost of shipment from Earth of physical display materials, audiovisual virtual reality displays will probably predominate.

Showcasing the Lunar Economy, Arts, Culture

But Lunans will also learn of occupations and hobbies, and sports, and recreations common on Earth which have been difficult or impossible to translate with justice in the settings of their new adopted home world. They will catch an idea of what it is like to sail, to soar, to ski, to run under open skies, to picnic under pillow-shaped clouds playing tag with the Sun, of what it must be like to hunt and fish and gather in the wild. They will learn of the quite different suite of natural perils: volcanoes and earthquakes and hurricanes and tornadoes and forest fires and mud slides and blizzards and floods and tidal waves. Lunans must be shown not only the roots of who they are, to appreciate more fully who they have become.

And they will learn of the somewhat similar and somewhat different challenges and achievements of other Earth-foresakers, those who have chosen Mars, or the asteroids or empty space for their world setting. they must learn of what they have left behind

The Luna City Museum of 2097 is likely to have earned its billing as a pillar institution of Lunan settlement culture and civilization. **MMM**

Early lunar frontier museums may be popular with those tourists to whom history is both important and fascinating. Without a knowledge of the historical background of what you are seeing, the things before you may be meaningless and boring. But that is only in the eyes of the boring beholder!

The sterile, airless Moon is already a depository of much cosmic information. Within some lavatube secure from cosmic weather, humans could create

The Grand Archives of Earth & Humanity

By Peter Kokh

Four billion years of geological archiving

Archiving, specifically and specially of the asteroidal and cometary debris bombardment of the lunar surface, and well as of the eons of solar wind particle buffeting, have built into the magnificent desolation of the global moonscapes an eons-thick scientific archive of inestimable value. As such, the Moon has served, and still serves, as a natural probe of the near solar environment that our human-made robotic probes can only hope to dimly emulate.

The conditions on the fully exposed lunar surface, even more so within the partial shelter of permashade, and best in the yet-to-be-sampled full-sheltered environments within subsurface lunar lava tubes are such that deliberate archiving by humans of both cultural artifacts and vulnerable biological samples and specimens, are a suggested-in-heaven industry of considerable economic value for future Lunan settlements. Archiving will be one Lunan activity with all the marks of a 'vocation' or 'calling'.

Archiving on Earth is, and has always been, an activity fraught with danger, peril, and inevitable disaster. Remember the Library of Alexandria, and the art treasures of Florence lost

in the flooding of the Arno, treasures and records destroyed in war, by earthquakes, mud slides, fires, and hurricanes, sadly, even by vandalism. The safest and most secure and environmentally stable environments on Earth can guarantee preservation of objects, artifacts, and records for relatively short times. Sooner or later, all human treasures preserved on Earth will be lost to the forces of human activity, weather, biological activity, and geological forces within Earth itself.

The sight lines of most of us are short. We pretend to worry about a slate-wiping asteroid that may hit us any time over the next few millions of years. Yet no Canadian or Scandinavian loses a night's sleep over the certain revisit of the great ice sheets within the much shorter time frame of the next ten thousand years or so. Most of us care about what carries over to the next generation. After that — we're content to let the next generation worry about it. That is why the inexorable deterioration of the biosphere and of Earth's living ecosystems does not bother most of us. It is sufficiently slow relative to our own personal four score years of life expectancy. Aprés mois, la deluge! ("After me, the deluge.")

But there have always been those with a more eternal vision, from the scribes of ancient times to the Pharaohs to the medieval monks. The upshot is that much of human history has in fact been carefully preserved despite common indifference. Yet in the long run, what we add by archeological, philological, and historical research only adds to the amount of knowledge that will inevitably be irretrievably lost.

The first task facing would-be curators of the Musea Humana, is to find a depository site large enough and secure enough to preserve accumulated human intellectual, industrial, cultural, artistic, and similar wealth not just for a few generations, or even some centuries or millennia, but for veritable eons — yes, for billions of years!

Why! Certainly some for religious reasons based upon fundamentalist literary interpretation of this prophetic text or that, will be dogma-certain of the impending "end of the world" and see such an archiving task as complete folly and poppycock.

This essay is for the rest of us, not fortunate enough to be blessed with such private certitudes. For us, the reasons why are several. Trans-generational memory, without the prop of preserved reminders (museums and archives) are very short and quite inaccurate. Handing on knowledge of the present and past is one of the sure values we have to give the generations who follow us (along with a well-husbanded environment over which we exercise only temporary stewardship, a weightier burden than most feel or realize.) We need to preserve the record (as well as to add to it!) in a way that will keep it safe and inspirational and educational for generations to come. We have to think in "time capsule" mode.

Beyond the edification of far future descendants is the more mystical need felt by even fewer of us to preserve the human, and Gaian, record even beyond the possible death of humanity and Earth life as a whole. For whom? For others, maybe never, maybe just once or twice - we cannot know or estimate - of other origins, who happen by this way in their sojourning through whatever interstellar neighborhood the ruins of Old Earth find themselves at the time. It is a need, a sacred call, to give witness. For what we have achieved and done, at least the modicum of positive within the pile, will give eloquent testimony whatever Creative Agency(ies).that led to and fed our rise as an intelligent species.

The only place to do such archiving for the eternities is on the Moon, in (an) intact lava tube(s) that has (have) already survived inviolate for going on four billions of years — not millions, billions! Any passerby surveying our solar system,.in whatever shape it may be in at the time, however distant in the future that visit may occur, cannot but come to the same conclusion. In all this System, lunar lavatubes are the most secure possible repository. (This is, of course prior to the Sun's eventual aging and pre-death expansion into an inner planet melting red giant star before contracting into a white dwarf cinder some billions of years down the road.).

If you follow this line of reasoning, it should become clear that any visitors who have come our way in the distant prehuman past will have seen lunar lavatubes as the only site worth

considering if they chose to leave behind some testimony of their passing (whether it be information about them-selves or the more Cheshire Cat-like smile of leaving us a record of the Earth and its biosphere of that time, something of a depth and completeness and richness that we could never hope to reconstruct on our own. Thus Incomprehensibly enriching witness of a visit can be left without prejudice to the "Prime Directive" which may enjoy widespread if not cosmos-wide respect.

When we think of archives, we think of such inevitably trivial data such as genealogical records, and perhaps a more worthwhile mix of artistic and literary treasures encompassing the mediocre and degraded as well as the sublimely inspired. Government, institutional, bureaucratic and other historical records will be in the trove, to be sure - leaving to the future to find whatever is of value to those mining the hoard. Exhaustive samples of industrial creativity and scientific achievement must be included if the whole sample is to have unskewed worth.

Biological records will be a principal part of the whole. Intact preserved samples of every extant species will be priceless in a future in which many species will have become extinct. A geological picture of the ever-changing Earth and an astronomical survey of the solar neighborhood out to galactic depths will help future visitors pin down the epoch in which the archives were created, and the length of time during which they were maintained.

Archive science will spur much inventiveness as archivists strive to find and use ever better methods of preservation, display, and cataloging. As such, archiving will become a driver of progress of considerable value, creating for Lunans considerable intellectual property value.

At present, all industrial, historical, and art collections and records on Earth are at risk. In many cubic miles of avail-able lunar lavatubes, immune to cosmic and geological events, with constant temperature, absolutely dry vacuum, total darkness and minimal background radiation, we will find our single best bet to keep safe for others the record of what we have collectively achieved, as well as of what nature has left us to steward. Low-maintenance very long life presence/motion-activated solar electric lighting along archive aisles can be installed for use during surface dayspan. **MMM**

The Archives Project and Tourism - Not everyone will appreciate the importance and enormity of such a project destined to far-outlast the Pyramids. It is not something likely to be launched in the first decades of the lunar frontier, and not thus a must-stop on any tourist itinerary. But once a location has been picked and a commitment made, there will be tourists for whom it will mean something to have visited this site.

MMM # 105 May 1997

Burial off Planet

By Peter Kokh

From Star Ashes to Star Ashes: Disposing Remains in Orbit

With the orbiting of the Celestis capsule, via a Pegasus launcher, carrying the cremated remains of twenty-some people, it would seem that an historic threshold has been crossed. However, the orbit is too low and the remains will be "in space" for only about a year before a "fiery reentry." What we have is only a gesture, an overture. The day is yet to come when the first human born of Earth-clay will be laid to rest in whole or in ashes, truly off planet.

Yet the Celestis mission fails only because the sole affordable launcher wasn't powerful enough. Psychological and legal barriers will have indeed been dismissed and the gates to heavenly disposal are now clearly open.

Where are more appropriate sites located? To be above the point where orbital decay induced by drag from high atmospheric traces will inevitably win out, any "orbiting cemetery" should be at least 450 miles or 700 kilometers above the surface, not that difficult a destination. "Higher LEO" may soon be a popular resting place for a growing number of the cosmically-conscious well-heeled.

If the Russians want to get into this moneymaking act, their Molniya launchers and Molniya orbits might quickly become much more popular, both with those anticipating internment in space and with the beloved whom they leave behind on Earth. Molniya orbits are very eccentric and can be launch-determined so that their low points (perigee) at which the internment capsule is traveling very fast (both actually, and through the overhead sky) is over the part of the world opposite their homeland, while the high point (apogee) at which it is traveling very slow (both actually, and through the overhead sky) lies over their homeland for a major portion of each day, noon to midnight, for example.

Internment in GEO, or geosynchronous orbit, would be both more expensive and much more difficult to arrange, as GEO slots are already too limited and need to be reserved for communications etc. More expensive yet, at least at this juncture, would be internment in the L4 / L5 Lagrangian Sargasso-like dust seas. These areas, long popular with Space Settlement enthusiasts (e.g. the L5 Society) center some 240,000 miles out in the Moon's orbit, respectively 60° ahead and 60° behind the Moon's position, keeping approximate formation.

Another possibility is internment in "solar" orbit, beyond the shoulders of the gravitational well of the Earth-moon system. This will appeal to those who see mankind expanding to fill "all the space under the Sun". Next in expensiveness would be capsules on solar "escape trajectories", following Pioneers 10 and 11, and Vikings 1 and 2 out of the system altogether, forever to drift among the stars at random. "Ad Astra", it will hype on the brochure. "To the Stars, your personal dream can come true!"

Not only will residents of Earth be buried in such orbits, a few future residents of the Moon, Mars, and other surface locations may also choose such arrangements. But, as opposed to visitors, those who have come to settle, or who have actually been born there, will predictably strongly prefer burial of some form on their adopted home worlds.

So far, we have been talking only about disposition of ashes, which weigh far less and are much more compact than whole bodies. The fuel and transport bill for intact burial in space could be as much as a hundred times higher. However, it goes without saying that many who actually die in space, stationed there or in transit, will simply be set adrift out the airlock with appropriate ceremony, Navy (and Star Trek) style. Their fares into space have already been paid, and this disposition will be an incrementally inexpensive option.

On Other Shores

Will people who have lived all their lives on Earth and never been beyond orbit choose disposition of their remains on the Moon and Mars or other planetary surfaces? Certainly: as soon as the option becomes affordable and feasible. Crash-landing of Celestis-like capsules on the Moon is certainly not technically or financially difficult, but neither may it be seen as desirable. But soft-landing on-surface disposition of such capsules should not be that much further down the road. For myself, if I had the bucks to choose, I'd want my ashes strewn on some Luna City memorial flowerbed — that presumes an outpost, still over the horizon. [See "Funerals Befitting Future Space Pioneers" – pp. 25-26 above]

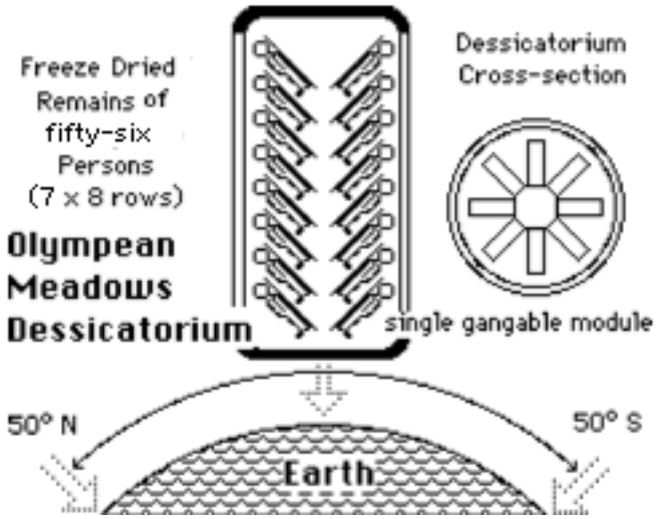
More than ashes?

While cremation has long since shed its 'antiresurrection' stigma, there are surely some who would prefer to keep their bodies more intact and yet would like to be interred in space - somehow. Making such an option affordable would seem to demand some way to reduce the

body's net weight. A few years ago, an entrepreneurial Minneapolis outfit offered to "freeze dry" departed pets "in whatever favorite posture" the customer would like. We have heard no more since of this enterprise, and assume that at nearly a thousand bucks a shot, there was insufficient business to provide cash flow. However, apparently the technological hurdle from freeze drying banana chips to whole pet bodies has been successfully mounted. (We could find nothing on this via the web search engine we used).

Nature has led the way, of course, preserving the remains of birds and seals in mummified freeze-dried state in the Antarctic. We have suggested before the ready-to-seize entrepreneurial opportunity of offering the option of internment under glass (to keep out flesh-blackening ultraviolet rays) and under a heavy "hardware cloth" mesh screen (to keep out scavenging Skua birds) in one of the Antarctic "Dry Valleys" like Wright or Taylor, where one could lie out in the open, naturally preserved face-up under the stars. We have dubbed such a future resting place a "dessicatorium", and suggested it as a preview of above-surface internment on the Moon and Mars (atop Olympus Mons, for example).

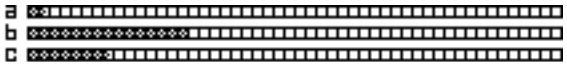
Dessicatoria in orbit? More expensive than Celestis? Sure, but why not? Bodies could be cordwood stacked, staggered on a bias under a glass hull, to faced Earth, or the stars, in whatever gravity-stabilized orientation they preferred.



The Canopic Option - Less Expensive Yet

Animal and human bodies are approximately 70% water by composition. So freeze-drying would make the proposition of "intact" burial off planet that much more affordable. Taking a page from the ancient Egyptians, we can improve on this further. What we want to preserve intact is the visible body. We can eviscerate it first, cremating the internal organs (with brain) and placing the ashes inside the body shell in a small capsule called a Canopic Jar.

To compare, the all-ash "Columbarium" keeps some 3% of the original live body weight. The freeze-dry "Dessicatorium" preserves about 30%. Canopic Dessicatoria (organs to ashes) would keep about 15%



% of live weight a Cremated (all ashes)
b Integrally freeze dried body
c Dried body shell, organ ashes

Visitation?

Next, of course, will be enterprises providing internment site visitation by the bereaved!

MMM

The Basics Of Freeze Drying from http://www.virtis.com/basics.html

Freeze Drying or Lyophilization: a process of stabilizing initially wet materials (aqueous solutions or suspensions) by freezing them, then subliming the ice while simultaneously desorbing some of the bound moisture. Following removal of the ice, desorption is prolonged under vacuum.

- Desorption: The release of liquids and gas trapped within a substance.
- Sublimation: Vaporization or evaporation wholly from a solid phase without melting.
- Primary Drying: involves sublimation of ice, with concurrent desorption of bound moisture.
- Secondary Drying: Prolonged drying stage for desorption until desired product consistency.

To preserve a product without altering it, there is no replacement for freeze-drying. This gentle process removes moisture from aqueous product, without affecting its biological, chemical or structural properties. A rigid ice matrix holds the solid components in place, maintaining item integrity. Conventional drying typically causes shrinkage or chemical reactions, damaging cells, rendering the item useless for final display.

The process has three basic process steps:

1. **Freezing** - In the first step, the product is frozen solid. The final temperature must be below the product's eutectic, or collapse temperature, so that it maintains its structural soundness. Then the condenser and vacuum systems are energized for the next critical process step.
2. **Primary Drying** - In the second step, the unbound water, as free ice, is removed by converting it directly from a solid to a vapor, by sublimation, under vacuum, to ensure that the pressure of the water vapor remains below its "triple point", as required for sublimation to occur.
3. **Secondary Drying** — After all the free ice is sublimated, there may still be enough bound water to limit the body's structural integrity and "shelf life". During secondary drying, the sorbed water that was bound strongly to the solids in the product, is converted to vapor. This can be a slow process; the remaining bound water has a lower pressure than free liquid at the same temperature, making it difficult to remove. Secondary drying starts during the pr-mary phase, but must be extended after the total removal of the free ice to achieve low enough residual moisture levels.

Freeze-drying is complete when all free and bound water is removed, resulting in a residual moisture level guaranteeing the desired biological and structural characteristics of the final product in a state that can be preserved indefinitely.

While there will be an extra charge (over and above simple cremation) for the Canopic option, and while space or lunar internment of one's Canopic remains will be much more expensive than that of "a symbolic fraction of one's cremains" - on weight grounds, this option will be far less expensive than internment of one's dessicated body. Transportation costs outweigh all other factors. But this will be an attractive option for some, including some lunar tourists, even for many lunar-tourist wannabes, who never did get the chance.

MMM #107 - July 1999

As the Earth Turns ... 

Earth: Color Medley Calendar in the Moon's Nearside Sky

By Peter Kokh

[Astronaut quotes below were passed on to us by Cynthia Griffin, Space Research Associates, and are from remarks they made to an audience of military personnel and civilians at the May '97 National Museum of Naval Aviation's annual symposium]

In "Seven Wonders of the Moon" [MMM #69, OCT. '93, p. 8] the view of Earth, hanging there perpetually in the Nearside Sky was listed as one of them. We billed it as "an apparition in the lunar nearside heavens with 3 1/2 times the breadth, blocking out 13 times as much of the starry skies, and shining with 60 times as much glaring brilliance as does the Moon as seen from Earth — all in a spinning ever changing marbleized riot of blues, greens, browns, and whites."

Earth as Clock and Calendar

Earth-in-the sky will offer future Lunans endless fascination as well as a psychological anchor (for better of for worse) for their morale. More on these benefits later. First we want to outline how Earth offers clues to (a) the time of the lunar month or "sunth" as we've more aptly named it, (b) the time of [calendar] day or date, and (c) the time of the year.

TIME OF SUNTH: Earth-in-the-lunar-sky goes through the same series of sunlit, night-darkened phases as does the Moon in our skies — with some spectacular differences. "New Earth" when eclipsing the Sun during what the Earthbound interpret as a Lunar Eclipse will appear as a dark circle in the heavens crowned with the fiery ring of the sunset-sunrise line as sunlight scatters in the dust of Earth's atmosphere. At this and other times, the night-darkened portion of the globe has become in this century increasingly "star-studded" with the city lights of burgeoning urban areas as well as oil and gas field burnoffs of "waste" natural gas and hydrogen. Meanwhile the frequent reflection of the Sun off ocean and ice accentuates the sunlit portions.

The point, not to wander in wonder, is that New Earth corresponds to Full Moon (the entire Nearside hemisphere in dayspan); First Crescent Earth to the waning Moon (nightspan advancing from the east over Mare Crisium etc.); First Quarter or "Half Earth" to nightspan having advanced to the central meridian of Nearside, dayspan advancing to the central meridian of Farside, etc. In other words, as seen from each other's surfaces, the phases of the Earth and of the Moon are opposite. In practical terms, the lunar nearsider will be able to deduce from the Earth's "phase" what is his local "time of the sunth": just after local daybreak, dayspan morning, dayspan afternoon, etc. Of course this will differ according to where the viewer is on the nearside (i.e. at which meridian).

TIME OF DAY (DATE):

While the Moon keeps the same face turned toward Earth at all times, Earth-in-the-Moon's-sky turns on its axis once every 24 hours. Whether the viewer sees the Americas, the Atlantic, Europe & Africa, Asia and the Indian Ocean, or the Pacific as facing him, will tell him what portion of the local 24 hour date it is (distinguishing date form the 14.75 date long dayspan and the 29.53 date long sunth). Depending on how Lunans set up their local calendar and time reckoning rubrics (that is if they do not import unchanged the time reckoning system of Earth), the above concordance may be fixed or it may precess by an hour every 40-41 days if Lunan calendar is set up as I've suggested (so that there are exactly 29.5 dates per sunth, rather than 29.5306).

TIME OF YEAR (SEASON):

How the Earth's axis tilts with relation to the Lunan observer at different times of the sunth, will tell him the time of year. The tilt will shift full cycle through the sunth (sequence of phases). If at 1st Half Earth, the north pole tilts toward the right (towards the Sun) it is northern summer, southern winter Ditto at 2nd Half Earth if the tilt is to the left, at New Earth if it is away from the observer, and at Full Earth if it is towards the observer, and so on.

Accompanying the tilt will be confirming visual clues: snow cover in higher Northern latitudes or in higher Southern latitudes corresponding to that hemisphere's winter, the other hemisphere's summer, and so on. Yellow-oranges replacing green shades in temperate zone forests will indicate Fall in that hemisphere, Spring in the other hemisphere. More seasoned observers will be able to recognize seasonal clues in between to give a better approximation.

Pattern Watching

On the ball Lunans will be able to look up at Earth and tell the time of day (date), a close approximation of the date of the sunth (month), and which sunth/month of the year it is — all at a glance. It is the spectacle of Earth, however, that will turn that glance into a lingering observation, the seer into a transfixed looker. While Earthbound students can patiently study an all but changeless Moon, lunar settlers and visitors looking up at Earth will have an unending drama of riveting kaleidoscopic change to admire and study. It will be a treat without the distraction of flora and fauna and weather in the foreground, a Van Goghish canvas of color understatedly matted by black sky and gray regolith.

The first impression will be of ever changing cloud patterns; of hurricanes, cyclones, and typhoons; of storm fronts. Playing hide and seek with the shifting clouds will be the blues of the oceans and lakes and seas, the greens of grasslands and forests, the light tans of the deserts, and the glaring white of snow and ice. Beyond the day/night terminator, again playing hide and seek with the clouds, will be a light show extraordinaire: lightning and forest fires on the natural side, city lights and oil and gas burnoffs added by man. Different observers will see and watch for different things, each according to his/her own interests. Some will habitually count lightning strikes, jotting numbers in a log. Others will try to catch a glimpse of the light patch that locates their hometown lights or the lights of other towns, cities, and urban industrial archipelagoes.

Relatively few sets of elements will contribute to the never repeating sequence of Kaleidoscope treats. Not all the elements will appear with the same frequency: for example, the appearance and track of the approximately 60 mile wide Moon Shadow across the lit face of the Earth during what terrestrials experience as locally very rare Total Solar Eclipses. And the relatively glare-free conditions of solar eclipses (which we experience as eclipses of the Moon), many fainter nightside light glows may become visible to the practiced lunar observer.

"Humansign": Earth as an Inhabited World

That Earth is an inhabited world will be quite apparent. In the night portions of the observed face we will see the city lights, some unnaturally frequent forest fires, and the oil field gas burnoffs. In the sunlit portion of the Earthglobe we might see some agricultural patterns, and even detect portions of national borders betrayed by differing land use patterns on either side. We'll also see slow changes from advancing deforestation and desertification. Man-made reservoirs will catch the sunlight where once their was all-but-undetectable river valley. And we'll spot natural floods that are here and their 'controlled' by man-taken measures. All these signs will be studied acutely by those keenly interested in the great unplanned experiment of environmental "deterraforming", going on more or less continuously since the invention of slash-and-burn agriculture in Europe some 8,000 years ago.

For those fascinated by Earth's city lights and their identification, an amateur observing league may give out "Edison Certificates" to those who have correctly identified a representative selection of a hundred-some urban concentrations - much like the Messier Certificate Program in which backyard astronomers seek to identify star clusters and nebula on an early and popular list of the brightest such objects. Advanced observers will be on the watch for blackouts, major fires, night launch rocket booster burns as well as fiery nightside reentries.

For the Earthborn, night lights of homelands and hometowns and spaceport points of departure will hold special interest. For native born Lunans, night objects sought out will include a less predictable list of various places they've each heard and read about, and which have fired their imagination.

Naked eye observation of Earth

Full Earth illuminates moonscapes with sixty-some times as much brilliance as Full Moon brightens Earthscapes. But without a dust and water vapor laden atmosphere on the Moon, Earthside shadows will be inky black and impenetrable. A happy result is that starlight is not drowned out.

Yet not all lunar settlers and visitors will be able to appreciate Earth-in-the-sky with equal ease. To paraphrase the opening sentence in Caesar's report on the Gallic Wars, "All Luna can be divided into four parts".

In the central portions of Nearside, Earth is either directly overhead or at a very uncomfortably high angle above the horizon. We might nickname this central area **The Crooknecks.** It includes most of Mare Imbrium, Mare Nectaris, Mare Serenitatis, Mare Tranquilitatis, Mare Nectaris, Mare Vaporum, etc.

The Postcardlands are the peripheral stretches of nearside, regions in which the Earth hovers perpetually a comfortable 5-40° above the horizon. Adjacent to these, straddling the "limb" of the lunar globe which forever keeps the same side turned towards Earth are **The Peek-a-boos**. As the Moon's axis is not perpendicular to its orbit around Earth and because that orbit is somewhat eccentric and the Moon travels faster when nearer Earth and slower when further away, all the while rotating at a fixed rate, about 7° to either side of the 90° East and 90° West lines are alternately turned towards Earth and away from Earth, psychologically annexing about 9% of "Farside" to Nearside.

Together the above three regions cover 59% of the Moonglobe. The remaining 41% might be dubbed **the Obliviside**, the Farside heartland from which Earth is never visible - as the saying goes, "out of sight, out of mind."

Special Observing Equipment

Special equipment will not, without signal relay, make it possible for deep Farsiders to observe the Earth. But in Greater Nearside, if we might call it that, many of those enthralled by the sight of Earth will be motivated to go beyond Earth-facing picture window portholes in their shielded abodes.

Oculars and binoculars will be among the simplest terrascopic assists, along with large Fresnel lenses or projection lenses in front of windows, much as late 40s/early 50s small screen TVs used similar fore screens to magnify the view. Special amateur optical telescopes designed with the aperture above the surface, but the observer eyepiece optics within the pressurized habitat for direct shirtsleeve observation will be popular with purists.

But for others, HDTV monitors, interactively zooming in on selected portions of the Earthglobe, will provide even better views. There might even be a dedicated fully interactive yet live Earth View Channel offering not only spectacular live detail, but also multi-spectral false color enhanced imaging that cues in on ultraviolet, infrared and other cues in the more complete light spectrum. various interactive programs may search on demand for lightning flashes, pick out keyed in cities or other locations, even overprint city names of areas on which the viewer has focused in. Instead of the view from the Moon, auxiliary channels could give the view from LEO and GEO satellites, or even from future flank observation outposts in L4 and L5.

As on Earth, some avid observers will be heavily into photography, others into interpretive drawings, and yet others into raw and immediate unfiltered live observation. Yet glare reducers and variable masks for night side viewing will be standard (and the automatic default setting on TV).

Earthsight as an Umbilical Fix

The riveting sight of Earth will be the chief anchor with 'reality' and with the heritage of their individual pasts for the early Lunan pioneers.

> ``Landing on the Moon was not nearly as overpowering and as memorable as just going to the Moon and looking back at Earth. We went to explore the Moon, and in fact discovered the Earth." — Eugene Cernan.

Looking out the Apollo Module porthole from out around the Moon, Apollo 8 and 13 astronaut James A. Lovell, looking back at Earth, was able to block it out with his thumb. Later

he recounted, “Everything that I ever knew - my life, my loved ones, the Navy - everything, the whole world was behind my thumb.”

One can argue if this is good or bad. Deep Farsiders may tease Nearsiders about their mommy-fixation to Old Earth, boasting of a keener, deeper openness to the Universe at large, and of a greater space-hardiness that results. We’ll see. **<MMM>**

MMM # 109 October 1997

LUNA CITY STREETS By Peter Kokh

Foreword

[NOTE: In MMM #52 FEB ‘92 p. 2 “Xities” we introduced the term “Xity” (to be pronounced KSIH ty, not EX ity). “Beyond-the-cradle off-Earth settlements (“Xities”) will be fundamentally different from the familiar Biosphere-I coddled “cities” that have arisen over the ages to thrive within the given generous maternal biosphere that we have largely taken for granted. Elsewhere within our solar system, each xity must provide, nourish, and maintain a biosphere of its own . Together with their mutual physical isolation by surrounding vacuum or unbreathable planetary atmospheres, this central fact has radical ramify-cations that must immediately transform space frontier xities into something cities never were.”

In the same issue, the following article “XitiTech”, pp. 3-5, we investigated a gamut of essential xity functions, some familiar but strongly redefined, others new and without precedent, and their demands upon the structure of xity bureaucracies, government, and politics.]

The “Streets” of Luna City

We might define a street as an engineered passage-way that connects buildings and other places where people, live, work, shop, play, and otherwise congregate. The earliest improvements in the construction of village and urban streets include paving and guttering.

In temperate climates and seasons, the structure of a street and access to it is simple. In more extreme climates and seasons, access to the street has encouraged the construction of buffering foyers, porches and awnings, and pedestrian arcades as well as the donning of gear more or less adequate to the inclemencies to be braved.

In more modern times, we have seen the emergence of climate controlled pedestrian malls everywhere where heat, cold, rain or snow might interfere with profit-generating shop-ping activities. And we’ve seen as well the downtown sky-walks and underground galleries facilitating the busy bustle of vibrant snow belt downtowns, for example, those of Montreal and Minneapolis. Yet, despite such developments, it is still far more common for pedestrian and vehicular traffic to share rights of way.

In the thirties and forties, it was the common shared vision of the future that grade separations would universally replace in grade intersections. The expense of such a widespread infrastructure rebuilding, however, has limited this “stop-free” feature to all new “freeways” and “expressways” and scattered ultra-busy urban arterial intersections.

On streets of mixed use, the tendency has always been to maximize the amount of activity they enable. They are landscaped for maximum ambiance and attractiveness, and lined with shops, eateries, service establishments and other amenities meant to encourage pedestrian and vehicle stop-ins.

What might the streets of a future Luna City be like in the early era before the emergence of air-holding "mega-structures" such as crater domes, rille vaults and sealed lava tube courses?

On the Moon we have inarguably extreme climate at all times: radiation-washed, micrometeorite-splashed hard vacuum with extreme though superficial temperature swings. A more benign "lee vacuum" is available at the price of a ramada* or canopy over the trafficway. But for urban in-town purposes, all purpose pressurized climate-controlled shirt sleeve accessible pedestrian and traffic tubes will be as vital as the pressurized, climate-controlled shirt sleeve accessible habitats, labs, factories, shops, offices, etc. that they link in one inter-continuous mini-biospheric maze. In the course of everyday life, the urbane Lunan will don a spacesuit only during infrequent but seriously conducted "decompression drills". Even travel "abroad" to other settlements or outposts will be by hard-cocked vehicles, our airport jetways offering a very primitive foretaste.

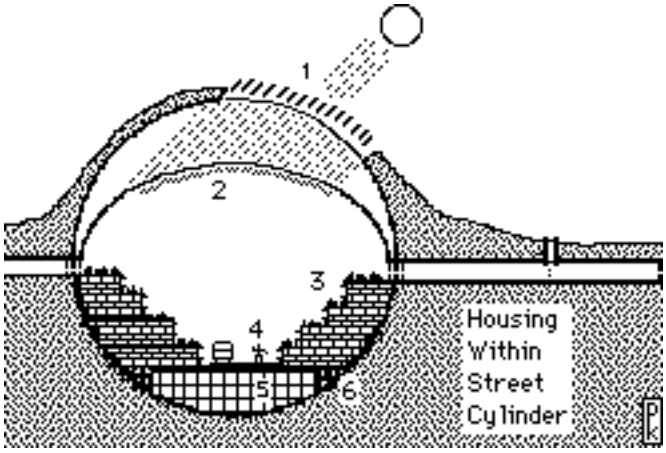
Size and Scale

The humble ancestor of the lunar settlement street will be the outpost hallway as it first becomes suddenly transformed by the merchandising of dawn era made-on-Luna artifacts (wares, wears, or both). As the outpost is superseded or absorbed into a conscious settlement effort fueled by the availability of locally processed building materials and architectural components, such cramped passageways will be followed by much more spacious corridors handling both people and vehicles.

If we must build these long interconnecting cylinders to carry the everyday commercial and social intercourse of the lunar city, then surely it makes sense to build them on a generous scale, with ample radius to allow not only pedestrian and vehicular traffic, but serious agriculturally productive landscaping. This more directly interconnected city gridway-plex would then contain the lion's share of the city's shared biosphere and of its biomass-run climatic and regeneration flywheel.

As a reality check, however, it is important to add that such thoroughfare cylinder (sections) will not exceed in girth that maximum diameter which the settlement is currently able to fabricate. So the earliest settlement streets may be relatively more narrow, even as were those early streets of colonial Boston and Philadelphia that still survive. And perhaps that is as well, for the larger the volume to be pressurized, the more inert nitrogen the pioneers will need to import at high cost to the young settlement. The ideal is clear, however, and will serve as a driver of fabrication capacity.

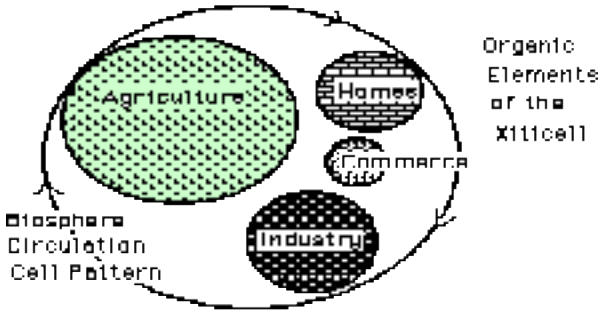
Once more generously radiuses cylinder sections can be built, these may be reserved for neighborhood-connecting cross-town arterials, and for commercial, industrial, and agricultural frontage roads. The narrower variety may continue to be produced for use as quieter, cozier traffic-restricted residential lanes. On the other hand, large enough cylinders could contain housing on their side terraces rather than just provide access to separately built modular housing, illustrated below:



Residential Streets ('Hoods) as Modules

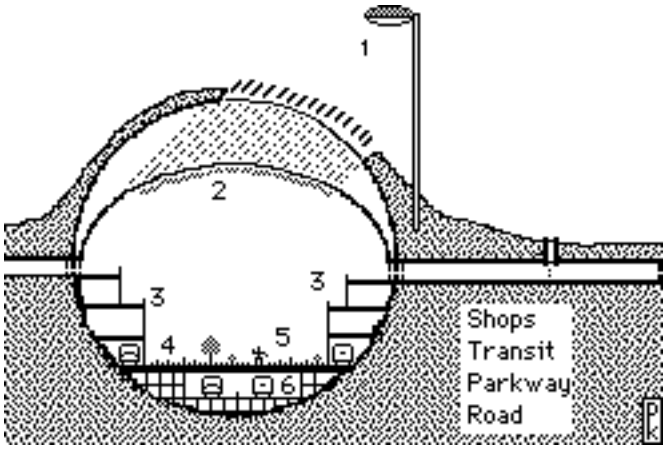
Cross-Section of cylindrical street module c. 40 m wide:
[1] shield louvers that let in the sunlight; [2] a suspended sky-blue diffusing "sky" - air pressure would be the same on both sides; [3] terraced residential housing with rooftop gardens; [4] the thoroughfare running the length of the (neighbor)'hood; [5] light industry and shopping, possibly offices and schools; [6] conduits for utilities.

Whatever their individual dimensions, the town street grid would present minimally clogging obstructions to an effective air circulation system. This could be set up to flow in neighborhood cellular loops* [schema below] starting with farms, flowing through residential areas, past commercial areas, through industrial zones and back into the farms in self-cleansing loops similar to the human heart-artery-vein-liver-lung loop. In contrast the aggregate of both individual and conjoined homes, town homes, and apartments, of shops, offices, factories, schools etc. that we more commonly think of as "the city" will in large measure be interconnected only indirectly, via the streetplex.



Basic Xity elements found in Xiticells

A generous radius would allow pedestrian and mezzanines lined with alcove shops and cafés, tiered above general trafficways and transitways, still allowing relatively uninterrupted green space on the floor and terraces. To make that work, relatively continuous solar access strips will be built-in features of the ceiling, if not replaced by artificial but more efficient grow-lighting. Nightspan lighting can make use of the solar access system (the actual lamps, and their heat, situated out-vac on the surface) or via artificial task and area spot-lighting.



A commercial street module

Cross-Section of cylindrical street module c. 40m wide:

[1] shield louvers that let in the sunlight during dayspan, artificial light during nightspan; [2] a suspended sky-blue diffusing "sky"; [3] terraced shopping mall on either side; [4] transit buses; [5] pedestrian parkway strip; [6] 'under-ground' road, utility conduits.

The ceiling vaults of these multipurpose galleries might be sprayed a soft matte-white-wash finish of CaO (lime) or TiO^2 titanium dioxide, whichever is the more cheaply producible from local regolith soils. Such an eye-relieving vault or "firmament" might be given an Earth-like sky-blue cast by backlighting it through blue glass panes or lenses, whatever the actual light source, or by carefully diffused blue neon cove lighting, using solar wind gases. Attention paid to this artificial 'sky' will pay off.

Free side wall areas can be undecorated, self-decorated playing to the character of the locally made building material out of which the street cylinder is made, decorated with glass and/or ceramic mosaic creations, billboarded (point-of-sale signage especially) or covered with commissioned murals or code-governed graffiti or popular street art of various forms.

These important superficialities to the side, the complete organic function of the street demands it carry the major utility runs: electric power with grid junctions, communications cables, fresh air ventilation booster fans and ducts, heavy and light stale air "gutter ducts", fresh water supply and used water drains, the latter carefully segregated by source (e.g. toilet, bath and shower gray water, kitchen sink-garden-farm-landscape runoff)

As we've pointed out elsewhere, "somewhat clean" reserve water on route to further processing could be channeled through the agricultural or landscape terraces via open canals and/or trout-streams and thus do double duty, creating ambiance, allowing canoeing and row-boating, fish-watching, even trout-fishing. Here and there sidewater lagoons can serve as swimming ponds and water lily gardens, even a lagoon for a city mascot pair of flamingos. Here and there, cascades and locks and waterfalls and arched pedestrian bridges can be worked into the scheme. Periodic dehumidifiers (humidity, not dryness, is expected to be the bane of man-made biospheres) can feed waterfalls and drinking fountains, draining into the fresh water supply lines.

The "Middoors"

The beachhead science outpost will be simply a pressurized indoors up against the outlocks vacuum, the out-vac. Whenever it makes its appearance, in such a government outpost or in an early company mining town, the construction of the first spacious atrium solarium garden will introduce a new kind of space - a space external to individual quarters, lab modules, and other work- and function-dedicated pressurized places, yet still keeping out the life-quenching vacuum beyond the airlocks and the docking ports. What we have called the "middoors" will be born.

From this humble beginning, airy, spacious, verdant middoor spaces will grow to the point that they may eventually contain the greater part of the settlement's atmosphere and biomass. And with all this, the "Holy Grail" "biospheric flywheel" will become much more of a reality.

It is within such spaces that longer, wider sight lines will appear, offering postcard views and vistas, to dull the edge of early day claustrophobia. The settlement will begin to take on the trappings of a little "world", a continuum of varying horizons. The effects on settler morale will be considerable.

"Indoor" spaces will be the more tightly climate controlled, allowed to vary only slightly from comfortable "room temperature" and humidity levels. In contrast, the middoors may be designed to swing freely, say from a late pre-sunset dayspan temperature that is tolerably warm and humid, to a late predawn nightspan temperature just enough above freezing not to harm the various plant-forms within. "Sunthly" "weather" patterns will add welcome variety and spice to day-in, day-out life.

That foremost conversation-making unpredictability of terrestrial weather, however, may be hard to program in. If temperate food plants are desired, perhaps an annual hard frost might be arranged one nightspan a year, as part of a partial cleansing freezing out of mounting atmospheric pollutants and impurities. It's a thought. And depending on ceiling heights of the street vaults, any gradual increase of humidity levels beyond a certain point might trigger mist-making condensations, say sometime after local sunset. At any rate, such mid-door "weather changes" will help keep the populace healthfully invigorated, as well as supplied something innocuous to complain about. A fringe benefit will be the generation of a whole new cottage industry to create fashionable "outerwear".

Intersection "Node" Modules

INTERSECTION NODES:

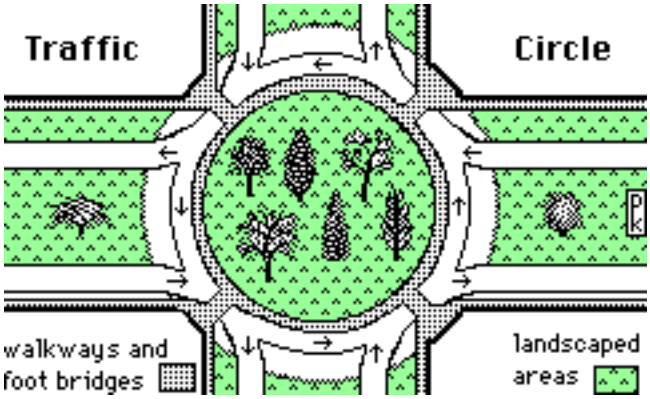
Try to imagine the current Mir complex without its pair of docking nodes, or the upcoming International Space Station Alpha without its module/docking port connectors. A lot like a Tinkertoy set without its connectors - don't work! The so-called nodes may be the lesser part of a complex architectural construct, by volume, but they are what holds everything together.

A street grid without intersections would be limited to a monolinear layout with street cylinder modules laid end to end. This is not an unworkable system, and I can think of at least a couple of U.S. towns that are pretty much laid out along one loonng street (Niagara WI, Bisbee AZ etc.) and many more that do have cross streets but are overall strongly linear, compressed between hills and shoreline, along riverbanks, in narrow valleys, etc.). But a linear network, however well it might work for computers (or not), is not a good way to encourage maximum networking and economic and social interaction between humans.

COMPLEX STRUCTURE: In comparison to the street cylinder modules, intersection nodes have to perform functions which make them complex architectural and design challenges.

Utility System interconnects: if utilities (electric, fresh water, waste water, communications) are carried in service chases in the lower part of the street cylinder (beneath park and road surfaces, etc.) then somewhere in the intersection node module, their must be tributary / distributary connections and access provided to service and maintain them.

Traffic Lane and Walk Exchanges: this can be kept simple, as in yield/stop sign/traffic signal controlled common grade crossings that are the norm in most terrestrial cities. Or an infrastructure choice can be made early on to provide full or partial grade separation "interchanges", separation not only of crossing vehicular traffic, but of pedestrian from vehicular traffic. These are architectural and engineering challenges only, constrained, however, by available money on the one hand, and by radius and scale (allowable elbow room) on the other. Next to the common grade crossing, the traffic circle is the simplest interchange solution.



A tri-level grade separation (2 free through-flow separated levels, a 3rd signal controlled turn level,alternately allowing two sets of turns as below) would be desirable where traffic volume is greater.

 N-E/W-S, S-W/E-N **&**  W-N/S-E, E-S/N-W

Traffic circles are used with success in many cities. A more generous floor plan radius with a high dome over a landscaped pocket park within the traffic circle, with grade sepa-rated pedestrian bridges is an example of what could be done.

Pressurization Sphincters:

By all estimates of lunar meteorite bombardment frequencies, (if you put an Earth-type city of 500,000 on the Moon's surface, you could expect one home per year to be "taken out" by depressurization from a meteorite strike, a loss rate far, far lower than most cities experience from fire) major depressurization strikes involving a direct hit on a street cylinder or intersection node should be very rare indeed, less than one a century in a smaller settlement. All the same, we could not afford one such strike to depressurize the entire "middoors" grid, and with it, the bulk of the settlement's biosphere. The only way to prevent this however is by emplacement of closable pressure doors or sphincters at intervals throughout the grid. Now these could be part of the intersection nodes, at the point where they connect with the (four) street cylinders, or they could be part of the street tubes themselves at each end, or, more economically, along the midpoint of each (halving the total number to be built and maintained). These are architectural and engineering questions. And quite a design challenge too, if it must be ready to deploy at anytime, even if unused for decades.

Perhaps there could be alternative systems in place to deal with minor "hull" breaches and leaks where air loss and air escape velocities are low. Any such system would be triggered either mechanically (power off fail-safe) or electronically by devices that sensed sudden pressure drop, or sudden increases in normal ventilating air current velocities. The salient estimate is of time needed to clear the area at risk.

Sound Baffling:

If we don't want the settlement and its middoors street-plex to be intolerably demoralizing over the long haul, architects and engineers will have to give full attention to sound baffling - something that is of much less concern in our terrestrial open-sky cities. The needed materials and construction methods should pose no problem. Whether Sound-baffling features should be built into intersection nodes is a decision that will be made opportunistically, depending on overall design and other special features. Certainly, vegetation and trees would help.

MODEL VARIATIONS:

There will be a number of intersection node modules, depending on the mix combination of intersecting street cylinder sizes and on whether or not extra height is allowed to enable grade separations for smoother traffic flow. One might expect intersections of four

residential street tubes to differ quite a bit from one joining four commercial avenues, or a pair of each.

USAGE DESIGN CHALLENGES:

Additional tweaking of designs is in order to meet expected use patterns: hosting town center institutions, offices, commercial shopping, entrepreneurs, cottage industry and arts and crafts markets and fairs, food court and rendezvous plazas, hosting festivals and parades, etc.

Signage, Lighting, and Individual Ambiance can be given architectural roots, and left to user embellishment. No busy settlement intersection need look like any other (e.g. the strikingly different, each stunningly beautiful stations on the Moscow Metro Circle Line).

To serve pedestrian traffic between parallel or neighboring streets in areas where intersecting streets are far apart, "shortcut" pedestrian "cunnicular" tubes might be built. These will be small in radius, perhaps with a shallow side terrace for hanging plants, flowers, bonsai forest strips etc.

The Parking Question

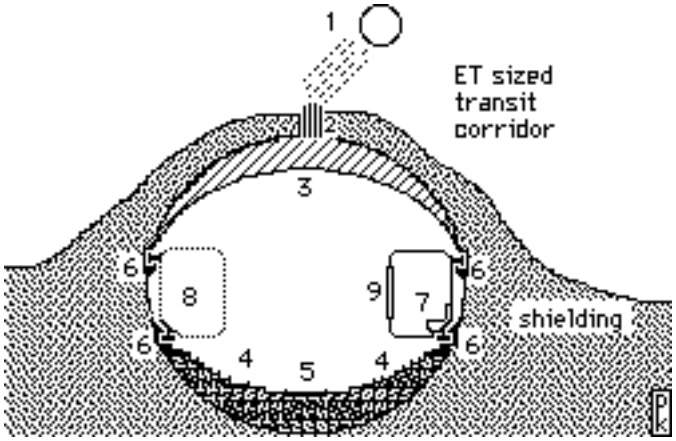
Any discussion of streets not touching on parking would be critically incomplete. Off-street parking ramps or garages could be located next to intersections and/or mid-block as need suggests. Commercial and industrial streets with ramps sized adequately for customers and employees, could be paired with pressurized alleys allowing delivery and pick up of goods and wastes. Residential streets may have private carports or driveways, with visitors using mid-block ramps. In all cases, on-street parking, a form of unsightly clutter run wild in Earth cities, can be wholly avoided.

Private Vehicle Options

In smaller settlements, bi/tricycles and even pedal driven family vehicles might not be uncommon. Amusement Park bumper car style personal trolleys and taxis are an option along with battery-powered autos. Open, surrey, and convertible types will be common in the climate-controlled environments of pressurized settlement streets.

Public Transit Options

In the same environment, public transit vehicles can also be open-air, starting with simple railing-sided flatbed street rail cars with benches, operating automatically much as modern operator-free elevators. Trackless trolleys are feasible. Battery operated coaches will be more expensive to operate. In the light gravity of the Moon, side-rail suspended cars and vault-susupended monorail cars should be very feasible and popular. Station stops could be just before or just after inter-section nodes, or handy to mid-block pedestrian bridges.



KEY: (1) Sun, (2) fiber optic bundle sun pipe, (3) sky-blue sunlight diffuser (same air pressure both sides), (4) terraced plant beds, (5) gardener's path, (6) wall-mounted rail suspension system, (7,8) bench seat transit car, (9) door.

Special Uses

Commercial concentrations can either grow up around favorably designed or well-placed intersections, or alongside individual street cylinders themselves. “Nucleus” intersections can be built at planned intervals, each to develop their own individual mix and ambiance as neighboring enterprises and cottage industries and neighborhood associations make use of them. One such may in time emerge as hub of “the downtown” but that can be left to the free unfolding of city life, and need not necessarily be preplanned.

Some streets may be specially designed to handle ethnic, music, and art festivals. Others can be laid out with parades in mind. And some should be intended to serve as park strips for retreat and relaxation and fuller enjoyment of urban greenery, maybe even token urban wildlife [see below]. [See “Pioneer Holidays” – pp. 58-59 above.]

Custom Frontages

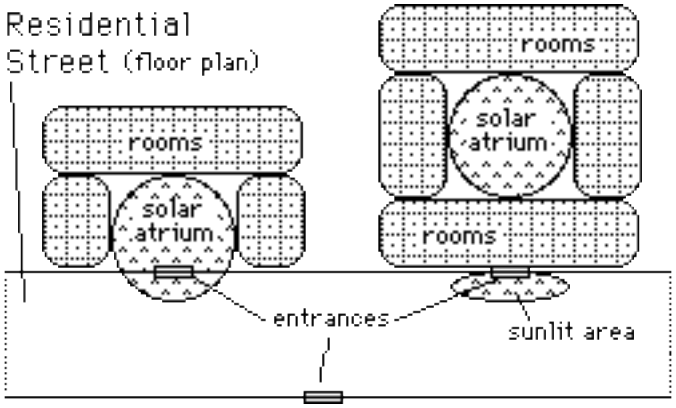
Pressurized residential lanes, commercial avenues, and industrial roads will each offer their respective frontage-holders the opportunity to landscape, remodel, and redecorate the entrance vicinities to their individual residences or establishments. It is this street-connected building interface that is the latter’s public face. The out-vac exterior (elevations), in contrast, will in most instances be seen by very few, and consequently invite little image-broadcasting attention.

Each pressurized cylinder designed to host a street-scape will come (be built) pre-outfitted with a particular placement of doorways and doorway types, — dockage, if you will, for adjoining pressurized structures. The various side entrance formats will establish a fairly rigorous zoning regime: residential, commercial, industrial, agricultural, etc.

For proprietors and homeowners, flower and plant beds, whether merely decorative or useful (fruit, vegetable, herb & spice, dyestuff, fibrous, pharmaceutical, etc.) options are quite varied and lend themselves to personalization both in choice and arrangement. Complementing them, doorways and façades can be variously done in cement, ceramic tile, brick, stained glass, pebbledash, metal, etc. Holiday and festival decoration can be made of creations from harvested biomass.

Residential street sidewall section, suggesting how homeowners might customize their entrance façades.

Pools of dayspan sunshine may mark every entrance to off street property, provided for in advance by the positioning of solar access in the cylinder vault. This external “atrium” can be contiguous to, or separated from, a larger solar garden atrium central to the home, etc. There are lots of options, and a healthy variety will be the result.



Each entry becomes the canvas for a distinctive statement. The street frontage serves as the interface through which individual-private and shared-public worlds meet. The entrance, whether to a residence or an establishment, is a special fixed place that sets the mood and tone for all who enter. It says "I'm unique and proud of it."

There are, of course, also those several mobile interfaces with the world which accompany us on our excursions into it and through which we also state our identities: hairdo, cosmetics, jewelry, clothing, and personal vehicles. To serve all these markets for personalization, as well as in-home custom decor and appointments, a healthy variety of cottage industries will rise and thrive.

What about homeowners and proprietors who chose to leave their streetside home or establishment entrances and frontages uncustomized, anonymously undifferentiated, accepting the "issue" doorway and marker, etc. The city can either choose to accept this, so long as the public premises are kept neat and tidy, or set minimum standards for decor and landscaping, and, where these are not met, making the improvements itself to be paid by tax assessment on the negligent party - such is "the system" in Oak Bay, an affluent garden suburb of Victoria, British Columbia

Streets that serve food-production areas (farms) might be encouraged by tax law to provide adjacent small parks and garden spots for the public as well as roadside produce markets. Because there are no natural lunar annual "seasons", crop harvests can be staggered to occur every sunth (29.5 days). Fresh produce will generally be always available.

[If the settlement in whole or in part, adopts a temperate climate with a hard frost sunth, in order to produce temperate zone fruits and vegetables, this would not apply. In this case, there could be two sunth-short frosts and two five sunth growing seasons annually.]

This said, however, in time, to serve growing demand for partially processed foods and the domestic meal preparation time-savings they represent, food processing enterprises may sprout up along these farm frontage roads. They will be supplemented by cottage industry home canners selling their wares in neighborhood markets. The farm road processing outlets will want to make their frontages as attractive as possible to potential customers. To do this they will use a variety of inorganic decoration methods, as well as landscaping and, of course, product display.

Doing Without "Commons"

The "commons" are areas owned by "no one" - thus subject to neglect, trashing, and cancerous blight - or by "everyone" and thus maintained at taxpayer expense. The difference between the two is nothing more than a budget-mandated choice tipped by the good or bad graces in which adjoining property owners are held at city hall (who is most effective in greasing the palm). Instead the city should be concerned with utility and recycling systems and biosphere regeneration and maintenance. These city gut systems can be maintained by youth during tours of "universal service" to keep the tax-supported payroll to a supervisory minimum. City adoption of "commons" area creates the temptation to show favor and disfavor (e.g. to the rich and less-affluent respectively).

For areas available for planting and landscaping, both options can and should be avoided. This can be accomplished by individual or corporate ownership of larger plots, and individual and group adoption of maintenance chores in the upkeep of smaller plots. Groups can be of homeowner cooperatives or business / marketplace associations. Local grocer/eatery coops can run garden spaces of spice and salad stuffs. plots Cottage industry market coops can manage decorative gardens placed within or alongside them.

The model for this is the spreading adopt-a-mile programs one sees more and more along the approaches to cities and towns in this country. Individual and group self-pride and good-natured rivalry combined with design talent and maintenance energies can lead to a very high average state of both adopted plots and the larger privately owned plots within the various street cylinders. Wealth, of course, will "out" and the adopted "commons" of more well-to-do areas will inevitably be, on average, more luxuriant and decorous, than those in lower income

areas. Wealth, however, has no native monopoly on inventiveness, hard work, art, and ingenuity - these are the great levelers.

Local Sign and Advertising Media

Even without such terrestrial standbys as paper, cardboard, wood, plastic, and organic base paints, Lunan proprietors and entrepreneurs will have a variety of materials with which to produce signs and ad boards. For relatively "permanent" signs (street names, house numbers, etc. and business names) backlit mosaics of stained glass and front-lit mosaics of glazed ceramic tile are two of the more decorative possibilities. Engraved or bas relief monochrome ceramics and concrete, and metalwork signage of various sorts will also work. Neon signs, using easily recoverable solar wind gases (banked by adsorption to the fine particles in the upper layers of the regolith soil overburden) such as argon, neon, xenon, and krypton will be feasible.

For transient and frequently changing signage and advertising, digital electronic display boards may be the solution, though vegetable-based water colors on recyclable craft paper are a less expensive option. If you come up with still more ideas, please share them.

Street Vegetation and Forestry

Purely decorative flowers, plants, shrubs and trees producing neither food nor fiber, herb or spice, dye stuff or pharmaceutical, will be hard to justify. An exception might be a memorial floral garden partially fertilized with the ashes of departed pioneers. Such a special spot is bound to become a favorite backdrop for wedding photos etc. Some small luxuries are simply worth the cost.

Fortunately, some environmentally conscious landscapers are having great success on Earth making decorative and ornamental use of food-bearing plants and trees. Pioneers may enjoy no oaks or elms, pines birch, or cypress - but there will be orchard trees like apple, pear, cherry, orange, banana and the like, and fiber-producing trees like Kapok. Others have suggested bamboo, useful for making informal furniture, scaffolding, etc.

Personally, while I can see a great role for bamboo on nitrogen and carbon rich Mars, the idea of permanent withdrawals from the costly, volatile-limited lunar biospheres seems an obscene luxury. Perhaps it can be allowed if accompanied by a discouragingly high luxury tax, high enough to pay for the replacement volatiles involved. Along the same line, wood may be so precious on the Moon as to make it a favorite jewelry stuff. Hard cherry and apple would be natural for such uses.

The major determinant, however, will be the design climate of the street-grid biosphere. If semitropical, i.e. never freezing, we'll see a completely different list of food bearing plants than if it is designed to freeze seasonally, in temperate fashion.

Possibly various neighborhoods could be designed diversely in this respect so that the city as a whole enjoys a greater variety. It is the more likely that climate will be a city-wide choice, however, and that some towns will be temperate, others subtropical, others tropical, etc. Variety at the produce market will then come from vigorous inter-town trade. Such differences in town climates will also generate healthy inter-settlement tourism, making possible welcome changes of scenery.

Many fruit and vegetable plants produce blossoms prior to fruiting, and such blossoms can take the place of purely ornamental blooms in adding seasonal dashes of color and beauty. Simple juxtaposition of useful plants of various heights, shapes, and shades of green will be pleasantly decorative enough as a free plus.

As to trees, we will see a definite change in maximum allowable height as the settlements grow and mature. The first "pocket forests" may actually appear in early outposts - caricature groves of "pet" bonsai trees. There will be room for little more.

Next will come dwarf orchard tree varieties which can be planted even in in-home atrium garden solaria. But as street cylinders of ample radius are built, we will have room for much taller fruit and fiber trees, even bamboo grasses. [See "Moon Garden" - pp. 2-3 above.] [See "Parkway" - pp. 10-11 above.]

Urban Street Wildlife

A biosphere without wildlife might be more efficient. But it would fail utterly to teach and remind young settlers of the host planet, teeming with wildlife, into whose midst the human species emerged. It will be both more educational and more morale-boostingly healthy to have some wildlife, however sparse and token.

The worthiest niche will be for pollinators. On Earth, these include honeybees, hummingbirds, some butterflies, and some bats. Their presence will give delight to many, as well as teach how real ecosystems work. Where plantings are in soil rendered from carefully aged regolith with the assistance of microorganisms, earthworms will introduce yet another phylum, yet another example of life's tremendous capacity for diversity.

A small captive flock of slow-breeding flamingos might quickly establish itself as the popular town mascots without devouring too much recyclable biomass. Certainly such animal mascots would cost the settlement orders of magnitude less than would any human mascots of some monarchy!

If there are open water canals making use of reserve water in process of treatment for recreational use, these can be stocked with both game and decorative fish (e.g. trout and poi). A large aquarium would serve even better to teach and remind youngsters how life began, in the oceans. We hope to speculate more on such options in another article. [See "Animal Life" pp. 9-10 above.]

The Street Plays Host to City Life

The first settlement streetscapes will be pretty drab with few decor and landscape options; little variety in apparel; a paltry selection of consumer goods, mostly of crude "experimental" quality. As settlement industry diversifies in search of an ever longer list of export goods, new materials for building and crafting and artwork will appear, new finishes, new colorants, new tools, new methods. (Bear in mind that anything the settlers produce for themselves can be exported at a price advantage to other in-space markets.) [See "Moon Mall" – pp. 3-4 above.]

Variety and diversity will grow exponentially as afterwork cottage industry activities arise to serve the unquenchable thirst for the custom, the different, the personal, the truly beautiful. Street markets, at first hit and miss in both times open and space will become regular, then permanent, and grow from flea market caliber towards a satisfyingly department-store-like spectrum of selections.

As versatile food crops increase in number, menus and cuisines will diversify and a wide range of interesting eateries and the odors associated with them will soon become taken for granted. As the variety of musical instruments fashionable from lunar materials grows, the number of good street ensembles will mushroom, as the number of acapella singing groups diminish (e.g. barbershop quartets). [See "Moon Music" – pp. 4-5 above.]

The more consumer products, the greater the volume and variety of discard objects. Reuse and recycling sorting bins and exchange marts will grow.

Because capital production equipment as well as service facilities to be enjoyed by all will be expensive, less will go farther if used and enjoyed, as the case may be, around the clock. The settlement will work three staggered shifts without chauvinist preference for one over the other. With the solar clock set on 4 weeks instead of 24 hours, different streets and whole neighborhoods can have their own day/night lighting cycles. [See "Dayspan", "Nightspan", "Sunth" – pp. 23-25 above.]

The corollary is that the neighborhood-joining commercial, market, dining and entertainment street areas should be alive, vibrant, and interesting around the clock. Market stalls and cottage industry shops might be time-shared by coop members, or their goods sold round-the-clock by caretakers on a consignment basis. And always, the street will be the place to indulge in the universal pastime of people watching.

Whatever the part of 24-hour lighting cycle, settlement streets will take on a different personality and ambiance depending upon whether it is dayspan or nightspan out-vac. It is not

only a matter of the availability or not of magically healing sunshine. The number of people on the street, their energies and moods, and the quantity of cottage industry goods available will all cycle with the local 29.5-day sunth. Many production employees will change from energy-intensive to labor-intensive jobs as night falls and with it the total available electrical power. Street activity cycles will follow suite.

Some landscaped areas will sport park benches for shoppers and workers on break to take a respite. Urban pocket parks work best if they are not secluded. People want to relax, yes, but such relaxation is enjoyed the more if it is in a peaceful spot in the full midst of the vibrant city bustle all around. Check and see: well-intentioned secluded urban parks are almost always relatively unvisited.

Role of the Settlement College/University

Any settlement institution of higher learning stands to play an enormous role in the development of the local culture and civilization and of the media and tools by which it is expressed. All this will be on display directly or indirectly on the streets. A university would assist on site companies in the development of new locally-sourced building materials, appropriate architectural systems and construction methods. Its research may contribute to the appearance of new finish and decorative materials as well as an expansion of the available color palette. All this will affect the basic appearance of the pressurized street cylinder and its decoration.

University assistance in cottage industry formation will help speed the diversification of products available in street-side markets and shops; development of musical instruments fashionable from local building materials will have its affects on the sounds of the street; development of new plant hybrids will enrich and diversify landscaping options; the list goes on and on.

The Street as a Default Home

What about those temporarily or chronically unable to come up with mortgage payments or rent? What about those who are willing or forced exiles from homes that were dysfunctional so long as they remained in them? What about those overcome with mental disorders and disowned by relatives and friends? Lunar towns fly the flag of "Tanstaafl!" - "there ain't no such thing as a free lunch." Every pioneer is expected to be productive.

It may be required of all who would come, or of their corporate sponsors, to place in escrow funds for return passage to Earth in case they grow unhappy with settlement life or should the settlement becomes dissatisfied with them. This measure will take care of some of the problem and minimize the effects of economic dislocation and job loss. But people will still fall through the cracks that remain.

There is hard work out-vac, building roads and bridges over rilles, erecting habitat and other pressurized structures, mining, and other sundry field work tasks needing to be done if the settlement is to survive. It will be work that will attract some, but too few. Here then, is a niche for an out-vac service corps into which the temporarily or chronically dislocated can serve in exchange for food and lodging and the buildup of a nest egg for a fresh start, a fund that cannot be touched until it reaches a certain minimum. In addition, there may be in-city universal service type jobs going unfilled by the available youth pool (of say 18-20 year olds). There will be opportunities, too, to join other lunar and off Moon settlement endeavors, hard pressed for recruits (Mars, Ceres, etc.). Such efforts may oft' be sink-or-swim enterprises tending to shape up those involved.

Any such potential problem as homelessness must be tackled on many fronts. Prevention is vital. Vocational and occupational job counseling and retraining; pre- and post-marital counseling; parental and family counseling; crisis management; work schedule options; residence options, etc. Some of the bill for this work might be paid out of a tax on companies doing work on the Moon and importing workers and their families. The rehabilitation work might in part be done by OMOs, occupational maintenance organizations. What is needed is not

job “insurance” (i.e. unemployment compensation) but job “assurance”. But there remains leftover work and vocation aplenty for service clubs, religious orders, and churches.

Those still falling through the more stubborn cracks can be provided storage lockers for what belongings they retain, lockers to which is attached a legal address for receipt of mail, and for listing on job applications. This host facility might provide cooking facilities and showers. Use of such a facility will bring with it a requirement to participate in retraining and rehabilitation programs. This is in everybody’s interest. Tanstaafl still rules!

The criminally misfit need to be handled in the same comprehensive way. We cannot afford to lose a person’s potential productivity through money-, personnel-, and resource-sucking incarceration. Involuntary out-vac service corps work, as outlined above, should be the extent of punishment, as opposed to rehabilitation, repatriation to Earth, or reassignment to asteroid colony backwaters.

Gateways and Highways to the Hinterland

In its infancy, a settlement may do well with a single gateway, a bank of docking ports for out-vac surface-plying trucks and coaches. But if and as the town grows, the need might arise for a number of peripheral gates, depending on the way highways to and through surrounding areas radiate outward from the settlement site.

In time the original town limits will be leapfrogged and the various gateway dock areas will be surrounded by urban development. New gateways will emerge along the new outskirts. But the older ones may remain for express pickup and deliveries to various points within the now larger city. Surface express routes might serve these older. Neighborhood gateways will attract adjacent in-city commercial and market development, park plazas and entertainment zones, hotel/motel and apartment concentrations, etc.

Where public coaches ply these city-top express routes, adjoining property owners may feel a belated need for surface decoration or adornment of previously plain regolith shielding mounds. [See “Moon Roofs” pp. 40-41 above.]

The Unfinished City

“Praise be the darkness, and Creation Unfinished!”

Ursula K. LeGuin, in “The Left Hand of Darkness”

If any of us came into the world to find it, its culture, its civilization and cities “finished” we’d be at an intractable loss to find personal meaning or significance to our lives. It is because the world and the city is unfinished that it is both breeding ground for evil and an opportunity for good.

Urban planning must always remain tentative, confine itself to infrastructure and resist the temptation to divinely proclaim the details, stifling individual initiative and expression, suffocating the vibrant vitality that comes from unexpected spontaneity. The city is livable only to the extent that for each of us there is an opportunity to contribute our own individual “brick(s)”. The off-Earth “Xity” [= a city that has to concern itself with creating and maintaining its own biosphere] is a shared undertaking of unprecedented challenge and scope.

As such the proposition to establish a “Xity” will attract architects and city-planners who would play god, deciding everything, reducing all who shall ever after live therein to lives the more meaningless because of the lack of opportunity to help finish the unfinishable city. It is only the unfinished city that lives, that is alive. Future off-planet cities, whether they be on alien surface scapes or within O’Neillian rotating constructs, must begin life only partially determined. This is a challenge foreseen, to be sure, by no science fiction/fantasy artist with whom I am familiar. Their cities are all uniform in architectural style and plan, all new (rather than a mixture of new and old) and inevitably gleaming, as if created not bit by bit like living world-challenged things, but all at once like some bauble in a bubble.

Enthusiasts captivated by such untrue-to-life artistic renderings may not make the best pioneers. The frontier will always have rough edges and the pioneer’s calling is to smooth them down, one at a time. There will be no abracadabra cities out there, just frontier towns whose

inhabitants will find their lives enriched with the real life chance to make a difference, to help finish the never finished.

Examine yourself, score yourself, and take another look! Because it is so very unfinished, the frontier settlement or city will be most rewardingly livable. To be sure, the great megastructure cities such as O'Neill colonies, proposed domed craters, vaulted rilles, the main "plaza" structure depicted by Rawlings in Ben Bova's "Welcome to Moonbase" are visually alluring and inviting. Their high ceilings allow expansive vistas within which individual dwellings and other buildings can be built using familiar construction methods to create Earth-mimicking urban environments. But despite their postcard-worthy panoramas, such fixed-size cities will quickly become vitality-suffocating unless they are somehow able to expand in modular fashion (as in the Prinzton study of vaulted rille sections built as a series of villages in multiples of three. The discussion is moot, however, for in the near term, only modular lunar and space settlements can have realistically affordable construction and early occupancy thresholds.
MMM

MMM # 115 - May 1995

[Time to cool off!]

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

HARVESTED ICE RESERVES

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

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

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

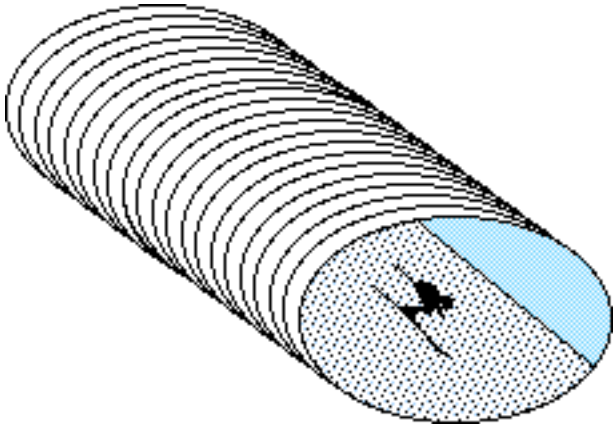
CONSTRUCTING THE HILL

At the lunar poles, one would not have to construct a hill. Hills, in the form of the inner slopes of crater rims, abound. In fact they frame the permashade areas in which the ice reserves are to be found. Right structure, superlative size, right location. A little grading to smooth the beginners run, a little more to make the intermediate and advanced runs more interesting,

cover it all with a shed, and Voilà! No, not quite. Pressurize it and the shed would blow off and the air would be gone. The shed has to be an ovoid or cylindrical tube that is pressure tight, bending to fit the graded slope bed prepared for it. Then, and only then, is the air tight cylinder pressurized, and snow piped in and deployed to the right thickness or better.

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

A permanently shaded equatorside inner slope of a near polar crater would make temperature control easy. Air pressure need only be high enough to keep the snow from subliming, but no higher, e.g. as high as Everest. And the thinner air would actually mean faster terminal speeds than we achieve on Earth, where air pressure, not gravity, are the ultimate determinant.



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

STAFF RECREATION & TOURIST INCOME

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

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

OUT-VAC SKIING ?  **WITHOUT SNOW ?**

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

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

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

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

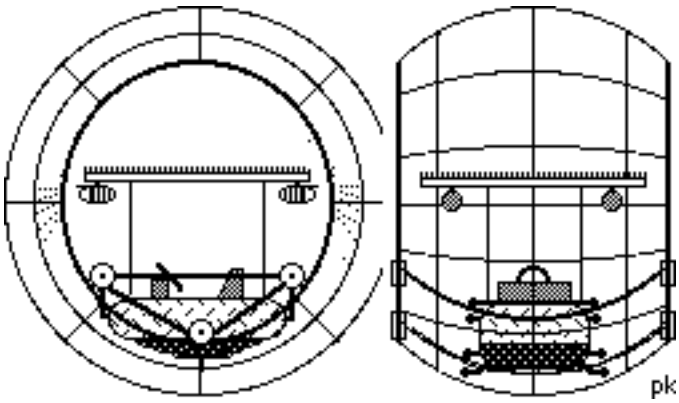
But let our imagination wonder yet further afield. Silicon is said to be an analog of carbon, both having a valence of +/- 4. Could there be a silicon analog? There's lots of silicon on the Moon. This rock-making element is second in abun-dance only to oxygen. But there probably is no analog - while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

FOR SOME - THE THRILL OF TEASING DEATH

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

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

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



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

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

LUNAR AMUSEMENT PARK RIDES

Then there are roller coasters. Pressurized cars plying an out-vac track that was high enough, could build up speeds never experienced on Earth where air pressure sets up an artificial "terminal speed" that can't be exceeded in an unpowered run. Some of the down hill

run of the coaster could be above the lunar terrain, but some of it could be tunneled into the surface, perhaps opening into a lavatube, with a sphincter gate, resembling so much normal hum drum lunar surface, opening just in time to swallow the horrified passengers into the pitch darkness of the lunar netherworld.

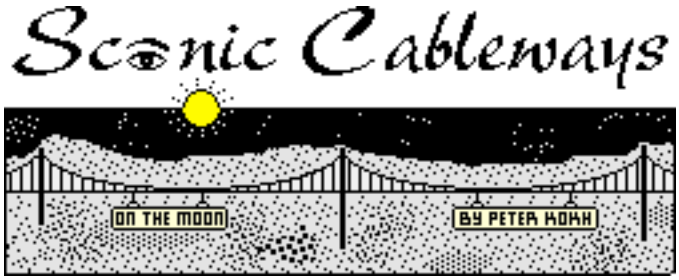
In the sixthweight, with the absence of wind, towers could easily be built miles high. Bungee jumping, anyone? But isn't all this another article?

OUR POINT

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

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

MMM # 117 - August 1995



By Peter Kokh

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

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

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

INTERMARIA PORTAGES & SHORTCUTS

On the nearside of the Moon, perhaps the majority of good settlement and outpost sites are along "shores" or 'coasts" of the interconnected Nearside Chain of Maria. This allows easy

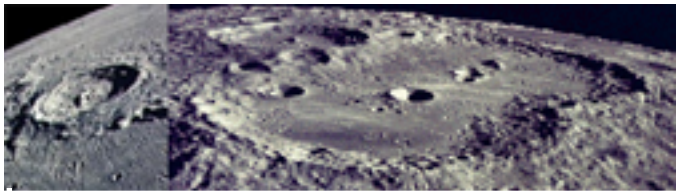
"highway travel" in general. However, one of the most-often favored maria for settlement sites, Mare Crisium, the Sea of Clouds (the easiest feature on the Moon for the naked eye to pick out, a real media plus) is land or more accurately highland-locked. Surface travel between the Sea of Crises and the nearby seas of Tranquility (to the west) and Fertility (to the south) would require surveying logical low-grade routes through the crater-pocked highlands.

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

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

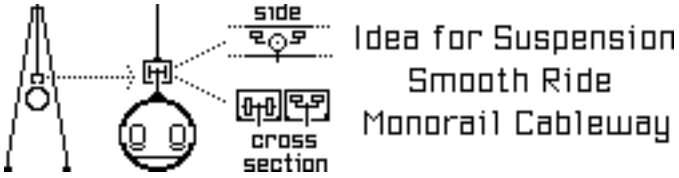
SCENIC RIMWAYS

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



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

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



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

Landcruising Gypsy House Boats

By Peter Kokh

LIVING ON THE ROAD LIFESTYLES

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

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

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

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

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

In any natural unfettered lunar society, there will be the long distance truck drivers, the traders, the road builders, the field prospectors, the out-vac sportsmen, whose spirits would suffocate within the confines of even the best designed settlement. How do we make a place for them, not just in society, but also out on the road and in the field, a place in which they are moderately safe from dangerous doses of cosmic radiation? [The solar flare question is another matter altogether. See MMM # 37 JUL '90, pp. 4-5, "FLARE SHEDS: Butt-savers in the lunar out-vac"]

TORTOISE SHELLS - THE CARAPACE

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

square foot, nearly a ton per square meter. Talk about road-hugging vehicles! Obviously, such vehicles would have high centers of gravity and need to be very wide-tracked to compensate.

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

LIGHTER WEIGHT SHIELDING MATERIALS

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

O oxygen [16] Ma magnesium [24]

Al aluminum [27] Si silicon [28]

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

Ca calcium [40] Ti titanium [48]

Fe iron [56]

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

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

Silica SiO2 = 60/**20** Magnesia MgO = 40/**20**

Alumina Al2O3 = 102/**20.4** Magnesium **24**

Aluminum 27/**27**

Foamed silica glass or hollow quartz Spherules would seem to be the most attractive possibilities, if they can be manufactured as a cheap byproduct of other priority materials. As quartz (pure silica glass) is transparent to solar ultraviolet, it is likely to be a high priority product of early lunar industrialization, as waste water could be purified of bacteria and pathogens quite simply by exposure to the sun in pressurized quartz-paned tanks. But silica, magnesia, and alumina are also likely to be produced early on for various uses. And aluminum metal alloy could conceivably be foamed.

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

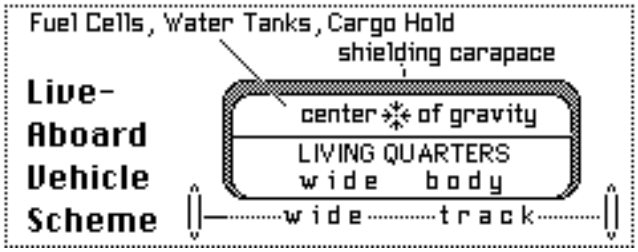
SHIELDS OF CARGO, FUEL, SUPPLIES, BATTERIES

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

Among such items are: banks of fuel cells, the bottled cryogenic hydrogen and oxygen that feed them and the tanks of water that they produce, other water reserves and water in treatment, and cargo holds

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

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



Among such items are: banks of fuel cells, the bottled cryogenic hydrogen and oxygen that feed them, and the tanks of water that they produce, other water reserves and water in treatment, and cargo holds

Cruising Mare Crisium

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

By Peter Kokh

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

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

The sea is essential only as a metaphor for a non-distracting motionscape. This can be a terrestrial ocean or sea*, the surface of relatively featureless lunar or Martian lava plains, and above all empty stretches of interplanetary space itself.

> *There are places on Lakes Superior and Michigan and Huron, the Aral Sea and Africa's Lake Victoria, where ships lose sight of land for appreciable stretches.

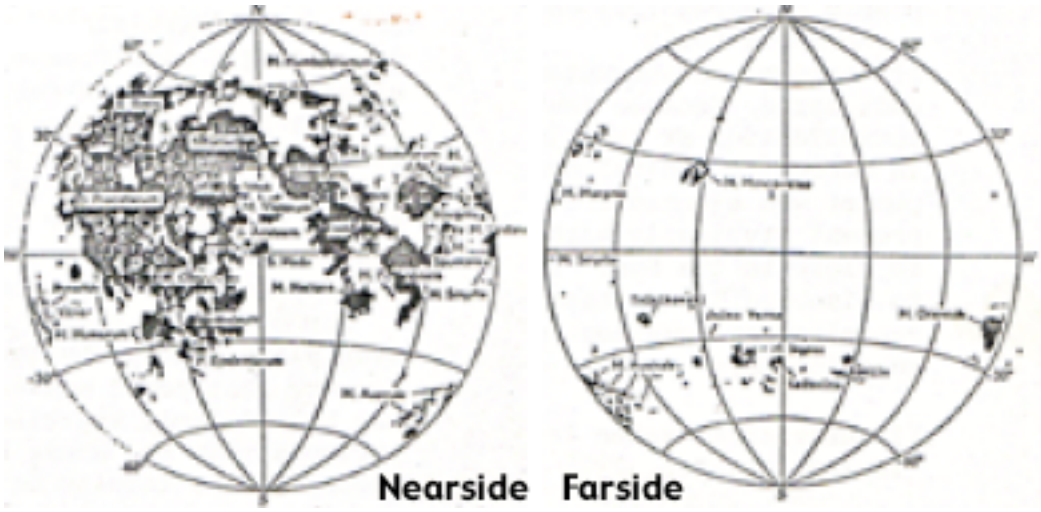
Such plainscapes, watery or dusty, support vessels or craft that can be gargantuan in their dimensions. Bodies of water call for streamlined hulls because the craft in question must "part the waves" to make progress. But by using a double hull catamaran plan, ocean ships can be amazingly wide. Port congestion with close-spaced piers may introduce an artificial constriction not "of the essence".

Why cruise "ships" on the Moon? Because they will provide the same welcome relaxation and escape from routine as do their terrestrial counterparts. As here, the object will not be to go anywhere, even for an extended visit (e.g. Europe), though brief visits may be made to small ports with local color to spice up the vacation: San Juan, Nassau, Ochos Rio, Aldrin Vale, Alpine Valley Junction, Rover Crossing.

As with terrestrial “floating resort hotels”, over time a symbiotic relationship will develop between the ships and their ports of call. The quest of the passengers for variety will work to motivate local artists, craftsmen, and performers to produce unique items that give their “port” a special and hopefully memorable flavor. Produce or get dropped from the circuit. This motivation with both public and private support will be strong, even if service to the tourist trade is a secondary part of the local economy. Occasionally the “ships” will test visit new stops, on or off their accustomed circuit(s).

Where on the Moon? Many locations on the Moon are suitable for this kind of vacationing. Keep in mind that rilles are as much an obstacle, however, as craters of size. Treat them as barrier reefs and large islands respectively. Even so, most of the lunar maria have sizable continuous stretches that should be negotiable by large, seemingly “floating” structures. In each mare, proposed routes will have to be surveyed carefully for obstacles and alternates. The whole idea is not to have to “fix” the route by cutting or filling or bridging.

Nearside “Seas” - Farside “Seas”



On the Nearside, since most of the large maria are interconnected in one great “Chain of Seas”, large scale cruising is a likely development. There is even one natural ready-made intermare canal, the Alpine Valley, that con-nects NE Mare Imbrium with S Mare Frigoris east of the conspicuous crater Plato.

While scenic shore-lines and other natural features will give some potential routes a big boost, in the end it will take the efforts and energies and imaginations of individuals to make it real. And that is something that can never be taken for granted.

Cruises on any of the maria along the limb (N-S East Limb: M. Humboltianum, M. Marginis, M. Smythii, M. Australe; West Limb: M. Orientale. L. Veris) where the Earth appears to rise and set in the sky monthly due to an orbital eccentricity effect known as “libration”, could be popular. During stretches when the Earth is just below the horizon, especially during local nightspan, the Milky Way will dominate the skies in a way that no human has yet experienced.

Nightspan cruising will be more popular on Farside (M. Muscoviense, M. Ingenii, Tsiolkovsky, etc.) if powerful blacklight headlights in the absence of both sunlight and earthlight does indeed show the moonscapes in a magical guise. Experiments on Earth with Apollo Moon samples in a dark room should tell us whether that is something to pursue or not.

The idea, we said, is not to have to “fix” a route by one kind of civil engineering or another. That said, there is precedent for just that on Earth where channels have been dredged, rivers dammed, canals dug or blasted, and locks installed to allow navigation where it could not otherwise have been supported. Cheating? To purists perhaps, but few practical people would give it a second thought. Pragmatic acceptance of “helpful” engineering will be accepted on the

Moon as it is here. In each case, the engineering feat will quickly fades into the background or asserts itself to provide special, even featured interest and enjoyment.

Overland cruising might even be supported along very carefully chosen highland routes through chained stretches of so-called “intercrater plains”. These favorable locations will be few and far between in the lunar highlands covering 70% of the surface. The corollary is that where they do exist in extent large enough to support such activity, this will be an economic incentive toward establishment of outposts in the area. In most cases this will be but one “plus” to be combined with other advantages outweighing any disadvantages before development will happen. Just one town at the “head” (i.e. nearest to a beaten path or inter-settlement highway) of such a proposed circuit of smooth-going terrain may be enough to get the ball rolling, cruise excursions giving rise to other stops along the route - eventually.

We do not suggest that cruise activity be an important factor in the establishment of early era secondary settlements, for one simple reason. A Cruise industry presupposes a large established population in which at least some hundreds of people may be motivated to take the same king of vacation at the same time. That won’t happen anytime soon.

Obviously, however, the way to start is small, e.g. with mare “yachts” and “schooners” that handle a few dozen to a hundred paying passengers plus crew. Indeed, mare cruising is likely to start with an upgrade of a live-aboard lunar “houseboat” of the type described in the last article. Design solutions must progress as well from smaller craft to larger ones. Of course, not everything can be scaled up or down. There are size thresholds above which things become possible for the first time and at which old tried solutions are no longer suitable. But one must never set the working threshold too high, lest one put it out of reach!

So in this article we are leapfrogging past the first decades of the frontier. But again our purpose is the same, to show that a surprising variety of activities we accept as commonplace on Earth (e.g. excursion cruises!) can be supported in some analogous way on the Moon. We want to expand the envelope of imagination and expectation which, if it were to rely only on the vision of NASA-contractor horse-blinder minimalism is pretty skimpy. It need not be.

We confine our scope to “defining” the functions of our topic - a lunar analog cruise ship resort hotel. Once again we invite the reader to provide constructive criticism as well as to suggest design architecture, engineering. mechanical, power plant and fuel options that work with the basic concept to promote its eventual salinization. To contribute your ideas, concepts, problem identifications, etc. either by email or stamp mail, see the contact information on page 7, column 2 “Reader Design Input Welcome”.

Here are some interior design considerations:

- ◇ size and passenger capacity (50-2000?)
- ◇ adequate shielding carapace over top and sides
- ◇ side holds for supplies and equipment lockers
- ◇ adequate solar flare storm shelter as parking under a standard flare shed is out of the question
- ◇ substantial mini-biosphere and life support with allowable passenger tasks and involvement
- ◇ resort hotel accommodations and features
- ◇ solar atrium - thick layers of glass composites or honeycomb of bundled fiber optics cells
- ◇ decktop observatory
- ◇ mall offerings and features
- ◇ diversions and entertainment
- ◇ crew promoted networking and socializing
- ◇ other onboard services
- ◇ full spectrum communications and libraries

◇ luxury touches
◇ carry-aboard coaches to take passengers to nearby scenic overlooks etc. over terrain the cruise-ship cannot negotiate - these can double as "lifeboats"

Here are some mechanical considerations:

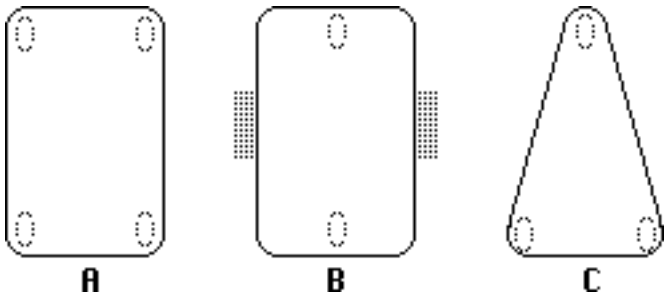
◇ oochie and nuclear power alternatives
◇ desired speed cruise 20 knots , flank 40
◇ use of "harbor tugs" for precision berthing
◇ very wide track to compensate for high center of gravity in a low gravity environment
◇ suspensions, track width, wheel radius, and clearance chosen for maximum stability, low sway ignoring small craterlets and boulders
◇ possible lowerable surface skimming observation platform for soft-suit moonscape observation in smooth terrain
◇ possible use of drag rakes to minimize wheel wakes in the dust, keeping the "sea" trackless

Here are some legal issues:

◇ Establishing cruise preserves to make as much as possible of the circuit corridor within flanking horizons (from the highest onboard perches) off limits to other surface vehicles to help preserve the trackless character of "open sea" (in concert with the drag rake feature mentioned above).
◇ Restriction of transecting corridors open to other surface vehicles in the vicinity of crossings with tunnel underpasses where possible
◇ Possible exemption from local government restrictions on gaming and gambling
◇ Traditional power of "ship" captains to conduct marriage legal ceremonies

If ever the era of low-paced living and leisurely travel "to" destinations returns, **Ships that go somewhere and take people somewhere** as once great liners took people between New York and Le Havre or Southampton across the Atlantic, land-sailing liners may someday take people "somewhere" on the Moon. We do not foresee that. For now we are talking simply of "cruises to nowhere" in which the ship itself is the destination, a vacation site at which you can't get into your car and hustle around just like you do at home during the work year. Cruising is meant to give a complete break to the pace of life. In this sense, "Love Boats" on the Moon are plausible.

A trio of sketches to prime your imagination. Feel free to start fresh and to look at other concepts.



Some Possible Chassis Plans for a Mare Cruise Ship
A Rectangular 4-wheel design B Rectangular whimsical "paddlewheel" design
C Delta 3-wheeled design

The paddle wheel design (at least the wheel placement) would allow greater maneuverability ("turning on a dime") than a conventional 4-corners wheel arrangement. If you wanted to press the paddle wheel analogy and allusion, you could design it so that it would pick up regolith that would fall off the trailing edge like water. Romance should not be pursued at the expense of practicality, however.

A three wheel design might be the most stable, especially over moderately rolling terrain ("high seas", if you will) although a conventional 4-wheeler would be fine in really flat areas. Of course, each wheel should be large enough to ignore pockmark craters, and have enough play in its independent suspension to handle those several yards (meters) wide without forcing a detour. A companion advantage of a delta design is that it would allow more passengers to have forward facing lounge seats.

We've tried our crude hand at **some ellaborative design options that seem promising.** But we'd like to see what our readers can come up with first before publishing any of these suggestions. While this brainstorming is perhaps a century ahead of its time, it is a horizon-stretching activity. More to the point, it is a mind-stretching exercise that will help in imagineering the near term lunar frontier as well.

So jot ideas down as they come to you, let them simmer, and once you sense you have the start of a "critical mass", start putting them together and see what you come up with, keeping score of problems solved, problems remaining, and problems created. Take breaks as needed, and send MMM the results when you have taken them as far as you can.

If your brainstorming stalls, you might want to look at a CCC design study for an 80 passenger Earth-Moon Hotel Cruise Ship [Moon Miners' REVIEW # 12, January 1993, pp. 2-8.---- http://www.lunar-reclamation.org/papers/transitel.htm]. While this study is for a vessel that plies space, not the lunar surface, the features included in the hotel portion are things you might want to take into account in your own design. Some of the design solutions may find a parallel in a mare cruiser, others not. But features included are a minimum:

- lobby
- grand staircase and/or atrium
- purser's office
- gift shop
- hair salon
- dinning room(s) and snack counters
- bar
- lecture rooms
- performance theater/stage
- cinema
- communications/computer room
- gym/exercise room
- library/quiet room
- chapel/meditation room
- dance floor/lounge
- hot tub/massage room
- observation areas
- three or more classes/sizes of staterooms

Some of these functions can be adequately combined in dual purpose rooms. You get the idea. MMM

MMM # 135 May 2000

1st Moon Tours - the Farside "Loop"

By Peter Kokh

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

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

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

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

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

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

The Ship

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

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

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

The Trip

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

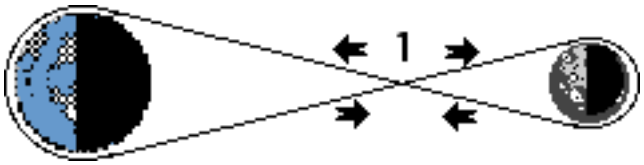
The trip -- in both directions -- would be even more complete as a "lunar" experience if some of the spartan furnishings could be designed to simulate the sort of decor that early settlers might be able to produce for themselves from local raw materials. Food choices could also add to the "on the Moon"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

On the way out, passengers could learn about lunar geology, preparing themselves to recognize and understand the features they will see up close: craters of various types and sizes,

the lava sheet seas of the maria, ridges, rille valleys, mountains. They could study the receding Earth and the approaching Moon through telescopes or with the naked eye.

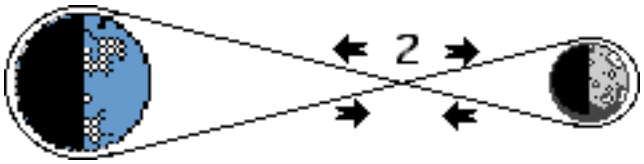
Four basic itineraries are available:

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

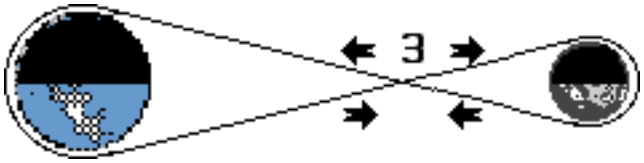


[These sketches are not to scale. In reality, the Moon is 30 "Earth diameters" distant from Earth (not 7, as shown) and Earth is proportionally larger than the Moon than shown.]

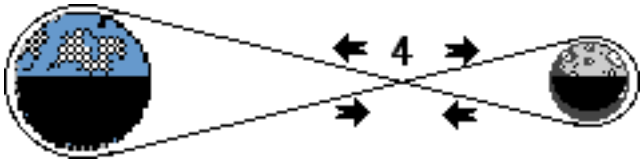
2. "New Moon" loop: the Nearside is dark except for the faint glow from Eartthshine (actually much brighter than Moon-shine) so we will see some dim and eerie Nearside moonscapes on the way there and back, especially close to the Moon. But the Farside over which we loop up close and personal, will be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



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



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



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

Looping the Moon

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

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

The Farside Club

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

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

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

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

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

On the way Home

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

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

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

An "All-In-One" Moon Resort

By Peter Kokh

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

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

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

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

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

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

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

Here's how we put it in "Seven WONDERS of the Moon" above.

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

"Libration"

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

Libration of longitude: the Moon travel's at a slightly varying rate along its elliptical orbit, traveling faster when it is closer to Earth, slower when farther. Meanwhile the Moon's own rotation about is axis continues at an unvarying pace. So alternately, as seen from Earth, the Moon seems to be turned slightly eastward, then slightly westward. In each case we can peek about 7° past the mean 90° longitude over the edge of farside. These 14°-wide strips, from 83° to 97°, both East and West, are called the limbs, or in MMM-speak, the "Peekaboos". For as we

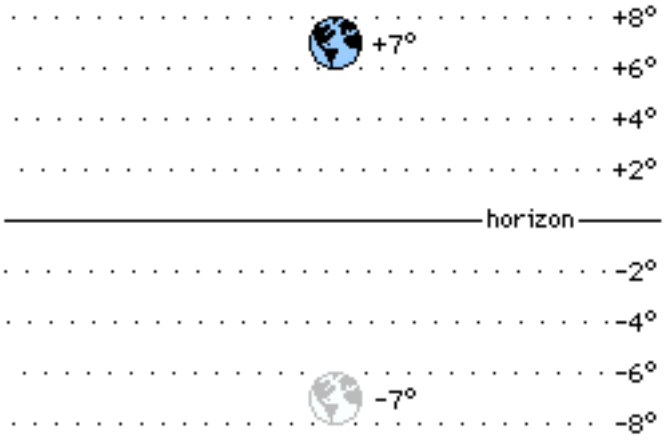
can sometimes see around the edge, to observers there the Earth is sometimes above the horizon, sometimes not.

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

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

António Cidadão has created a spectacular 133K animation illustrating libration along with oscillating distance, as seen from Earth. http://www.minervatech.u-net.com/moon/not_libr_ac.htm

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



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

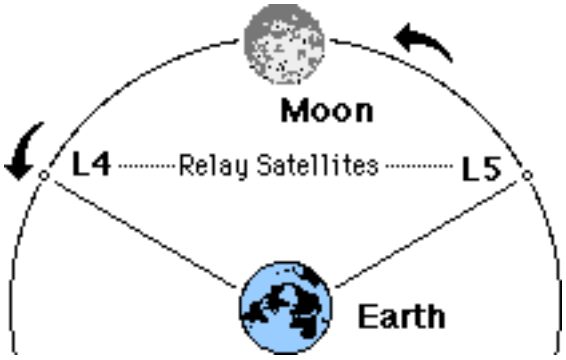
On the lunar surface, atmosphere is absent. But anywhere in the Nearside **Crooknecks** or **Postcardlands,** and part of the time in the **Peekaboos,** there is the distracting brilliance of Earthlight that must be baffled not only from view, but from reflection on one's helmet visor.

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

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

Our other constraint -- only easy excursions will be supportable, especially if the Hotel is built prior to the establishment of a full lunar outpost able to provide logistical support of any tourist operations -- helps narrow the "doable" area greatly. We will want to site our Hotel in, or at the fringe of a level, easy-traverse mare plain. This will allow deployment of line-of-

sight relay stations from the Hotel, out to at least 83°, E or W, from which Earth is always in sight.



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

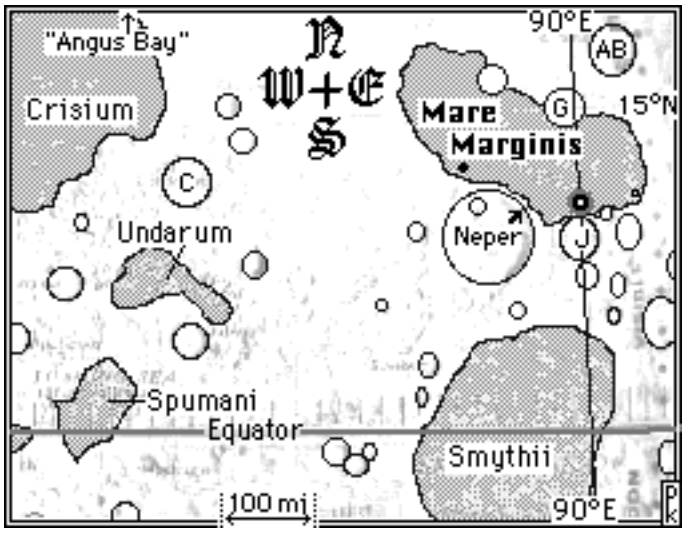
Along the western limb of Nearside, we don't find the ideal conditions. You could erect a Hotel at the extreme eastern fringe of Mare Orientalis, "Eastern Sea", the "Bullseye" in the center of the lead L4-ward face of the Moon as it travels about the Earth, or in its peripheral Lacus Veris, "True Lake".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

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

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

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

MAP OF MARGINIS, NORTHERN SMYTHII, AND EASTERN CRISIUM



Sites in Mare Marginis: * "Peekaboo Resort" * Earthlink Relay Station * Eastern vantage point * Neper Crater Lookout

LETTERED CRATERS: (C) Condorcet, (G) Goddard,
(J) Jansky, (AB) Al Buruni. ["Angus Bay" is an Artemis Society nickname for Mare Anguis, NW of Mare Crisium]

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

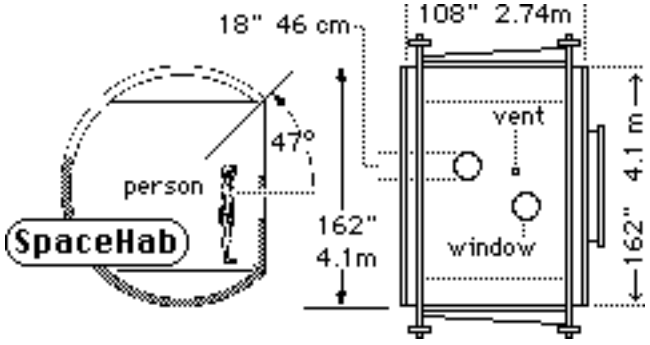
Neper, like Copernicus, has a central peak. Our suggested protocol [**Selenology**, AUG '89, pp. 18-21, "Extending the System of Lunar Nomenclature"] for naming such peaks is that if the crater bears the last name of an honored person, the central peak should bear his/her first name. In this case, Mt.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

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

Even more reassuring is that a look at this whole section of the lunar globe suggests that as the Lunar Frontier more fully develops, Mare Marginis will not find itself left out in some backwater. A "highway" from the Mare Crisium - Mare Anguis area could pass through Mare Marginis, then through the highlands between Neper and Jansky into Mare Smythii, before heading ESE in the direction of Tsiolkovsky, and Mare Ingenii, deep in farside.

What might an early Moon Hotel look like?

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

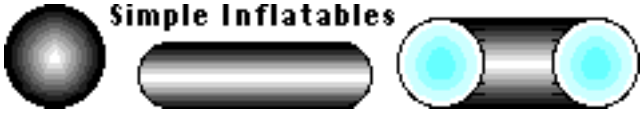


You would need at least that much to house and support a handful of hardy tourists, lead individual guided EVA "walks" in spacesuits, and take them on a few guided excursions to see the nearby "sights". The current reference mission for the Artemis Project™ Commercial Moonbase is SpaceHab module-based.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

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

Inflatables should be available offering "big dumb volume" for a spacious central commons and for a lunar "gymnasium." The ability to experiment with no-spacesuit lunar gravity in simple exercise, gymnastics, experimental sports, and even dance will make this a priority feature. Add on the capacity to make telecasts to Earth, and that will only strengthen

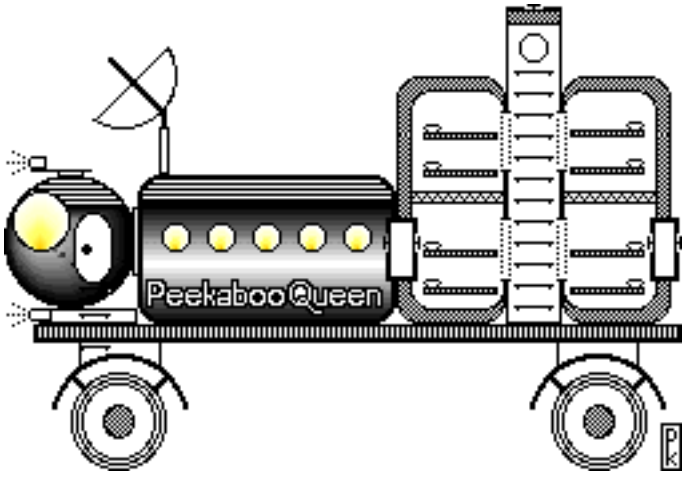
the market. A plain inflatable could be fashioned as a sphere, cylinder (upright or on a side), or as a torus (the most stable footprint).



As we listed in our ISDC 91 Paper "Lunar Hostels: An Alternate Concept for Both First Beachheads and Secondary Outposts, Part II, The Hostel's Share of the Workload" [See Above] such Big Dumb Volume is tailor-made for equipment-light, volume-hungry function spaces such as:

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

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



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

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

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

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

In time, entrepreneur homesteaders will establish an enterprise zone nearby the hotel (if not in sight of it). They will come to offer new services and goods, both to the Hotel, and to the tourists that come to stay there. This will be a first humble step toward a cluster of tourist

facilities such as we have at Estes Park, CO outside Rocky Mountain National Park; or at Gatlinburg, TN outside the Smoky Mountains National Park, or at the town of Wisconsin Dells near the river cliffs of that name.

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

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

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

An Alternate Return to the Moon Scenario:

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

MMM

MMM # 138 September 2000

Regolith Beach

A Lunar Golf Course

By Peter "Tiger" Kokh

Well, let's not talk about who calls me "Tiger" and just admit that I'm not a golfer. Yes, I've golfed, tagging along with my parents to humor them, and to do repentance for my sins - apparently.

Nonetheless, I do understand the gut-passion of golf addicts ("Some of my best friends ..."). We all have our different drums. But while I am not exactly a devotee of the game, that does not prevent the landscape architect in me from admiring the great variety of course layouts and host terrains. After all, if you don't have cable or satellite (as was my situation until recently), and are otherwise unoccupied on rainy Saturday or Sunday afternoons, there are times when you can't easily escape watching a round or two, especially when the real Tiger is playing.

This is an essay about Lunar (or Martian) Golf Course construction, with incidental remarks about appropriate adjustments of the Game itself to the reality of conditions on the new host planets.

First, forget the grass! Natural or artificial, "grass" would be quaint import absurdly out of place on any world without a native biosphere, as well as considerable and unnecessary expenditures in the name of tradition - not "the game" itself. What is essential for fairway, "green," and rough alike, is texture as it affects the ball's ability to roll, period.

The out world golf course architect needs to experiment with different sieves of tamped regolith (very coarse, medium coarse, fine, very fine) as to its affects on the bounce, roll, and direction of the ball.

1. Acquire or lease a variable sieving vibrator
2. Acquire or lease a medium size "steam" roller to compact the course and make it footprint-proof and improve the ball's "roll."
3. Build a one hole test course
4. Get an especially supple light weight space suit
5. Try your game. If the ball doesn't behave reasonably, rebuild the troublesome areas of the course ("fair"way, "smooth", "rough", or crater "traps")
6. Try it again (back to step 3)

This process may take a while. Who said it would be easy? One could perhaps get a good idea of the coarseness vs. fineness of rolled regolith mix to use by experiments on Earth with various mixes of crushed gravel, stone, and sand. That would cut down greatly on the amount of time- and money-sucking fiddling one would have to do on final location.

Color? Yes we can do green. Just mine a few million tons of Chromium Oxide and sprinkle liberally. On the other hand, one could take a "when in Rome do as the Romans do" approach and settle for a golf course palette that is much less expensive and costly to produce and maintain.

On the Moon: darker shades are available by using mare basalt regolith; medium ones by using highland regolith; very light ones, by producing calcium oxide powder (lime) from highland regolith for use as a whitening overcoat mix. All one needs is contrasting shades. Brighter ungrayed colors should be reserved for smaller objects and areas. Okay, you might splurge with chromium oxide on the "smooths" and thus preserve the sacred bovinity of the "green". Limited "rough" areas could be danger-marked with rust-hued iron oxide powder.

But you especially need to provide easy to follow and find coloration for the ball, the hole pins, and tees. We might want to abandon the traditional white color of the ball and

experiment with various fluorescent shades. Then, again, it may be easier to keep track of white balls against the graytone palette of the course and against the black sky, than one would think. We'll simply have to try the options.

On Mars: You'd probably want to use Mars' natural palette to best advantage and lowest cost, in color and shade differentiation of the various kinds of playing surface. If lime could be produced easily enough, that might be a good choice for the "greens" analog. But a limited amount of green chromium oxide would produce a pleasing effect, especially if terra cotta rusts are used for the inevitable "roughs" that guard the approaches to the "greens."

On Earth, courses in flat host terrain are themselves relatively flat. It takes a lot of "dozing" work to modify the given terrain appreciably. But we all appreciate the challenging effects of rolling terrain on golf competition, as well as to the scenic enjoyments that come as a fringe benefit. That's why we have golf courses in mountain valleys and along coast hugging bluffs. Finding just the right terrain for a beautiful and challenging course will be part of the golf course architect's job. Scenic enjoyment is important for the players, and for the audience, especially those of us who don't quite get the sense of hitting a ball and chasing after it to hit it again.

The lower gravities of the Moon (16%) and Mars (38%) along with the absence of appreciable wind resistance (vacuum, tenuous atmosphere) will mean adjustments to the equipment itself. The size and mass of the ball and the distribution of its momentum must be codetermined with the design and mass of the clubs if we want to keep hitting distances in check My guess is that lighter clubs and/or larger balls will be needed. Computer simulations may point the way to best design mix.

Shoes must give traction without tearing up the fairways. Rover tires may need very broad and relatively smooth treads. Golfers may need to carry along rakes and tampers to repair damage. But not to worry! Given the passion, we'll find a way.

MMM

MMM # 161 December 2000

Tourist Clusters on the Moon

By Peter Kokh

Foreword

In MMM #136, JUNE 2000, pages 5-8, we wrote about an "All-in-one Moon Resort." This article described the general advantages of various locations on the Moon from the viewpoint of visibility of Earth above the horizon, concluding that locations on the limb, where due to libration effects, Earth was sometimes just above and sometimes just below the horizon offered the "best of both worlds," that is, the advantages of Nearside locations along with the advantages of a Farside one.

The article also traced a surprising scenario, which is becoming more and more plausible as time goes on: tourism, not industrial development of lunar resources, may pace the opening of the Moon. What follows is a fresh, shorter, look at how tourist facilities are likely to multiply on the Moon.

The Dawn of Lunar Tourism

We are, alas, still a long way from returning human pioneers to the surface of the Moon. There are no NASA plans to do so – all such previous studies gathering dust on the shelves per instructions from Congress – and amorphous plans of China, India, and Japan to put people on the Moon cannot yet be taken seriously, none of these nations having yet put an astronaut in orbit. The Artemis Project would set up a first commercial Moonbase, and indeed, this seems a more plausible eventuality than Congress reversing course and ordering NASA to shake a leg.

Everyone waits for someone else to put precursor pieces of the terracing puzzle in place, however, and so we do not seem to be making any real progress. That none of the would be movers and shakers has a critical amount of seed money is the harsh reality, of course.

We have all been quick to herald the opening of the Space Tourist age with the ISS visits of Dennis Tito and Mark Shuttleworth, the first "kids on the block" to come up with icebreaking money. Efforts to get additional camera-toting commoners into space through "creative financing" have so far not succeeded. That's to be expected. The more we rely on multiparty financing, the more failure points we introduce into the plan.

Yet interest of "ordinary people" in space tourism remains quite high. Once someone succeeds in bringing down the ticket price by a factor of ten, then a hundred, the flood-gates will first crack, then shatter. Regular traffic will lead to dedicated, if spartan, orbital tourist quarters. As prices continue to come down, and the number of ticket purchasers grows, whole new orbital tourist centers will be developed, unconnected to ISS.

Once we have a dedicated tourist shuttle, it simply requires refueling and reprovisioning that craft to send it and its passengers on a no-land loop-the-Moon up-front-and personal venture following the default path taken by the limping Apollo 13 craft. Indeed, as we have pointed out previously, tourists could skim over the Moon's farside before the next humans return to the Moon's surface. It is a simple fact that landing on the Moon, and then returning, requires additional hardware and fuel. See "Lunar Overflight Tours" – pp. 22-26 above.]

But where do we go from here? In the MMM #136 article cited above, we suggested that a dedicated surface "hotel" complex might be developed in Mare Marginis (or some other "limb" location.) But the actual step by step development of lunar surface tourism may start quite humbly, without any surface facilities at all. The first tourist lander craft will serve as a self-contained hotel, exactly as the Apollo Lunar Excursion Modules not only brought astronauts to the surface, and then returned them safely to lunar orbit rendezvous, but served as their "camp" while on the surface. Such a craft could set down just about anywhere on the Moon's surface, perhaps visiting a different location on each trip. This "butterfly" strategy would encourage repeat visits by some of the well-heeled early Moon tourists. And as anyone in business knows, the repeat customer is a principal mainstay of success.

First Dedicated Tourist Surface Facilities

From this point in time, it seems obvious that the first permanent habitat on the Moon will be a module (with auxiliary equipment) manufactured on Earth and transported to the Moon's surface. There is simply no other way to get started. We cannot rule out the possibility that once the facility is field-tested, debugged, run through a full lunar dayspan-nightspan cycle and judged "operational" by advance crews, its intended design use will be for tourists. After all, we do need to make the first outpost earn money, and tourism is certainly a promising source for a steady revenue stream.

However, this approach would seem to be a dead end one. Bringing pre-manufactured ready-to-deploy-and-use habitat space from Earth is forbiddingly expensive. There will be no way to get beyond the "rugged campsite stage" without first developing the capacity to produce lunar building materials, and modules, from processed local moondust – regolith. So while hosting occasional tourist visitors will be an important way to raise capital for testbed lunar industrial experiments, the principal and regular occupants of a first outpost will need to be those pioneering the early industrialization route. Only when we are ready to begin manufacturing, and assembling, and outfitting expansion habitat and function space from modules manufactured on site, can surface tourism grow.

Scattered Tourist Sites vs. Tourist Clusters

Here on Earth, there is a seemingly inexhaustible number and variety of tourist destinations, facilities, and activities from which to choose. In fact, this has been the case since at least the middle ages, but has never been so manifold and so accessible to the general traveling public as today. Yet while we can fly here today, there tomorrow, on a butterfly itinerary that samples many locations, a mainstay of surface tourism, especially for the driving public, has been the tourist cluster: one general destination that offers a great variety of facilities and activities.

The tourist cluster comes in many sizes. There are the mega-clusters of Orlando and Las Vegas, of course. But we are thinking of the many smaller clusters around the country whose development preceded these modern day wonders. Inspired by my own experience, four "gateway" clusters come to mind.

- **Wisconsin Dells, WI** - gateway to the scenic Dells of the Wisconsin River
- **Estes Park, CO** - gateway to Rocky Mountain National Park
- **Gatlinburg, TN** - gateway to the Smoky Mountains National Park
- **Cave City, KY** - gateway to Mammoth Cave National Park
- And there are many more similar clusters

1st Outpost - 1st Tourist Surface Itinerary Synergy

Now on the Moon, we will, in time, have clusters of tourist facilities and for-profit attractions (frequently disparaged as "tourist traps") at gateways to some of the Moon's more outstanding scenic attractions: the crater Copernicus, approaches to the Alpine Valley, for examples.

But it seems certain that the very first lunar tourist cluster will grow up in close proximity to the first lunar commercial-industrial outpost as it gradually develops into a true settlement.

Tourism requires support facilities and support services and people "on location" to man them. However, it will be a while before the tourist stream becomes a steady one and requires the "day job" attention of support cadre on location. In the beginning, tourists will arrive in small groups at infrequent intervals. Tour group leaders familiar with the outpost and the lay of the surroundings can themselves provide much of the support.

They will have the Outpost to visit, and make the tour of surrounding support facilities: solar arrays, fuel tank farms, construction sites, road-building sites, regolith harvesting and mining sites, processing facilities. And, of course, the local scenic high points.

As the stream of visitors grows in both numbers and frequency, one can imagine a definite symbiosis emerging between the tour operators and the Outpost and its staff. For example, an additional pressurized motor coach/crew transport could be paid for on a time-share basis by both the Tour Operator and the Outpost Agency and bring real benefits to both. New roads serving new scenic attractions as well as new mining or processing sites could be built. Tour Operator need for automated self-help rest stops would seem to be a made-in-heaven match for the Outpost's needs for a network of service garages/ emergency flare shelters. In short, we can expect a real, if partial, synergy between the driving needs of Tour Operators and the driving needs of an Outpost aggressively expanding in both size, staff, and diversity of activities.

That there will be some friction and disagreements will not discourage such a partnership. Only an Outpost that aggressively seeks to expand along for-profit vectors has any real chance of morphing into a real settlement. And we all know from experience here on Earth how important an economic driver tourism can become.

Location, Location, Location

It could happen that the first outpost-settlement-to- be will be quite close to a major scenic attraction. But it is more likely that scenic advantages will be an important but secondary consideration in site selection. Yes, to support a variety of marketable services, we will want a

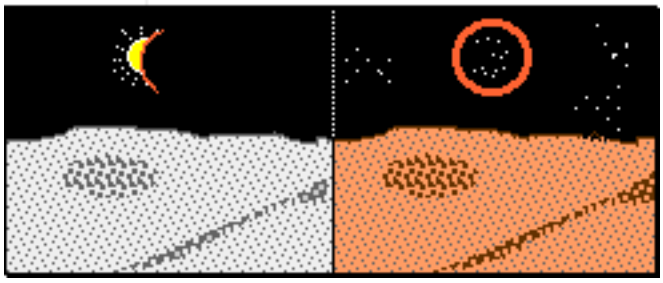
photogenic site, one with interesting moonscapes, and one from which Earth hangs in the sky not uncomfortably far above the horizon (in “The Postcardlands.”It is also likely that the outpost planners and site-pickers will have the foresight to realize that a mare-highland “coastal” site will offer the best strategic advantages for industrialization: access to both mare and highland suites of lunar regolith resources. And such a site will be much more interesting from a tourist point of view: vistas of great plains along with a setting of nearby mare basin rampart mountains.

Two such site proposals are Greg Bennett’s “Angus Bay” (commonly known as Mare Anguis, Sea of Serpents, an irregular winding mare-filled bay off the NE “coast” of Mare Crisium) and our own “North Junction” proposal for an outpost along the north coast of Mare Frigoris at the overland gateway to the north polar ice fields. Both offer comfortable Earth viewing and a mix of plains, mountain ramparts and craters.

In time, as diversification of the economy leads to the spread of human presence to many distant locations on the Moon, more scenic attractions will become accessible. A first “service station / flare shed / inn could lead to a cluster of tourist facilities of which providing access to the flagship scenic attraction in the area will be only the first.

In clusters, whether of tourist facilities, fast food restaurants, or automobile dealers, everybody benefits from increased traffic. The cluster provides something for everybody within a relatively small area, so more time can be spent on enjoyable activities, less on traveling from one to the other. Industrial diversification keyed to special ore concentrations may lead, but tourism will help build the future map of the humanized Moon. **MMM**

MMM # 164 April 2003



Eclipses: the Lunar Experience

ECLIPSES: THE LUNAR EXPERIENCE
By Peter Kokh

Every now and then, Earth-facing moonscapes take on the hues of a dimly lit Mars. But there will be no mistaking where you are. In the sky in place of Earth will be a black hole outlined with a ring of orange tones with only one ten-thousandth the brilliance of sunlight. And in that black hole, clusters of lights, Earth’s cities and fires, dotting otherwise dark continents. It **is Umbra.**

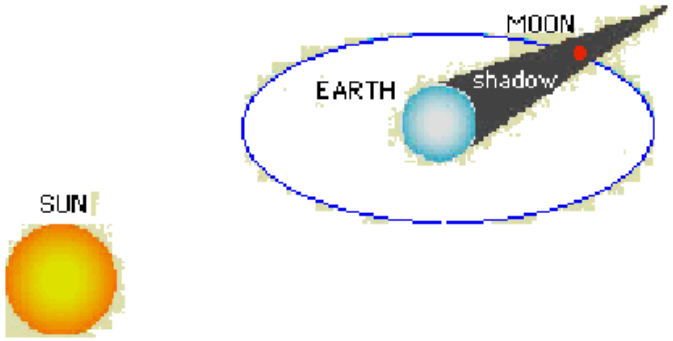
Thursday, May 15th, 2003, there will be a total eclipse of the Moon, visible from all of the Continental United States and Hawaii, and from most of the rest of the world except Asia

and Australia. For information about this event, go to: http://www.netspeed.com.au/minnah/2003/2003-1.html

For an Eclipse Computer that will tell you when (and where in the sky) the eclipse is viewable in your area, go to: http://aa.usno.navy.mil/data/docs/LunarEclipse.htm

Most everyone has seen a total lunar eclipse at one time or another. They aren't all that rare. But no one has ever experienced such an event from the Moon's surface. What would the experience be like? What would we see in the lunar heavens? How would it transform the appearance of the surrounding moonscape?

For observers on the Moon, what we Earth-dwellers experience as an eclipse of the Moon, will for them, be an eclipse of the Sun, our home star disappearing behind the Earth. So the phenomenon that they would/will experience will bear closer comparison to the one that those fortunate enough to have seen a total solar eclipse on Earth have felt.



Shown: Moon passing thru Shadow Cone (Umbra)

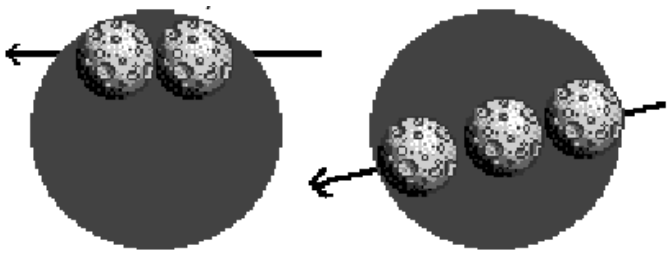
Let's try to visualize and feel the sight and impressions that future Lunan pioneers can anticipate.

Comparisons

Those of you fortunate enough to have witnessed totality in a total solar eclipse (anything even a tad short of totality counts as zilch – yes, there is that much difference) were probably as little prepared for the overwhelming effect of the experience on oneself as I was, when I saw my first from Minot, North Dakota in February 1978. The sky darkens gradually, suddenly going black, as the Sun disappears and the stars come out, in what should be bright daylight. Where the Sun had been there appears in its place a very black hole in the sky surrounded by a ring of flames, the corona. Meanwhile the air temperature drops some tens of degrees, and an eerie silence falls. For many first time witnesses, the experience is so unexpectedly transfixing that the goal of seeing yet another total eclipse suddenly soars out of nowhere to somewhere near the top of one's personal life agenda. For me, that quest next led to Bratsk, Siberia in late August, 1981.

Much of the magic of this experience arises out of an unlikely coincidence. The size and distance of the Moon makes its apparent size vary from just smaller to just a bit larger than the apparent size of the Sun. Total solar eclipses occur in the latter case. Because of the close approximation in apparent size, totality is brief, commonly two minutes give or take, with a maximum of seven.

But from the Moon, Earth's apparent diameter is some three and a half times as great as that of the Sun. When the Sun disappears behind the edge of the Earth, it will take quite a bit longer before it peeks out from the other side. Totality on the Moon can last some three hours.



Moon just inside Umbra through center of Umbra

For us on Earth, during totality, the Sun's flaming corona can be seen surrounding the black hole in the sky that is the Earth. From the Moon, the Sun's corona will also be eclipsed for most of totality. However, the black Earth will sprout its own "coronalet" as sunlight beaming down upon the hemisphere of Earth turned away from the Moon, lights up the dust in the atmosphere. This light is refracted into the shadow cone. Portions of the Moon passing closer to the edge of the Umbra will be brighter, those closest to the mid-umbra darker. Clouds and volcanic dust in Earth's atmosphere will also have an effect so the actual appearance, brightness, colors and color variation will change throughout the event and differ from eclipse to eclipse.

Watchers on the Moon will see an unbroken ring of sunsets and sunrises, much less brilliant than the Sun's corona, but also much larger in diameter, and an awesome sight. Stars hidden by the Sun's glare will reappear in the sky. The glow from this 'coronalet' will repaint the Moon's surface in very unmoonlike hues. For the pioneers, it will be a magical time in which they might imagine themselves transported to deep twilight on Mars! The direction and length of shadows will not change from what they would be if the Earth were not blocking the Sun. But the edges of shadows will be much fuzzier, contrasts less sharp. Familiar moonscapes will reveal themselves in this whole new light.

For crews, tourists, and settlers on the Moon's nearside, it will be an unforgettable experience. While for them, this will be a "solar" eclipse, the real show will be on the Moon's surface, with the show in the sky just completing the "Landscape." That's in contrast to the experience of solar eclipses on Earth where the main event is in the sky. For a treatment of the coloration and brightness-darkness of the Moon during Umbra, see "Danjon Scale:" http://sunearth.gsfc.nasa.gov/eclipse/OH/Danjon.html

Timing and Frequency

How often do these events occur? The Moon's orbit around Earth is tipped some 5 ° to Earth's orbit around the Sun, so the Moon spends most of the time either above or below the plane of Earth's orbit and does not pass through Earth's shadow every orbit. There can be as many as three eclipses a year, as few as zero. Only a third are total. While one seldom sees either lunar or solar eclipses noted on calendars - (just the phases of the Moon) "umbra" dates are likely to be noted on Lunan calendars. Where on the Moon Eclipses will be visible

The Umbra Experience is only visible on the Earthfacing side of the Moon. That means that the Sky Show of black Earth outlined by the ruddy sunrise-sunset ring of dust-refracted sunlight will be high overhead in the central areas of nearside (the "crooknecks") and at more comfortable elevations above the horizon nearer the limbs (in the "postcardlands"). Some events may be visible in the limb regions, others not, depending on the angle of libration (variance from facing Earth dead-on) at the time.

Both the proposed Angus Bay and North Junction sites will offer comfortable viewing, with Earth some 20- 30° above the horizons, with shadows of mid-range length. In contrast, at a site near the center of nearside, not only would the sky show be directly overhead (zenith), but there would be no shadows, it being a high "un-noon" situation. Tourists coming from Earth to experience the umbra will head to areas closer to, or in the limb region. Umbra will

occur early in dayspan for areas east of the Earth-facing meridian, at mid-dayspan along that meridian, and later in dayspan for areas to the west. Impact on frontier culture

The Moon is a world of gray shades, overwhelmingly so. Indeed, Lunans will be challenged to infuse their homes and settlement areas with color to make up for the sensory deprivation that greets them out on the surface. To be able to view familiar out-vac surroundings through the filter of sunlight refracted through Earth's dusty sunrises and sunsets will bring periodic relief and delight. Umbra will also provide the best viewing of the many clusters of city lights on Earth's nightside, framed in the sunrise-sunset ring.

The hours-long event will be occasion enough to let kids out of school, even workers. Umbra could even become a holiday of sorts. For these pioneers, who will have given up much that we take for granted, who can begrudge them this periodic pleasure. Add to that, that each Umbra will be different, and the same event will be experienced differently in various places on the Moon. **MMM**

Postscript: Umbra-clad moonscapes

Where one is on the Moon will make quite a difference. The relative brightness of the brighter highlands and darker maria (lava plains or "seas") will be much the same. The reddish umbra light may make some areas stand out. Shadows will be in reduced contrast with the umbra-lit areas and have softened edges (owing to the greater diameter of Earth's sunrise-sunset ring than the angular size of the sun's disk), but in the same direction.

During a short totality, portions of the Moon nearest the edge of the umbra shadow remain relatively bright, where as portions deeper within the umbra are considerably darker. For pioneers, the brightness or darkness of the eclipse "twilight" and of surrounding moonscapes will depend on one's position on nearside relative to the umbra center.

Popular vantage points - The spectacle will be more comfortably viewed the further one is from the center of nearside (the closer to the horizon Earth sits in the lunar "sky.") Vantage points that include both mare and highland terrain in the foreground will be more interesting. "Experts" and Umbra devotees may seek out special vantage points. Visiting Tourists - People will come to the Moon from Earth, even from Mars, to experience the brief spectacle.

Because of demand, prices for Lunar Eclipse Excursions flights to the Moon, or even just to loop around during the event, may be higher than other flights. An eclipse experience would highlight a visit The Spectacle of Earth's city lights. I think that the Nearside Umbra experience (by far the best to view Earth's city lights) should be added to the list, expanding it to eight, or supplanting the Straight Wall. The others: (Nearside) Copernicus (or other major crater), Alpine Valley, Lavatubes; (Farside) Tsiolkovsky, and the heavenly splendor of the Milky Way.

MMM

MMM # 172 February 2004

Lavatube Blacklight Fantasy Excursions

By Peter Kokh

In the previous article, we spoke of blacklight-lit fantasy out-vac surface gardens on the Moon's Farside where truly dark nightspan conditions exist. Yet despite the glaring presence of the Earth in the Nearside night-span skies, there is opportunity galore for this kind of fantasy lit fantasy gardening on Nearside as well, within lavatubes open for public excursions and

tours. It is not impossible that without the addition of anything artificial or human-altered, just with blacklight, lavatube surfaces may include spots and streaks that shine brilliantly in blacklight. We won't know that until we go there.

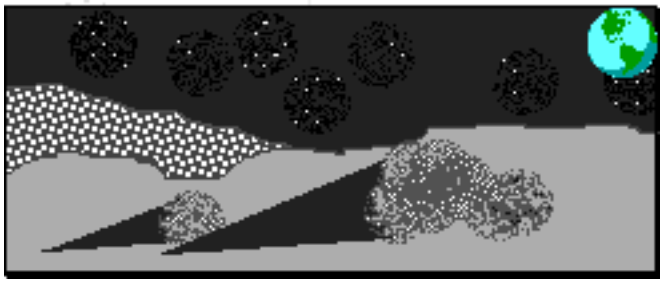
We can test if that is the case in terrestrial lava tubes. Our friends in Oregon L5 who have spent so many hours in a pair of lavatubes outside Bend, Oregon may have already thought of this and tried it. In the summer of 1992, with Oregon Moonbase team members Bryce Walden and Cheryl York as my hosts and guides, I had the chance to explore these tubes, much to my delight and fascination. I was amazed by the diversity of texture in the walls and ceilings of the tubes. This was testimony to the varying temperatures and viscosities of the flowing hot lava that formed them thousands of years ago. It had not occurred to me to bring along a black-light flashlight.

Preparing preexplored Lavatubes for Blacklight Excursions If the surfaces of lunar lavatubes prove to be sensitive to blacklight, a host of practical questions remain before installation of a blacklight system can become a technically and financially feasible project. The tubes are vast in size and a lot of power, lamps, and wiring would be needed. For "dayspan-only" tours, power could come from solar collectors on the surface. This site could operated by a commercial concession in a prime tourist traffic area.

We are talking about an era well into the future when there will be a substantial resident population and industrial infrastructure in place and when tourist excursions from Earth are popular and affordable. But even if none of us live to see that day, the possibilities can excite us and motivate us.

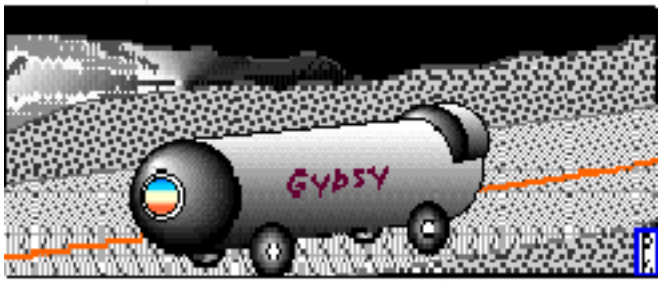
The blacklit lavatube could include fantasy forests and sculptures, all glowingly and beautifully revealed by blacklight. There are no limits, and like many tourist facilities, the manmade features of this site would likely grow as profits from tourists were plowed back into the investment. Why not an Earthside enterprise analog? **MMM**

Some of the Many things tourist from Earth will want to see and experience



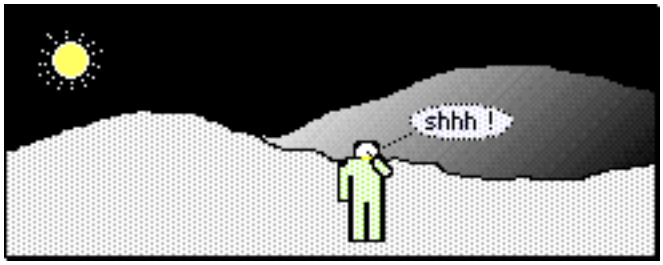
Nightspan Life — Out on the Surface!

"It was the nights before sunrise, and all through the town, moon folk kept cozy and busy deep down. But out on the surface, not a creature was stirring, not even a miner." Not! During nightspan, some Lunans will venture out there for work, others for play and recreation.



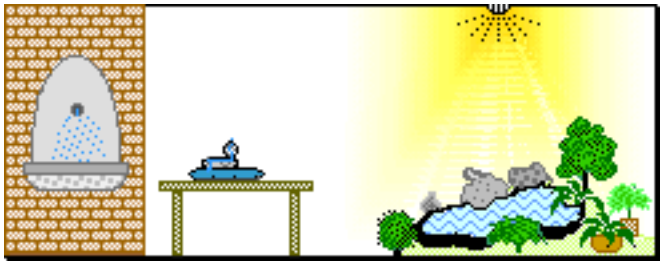
RV Campgrounds & Marinas on the Moon?

Why not? While the bulk of lunar pioneers may live in the settlements, there will surely be room, if not a need, for people who are mobile. Some will enjoy the mobile lifestyle, but yet be attached to their homes.



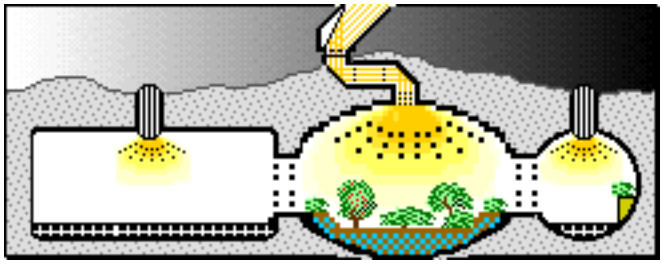
The Deep Silence of the Moon, and Humans

The Moon is now a very quiet place. How will that affect humans over the long haul? How will human sounds and noises play on the Moon?



Water Features Calm Pioneer Homesteads

Whether they are hung on a wall, placed on a table, or worked into interior garden spaces, water features such as fountains, waterfalls, and ponds could bring soothing sounds, visual interest, and opportunities for color to spartan pioneer habitats. More, they will be evidence of the "hydrosphere" that underlies every biosphere, on the Moon, just as on Earth.



The Heart of a Lunar Home: An "Earthpatch"

On Earth, if there is a feature that is considered the "heart of the home" it is the "hearth." Real fireplaces are a highly unlikely feature for Lunar homesteads. But pioneer homes will have a "heart" nonetheless, the interior Garden, a veritable "Patch of Old Earth." The "Earthpatch" will be important for much more than strong morale! It will be full of greenery, color, and fresh fruit and vegetables. Maybe even songbirds.

MMM # 175 – May 2004

Creating "Nature Walks" on the Moon

By Peter Kokh

Perhaps most of us have been somewhere in the countryside, mountains, forest, desert, shoreline, and havve noticed a sign “Nature Trail” and decided to talk the plunge. Chances are we will have enjoyed it, and if we took the time to read all the signs attempting to inform us about what we were looking at, emerged with a bit deeper insight into nature’s wonders and mysteries.

Some Nature Trails may point out a few geological features such as rock outcrops, waterfalls, and so on. But by and large, most of our Nature Trail educational tidbits are about flora (plants) and fauna (animals.) We tend to take the host geological setting for granted. And precisely because there seems to be a so much greater wealth of detail to wonder about and to delight in when it comes to plants and animals, the subtle differences in texture and color of rock and soil are at best, enjoyed as is, with no felt need to learn names, classifications, or significances. We simply take the inanimate context for granted.

I think on the Moon it will be different. Yes, we will have flora and fauna nature trails, but inside human-created mini-biospheres. Out-vac, on the barren lifeless surface, Nature Trails through the “magnificent desolation” will have only geological items to highlight and educate us about.

We do have a primeval need to identify salient things and details in our environment. It is the Adamic urge to “name” things. In the absence of visually distinctive plants and flowers and birds and other creatures to identify and “tag” with a name, I think our attention will automatically shift to subtle differences in the inanimate setting that we would not have paid attention to if plants and animals were present. Nature abhors a vacuum, goes the old saying, and so does the mind. The way this rock is shaped and textured and colored differently from that one will take on new significance and importance, in the absence of other things upon which to focus.

An Analog Moon Nature Trail Experience

This was all brought home to me most vividly in the summer of 1992, when, as the guest of Bryce Walden and Cheryl York of the Oregon L5 Society, I had a walk (and at one point, crawl) through tour of the pair of lavatubes that, at that time, constituted the “Oregon Moonbase” just outside Bend, Oregon. Being rather familiar with limestone caves full of interesting stalactites and stalagmites and other water-flow and drip-created features, I had expected a tube created by flowing lava to be rather uniformly devoid of interest. But I was amazed to see how the texture of the lava-flow-formed walls varied from place to place. I counted at least eight distinctive surface types. I felt the need to be able to identify this texture from that one and to understand what caused the differences. These details are things I may perhaps have noted, but paid no more attention to in a setting with plants and/or animals in the foreground to hog my attention. And there we have it. Geology for most of us remains in the background, because the living foreground pops out and monopolizes our awareness. Absent life, geology is the foreground and zooms into focus.

On the Moon

When we look at Apollo Moon mission footage, we notice differences, but perhaps do not dwell on them. The scene seems desolate at monotonous. Hello! There are no plants and animals - things we are used to seeing most everywhere on Earth. But for the Lunan pioneer, once the ingrained expectation of living entities no longer fogs our interpretation of what we see before us, I think we will start noticing this and that about the moonscapes - the subtle yet somehow interesting differences between this view and that, between this location and that. In theabsence of other things to “recognize” by name, we will want to know the name of this feature or that, and in the absence of that information, start creating names from scratch.

A lunar settlement will soon create nature trails through areas in which there are a variety of features that are noticeable, and about which the history of their formation, the mineralogical, and potential economic importance will be of interest (again, lacking anything else - read: living - to focus upon).

With the best of attitudes towards the Moon, most of us, given the chance to take a coach tour on the Moon, will become a bit bored after a few hours or miles. We don't appreciate the distinctions in what we are seeing. Consider these parallels on Earth. In the absence of the cultivated ability to see and appreciate differences, "when you've seen one waterfall, mountain, or city you've seen them all." Boredom is not without guilt. It comes from failure to cultivate an appreciation of distinctions and differences.

In the near and not to distant future

Nature trail education will help Lunan pioneers and visitors to enjoy what they see more thoroughly. But why wait? In the very near future, any of us will be able to go to the nearest IMAX theater and enjoy as never before possible, in wraparound attention-captivating detail, the moonscapes actually photographed by the Apollo astronauts, thanks to Tom Hanks and his crew and Lockheed-Martin. Look for "Magnificent Desolation" to open soon, and go see it again and again. See MMM #174, APR '4, p. 12

And why not fly a photographic lander-rover to an interesting spot on the Moon, do a lot of videotaping, and have Moon geology experts edit the footage for the more interesting and significant items, and with the help of science popularizers, create a DVD or IMAX Nature Tour of this or that moonscape we can all enjoy while stuck here on Earth. In the process we will be learning to appreciate the subtleties, and find the Moon a much more interesting and intriguing place. <MMM>

MMM #204 - April 2007

Lunar Zen Gardens Inside & Outside
The Blending of Interior and Exterior Spaces

By Peter Kokh

In last month's Mars-theme issue, we discussed how Martian pioneers could blend indoor and outdoor spaces. These pioneers will be working with a different color palette, and eventually, with something more than sand and rock: plants, once Mars-hardy plants begin to take root out in the open under a steadily thickening and warming atmosphere.

On the Moon, we have just regolith (sand analog) and rock to work with. Fortunately, these two elements have been media enough for artists in many cultures from the Stone Age through the present. Stonehenge comes to mind, but that, and many similar pre-Celtic creations are evidently something more than artful arrangements.

When it comes to sand, be it desert or beach sand, people (and children) have been drawing patterns and pictures in them with a stick from time immemorial.
http://hebert.kitp.ucsb.edu/sand/tradition.html

But the most refined art form combining sand and rock is arguably the classic, serene Zen Garden, in which an odd number of different shaped stones or rocks are placed in a "sea" of sand, complete with raked "ripples." This is an art form that begs to be translated with lunar elements found everywhere: moondust and boulders.

We can do this out on the surface, but also indoors: **Below** are designs perfect for a lunar home foyer.

Zen Gardens in Lunar Homes


Small **tabletop** Zen Gardens can be put in dens, bedrooms, anywhere people will enjoy having them.

A strange but fitting companion for a small Zen Garden might be a **Bonsai tree** planter, representing the forests left behind on Earth.

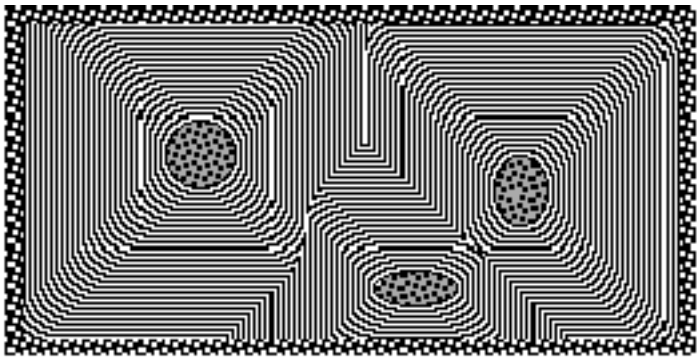
If there is a Zen garden just inside the airlock, there could be another just outside, especially if it is visible, along with persons coming and going, through a periscopic picture window. The garden outside, though constructed of thoroughly natural elements, puts a friendly, welcoming human touch on what otherwise may seem an alien and hostile landscape.

Inside, the Zen Garden will look the same only with very careful preparation. The moondust must first be purged of the troublesome fine powder component, the last thing we want to bring inside our living spaces. Then, using a magnet, one must purge as much of the iron fine component as possible. Why? Because the moondust has never been exposed to humidity before, and will begin to take on a rusty color instead of its characteristic gray tones. The effect would look somewhat Martian. An option would be to use controlled gradual purging of the regolith so that nearest the outside (nearest the airlock) gray tones would predominate, gradually shifting towards rusty shades at the end furthest from the airlock. This could symbolize an assimilation of the lunar environment.

Of course, there is no reason to limit placement of small indoor Zen gardens to the airlock antechamber. They might be even more appreciated in the foyer of a lunar homestead at the entrance to the home from a pressurized settlement street or passageway. Far more visitors will enter lunar homes from other pressurized areas than directly from the out-vac, the airless surface. As such it will be a statement that this is the home of Lunans, people at home on the Moon, welcoming others who have also made that passage.

Zen Gardens out on the Lunar Surface

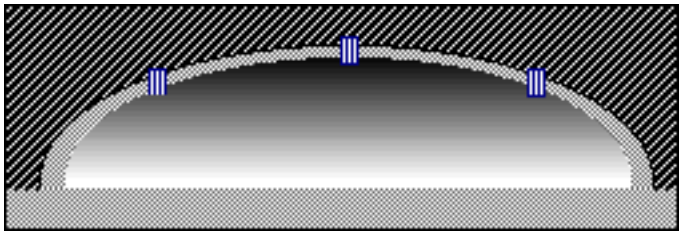
There is no reason to restrict Zen Gardens to the airlock entrance areas. On the other hand, as they take some labor in a space suit to create and arrange properly even if all the elements are handy to the location, we are unlikely to see the median strips in lunar versions of our divided highways in the form of a continuous Zen Garden!



We might see them as periodic trail markers, at road junctions, scenic waysides and rest stops. Wherever we create them, they will remind all who pass and enjoy them that we are Lunans, people who have come to live with the Moon in harmony. Zen Gardens, whether

indoors or out on the surface, will be a respectful way of saying that we will make the Moon a human world, even as it reshapes us as Lunans into its own people. <**MMM**>

MMM #207 - August 2007



↑ Unpressurized Out-Vac Sports Arena ↑

Sporting Activities in airless vacuum on a moondust surface in 1/6th gravity in a thermally mild, radiation-free environment

By Peter Kokh

In the illustration above, a shielded dome (of any architecturally practical shape capable of supporting a couple of meters~yards of sheltering moondust (as much of a load as a foot of equivalent material in Earth gravity). The dome-vault-shed could be of any size. The first one might be small, for demonstration purposes, but eventually "stadium-sized" out-vac areas could be erected for team sports.

Advantages of this environment:

- Does not need to be filled with air (that much nitrogen as a buffer gas would be expensive)
- Allows sports in vacuum, on the moondust surface, giving the authentic feel of the lunar surface, but without exposure to cosmic rays, intense ultraviolet, and micrometeorites
- Isolated from the dayspan/nightspan cycle and is thus thermally mild or benign. Expected playing surface temperature, and temperature of the dome ceiling would be the same as two meters~yards under the lunar surface, c. -4° F = -20° C (an environment cooler than the players)

We've seen photos and video of the Apollo astronauts, encumbered as they were by very heavy life-support packs, and very cumbersome space suits, hop and romp on the lunar surface. We wonder how high and how far we could jump, without all that excess weight.

In this more benign "lee vacuum" environment, we might have a chance to find out. Not only are the dangers of radiation, ultraviolet, micrometeorites, intense sunlight all avoided, but by raking the moondust floor free of rocks down half a foot (15 cm) we remove risk of suit and/or visor puncture. In the process, we could also remove most of the troublesome powder component if we wished.

Lighter Sports-suits

We have previously recommended shielded but unpressurized sheds for warehousing items needing to be regularly accessed or serviced as this would allow the wearing of lighter pressure suits allowing greater agility, for less tiring prolonged work activities. Let's take this up a notch. For sports activities we could wear what is called a counterpressure "skinsuit" much like a modern diving suit. It would be lighter and far less constricting of arm, leg, and torso movements.

Supported activities

Larger shielded but un-pressurized arenas would be ideal if we were to develop exciting lunar surface team spectator sports, as we will, in time. Volley Ball, anyone? But we can also imagine a whole lineup of lunar surface track & field events from sprints, relays, hurdles, pole

vaults, javelin throws, to long jumps -- you name it. Gymnastics too! We could have trapeze setups and trampolines to see how high we can really bounce! And why not circus type acrobatics on the flying trapeze!

The first of many

Such a facility could be created by one major settlement,for team sports. But as the rules of the various games matured as we became more experienced with what we can do inside such an environment, and as other settlements grew in size, it would be sure to be copied, and become a truly lunar and tourist experience. When unused, this could be the testing ground for new moonboots, moon bikes, etc.

A must-see, must-do tourist experience

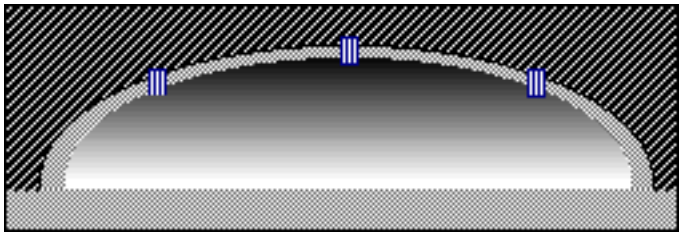
Supported activities would quickly become a signature part of lunan culture. Glass-walled pressurized areas along the perimeter would house ticketed spectators and VIPs. Tourists would want to get in on the act, using the facility when teams were not. A chance to get the full experience of lunar gravity on a somewhat natural lunar surface would rank high on the list of draws. **MMM**

MMM #225 - May 2009

By Peter Kokh kokhmmm@aol.com

In his latest book, "**How to Live on Mars**" Robert Zubrin comes to the topic of skinsuits, that hug the body, allowing much greater freedom of movement, and with much less fatigue. That's the good part!

While skinsuits will most likely be inferior when it comes to handling radiation and thermal extremes, these dangers are excluded in sheltered or shielded "lee" vacuum situations within lava tubes and in unpressurized warehouses and sports arenas (illustration below) that are sheltered from the cosmic weather. It is in these environments that we are to see widespread skinsuit use. Such suits are lightweight in comparison and allow much greater freedom of movement. More comfortable to wear, they will allow people to work and recreate for longer periods without becoming tired or exhausted.



See www.moonsociety.org/images/changing/lee-vac_arena.gif

Skinsuits are revealing

But we gain this comfort and ease at the price of embarrassment. Because a skinsuit is formfitting, it will showcase all the varied imperfections of one's own body shape. Potbellies, wide hips, flat breasts would all be revealed. Some of us will take that in stride. Others would predictably not be caught dead wearing such a suit.

Or so Bob Zubrin predicts! But there is an answer: lightweight outerwear that can partially moderate body shapes, and distract with color and pattern as well.

Skinsuit "Outerwear"

There could be hats, capes, robes, overalls; you name it. Meant for wear in vacuum over a skinsuit, these apparel items could be made of most anything cheap and easy to work with: woven metal fibers, even wires, yes even medieval style chain mail; scrap cardboard, fiber glass fabrics, metal plates strung together – the adventures of "trashure" (transforming trash into treasure.) Any material or style that will distract attention from bodily imperfections, yet not make movement cumbersome or awkward, will become something with which to experiment. And for inspiration; anything from historical periods, from science-fiction/fanstasy, from imagination is fair inspiration for creative designers.

One can imagine periodic fashion shows in Luna City, perhaps in a lee-vac arena, where models with very imperfect physiques, both male and female, would strut down a runway before onlookers behind glass observation areas, with a variety of materials, colors and designs. Over a skinsuit, of course! Whether stylish, fanciful, sheer fun, what does it matter? Skinsuit outerwear fashions will say, "We belong here, out on the moonscapes!"

This may become an anticipated periodic event even for those not anticipating lee-vac or out-vac excursions. With successive shows, and over the years, skinsuit "outerwear" items available in Luna City retail shops will grow in number, design variety, and sophistication.

Start of a Cottage Industry

Periodic fashion shows should be popular, and drive a startup cottage outerwear fashions industry. Over time, ever more pioneers, whatever their physique, will feel encouraged to explore what the out-vac and lee-vac environments have to offer. And for those venturing

out, the great variety of outerwear fashions would make emergency identification easier, and people watching that much more fun.

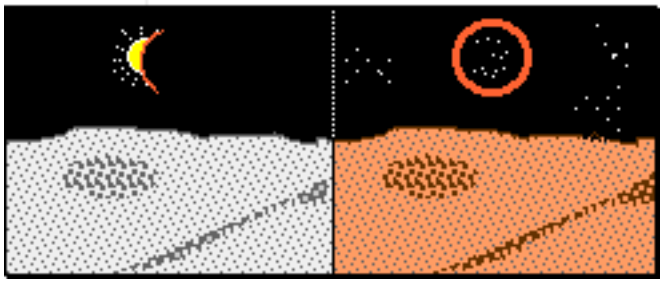
Skinsuit outerwear and new performing arts

Lee-vac activities would become more varied as well. Can you imagine ballet not only in one-sixth G, but in vacuum as well? Lee-vac arena sports team uniforms would be more interesting and fanciful as well – all part of team sports enjoyment.

Beyond the protection of "lee" space

But these "fashion" developments might also encourage more and more lunar residents to wear skin-suits with outerwear even in full out-vac, the unprotected "vac"uum "out" on the lunar surface. Such sorties would be less risky during the "moderate risk" conditions of "early morning" days and "late evening" long shadow days. Remember it is not quite 15 days from lunar sunrise to sunset! Temperatures will be lower, but not the radiation level.

Another "low risk" opportunity lies during the1-3 hour long solar eclipses when the surface of the Moon is lit with the ruddy light of the ring of sunrises and sunsets that circle Earth when Earth itself is blocked out as the sun slips behind it. (An event paired with total lunar eclipses seen on Earth.) During such periods, the out-vac will take on the appearance of marsscapes in twilight!



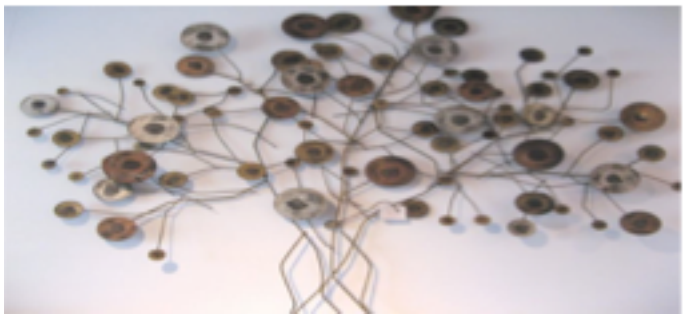
Every now and then, Earth-facing moonscapes take on the hues of a dimly lit Mars. But there will be no mistaking where you are. In the sky in place of Earth will be a black hole outlined with a ring of orange tones with only one ten thousandth the brilliance of sunlight. And in that black hole, clusters of city lights, and fires, dotting otherwise dark continents. It is Umbra. * See MMM #164 p. # - APR 2003.

Surface paths and trails for strolling

But before such surface recreational strolls can become popular there needs to be some encouragement in the form of "excuses to venture out:" something worth going out on the surface to see and experience. Most people will not just wander out on trackless wastes just for the sake of doing so, at least not often! But Luna City Fathers can encourage people to get out from the confines of the settlement encouraging the creation of "nature" paths that showcase local geological features of interest. Compacted and sintered, these paths will be relatively dust free yet allow enjoyment of the "natural" moonscapes to either side. Such a path could encircle the settlement, with bridges and underpasses where the path intersects roads into and out of the settlement. After sundown, rocks and cut breccias selected for phosphorescence could trace the way.

Art and Sculpture along the way

Sculptures of an ever more varied variety and originality along such paths could also attract exo-pedestrians. In turn, the opportunity to have their works seen and admired by many will encourage artists and sculptors to create objects of interest and fascination



R: Fanciful metal sculpture "moon shrub?" **L:** Free scrap metal is manna from heaven for sculptors

There could also be benches, each of a unique design (how about a pioneer design competition to stir extra interest?) and an objet d'art in itself would encourage walkers to take a rest, the better to appreciate the art and views along the way.

Animated Sculpture

On Earth, mobile sculptures are powered by the wind or sun. On the Moon, the solar wind blows at hundreds of miles per second, but is too thin and lacks the oomph to power anything. What about solar power? Solar panels could easily drive small motors and actuators to create mobile sculptures on moonscape paths and trails frequented by walkers after sunrise and before sundown. They'd work during high noon, of course, but few people would venture out on the trails at those times.

Let's use our imagination! Solar powered animatronic guides to explain landscape, rock, and geological features? Even programmed to answer routine questions? {"Where is the nearest restroom?" "Are there any vending machines nearby?"). Why not fanciful alien creatures that would leap out from behind a boulder to scare and delight children? Halloween when it occurs near local sunset could become a trail-event must!

The oldest, easiest hobby?

But perhaps the most interesting things to observe and study will be provided by the walkers themselves. They will no doubt appreciate this special opportunity to partake in the perhaps humanity's oldest hobby: going somewhere just to see and be seen – people watching! "Oh look at what she's wearing!" "If he thinks we can't see that he has a potbelly, he's fooling himself."

Bringing the Lunar Frontier to life while preventing neurosis and psychosis

Is all this idle diversion? What has all this got to do with anything? Getting pioneers to venture outside the pressure hulls of their settlement is absolutely vital to the long term mental

health not just of individuals, but of future lunar frontier society in general. We on Earth see the lunar surface as hostile, barren, life squelching, and something to be avoided at all costs. To tell the truth, those of us who see it that way are poor settler material.

It is imperative that the pioneers learn to make themselves feel "at home" on the Moon not just within their comfortable settlement homes and common spaces, but out on the surface as well.

The penalty of not doing so will be neurosis and psychosis not just of individuals, but very likely of lunar frontier society in general. If we are going to make ourselves at home, we need to do it in a "no holds barred" fashion.

Life-squelching cosmic rays and solar flares?
Tissue-burning ultraviolet?
The incessant micrometeorite rain?
The insidious, potentially poisonous moondust?

A lesson I learned from my mother is that "every apparent disadvantage remains so as long as we are looking at it wrong." "Change your attitude and try to see how that feature can be turned into an opportunity!" Then you will see it in its true light for the first time!

` Not a common attitude to be sure, but try it! It works. Now that's the stuff of which those pioneers who will survive and strive will be made of. Attitude is everything, and the naysayer, the timid, the "Oh, we can't …" crowd just doesn't get it, doesn't understand, and we have to ignore them and move on. The Lunar Frontier is our dream not theirs, and it is ours to pursue. The above attitude works on everything: from apparent life setbacks to obstacles on the road to the Moon and beyond.

Beyond the visions of "fellow travelers"

Some "pro-space" writers want to see robots do everything. "There is no need to put humans in such alien and hostile and godforsaken places," they advise.

But they have it all wrong. Venturing into new turf, into spaces that at fist seem hostile to human life, is something we have been doing even before leaving our home world in Africa to settle the rain forest jungles and the parched deserts of the first human continent, in a journey that would someday see us settle the north arctic which would have seemed as life-squelching to an early African in what is now Kenya, as life on the Moon must now seems to many of us incapable of getting past intimidating first impressions.

We have got to where we now find ourselves, a truly global species, by venturing into one new land after the other, where the wildlife, the vegetation, the climate, and the available resources were different from where we came from, from what we were used to and had taken for granted. And guess what? Each time we learned to make ourselves at home. Each time we learned to live with the "dangers" and "challenges" posed by the new territory.

From a more meta-historical vantage point, each time we developed ever more of our amazingly adaptive unsuspected human potential. Each time we realized more hidden human talents. Each time we brought out more of the potential that gives glory to the creative agency or agencies that have driven us and drawn us forward and upward. Why would some put a cap on what we humans can do? A cap based on past accomplishments in Africa 200,000 years ago would have been quite immature. A cap based on our accomplishments to date in the early 21st Century would be just as pre-mature. Our fellow travelers, those who would see robots explore space and access its resources but leave humans at home, are just that. Fellow travelers. We can use their limited support, but we must never accept the limits of their vision.

So you thought that this would be just a "far out" article on whimsical spacesuit outerwear fashion! Every-thing bears on everything else. Where we are and where we will be in the future is a web of endlessly varied possibilities. Let the adventure never end!

The Moon, its capacity to support a full flowering of human life quite unsuspected, will be the first of many new worlds. Why should this surprise anyone. Every element in our bodies, and in everything we see around us, other than hydrogen which is primordial, originated in the furnaces of star core explosions.

"Of stardust thou art - And to the Stars thou shalt return"

Now that is a "pilgrimage", a "directive", that will take us centuries, millennia, maybe eons to pursue. We are at the "baby's first steps" stage, the most critical of all. We have yet to truly integrate Antarctica into our human metaworld, and timidity, self-doubt, and endless diversions threaten to stifle our next frontier-exploring efforts. Are humans up to the challenge? Despite every thing that should give us pause, a look at our past should encourage us. We have always taken that next step and we have always succeeded. Now is certainly not the time to doubt either our own capacities our our destiny.

But each time, only a few pioneer the new "world" and they do so despite the discouragement and disinterest of the many who remain behind. <**MMM**>

MMM # 244 April 2011

Could "Paying Working Tourists" Open the Moon Faster, for Less?

By Peter Kokh

How we've done things up to now: who builds what

The cost of doing things in space is undeniably increased by the way hardware (rockets, for example) are contracted out with provisions that highly favor chosen contractors, by decisions motivated by political considerations, of which State or Congressional District will be most benefited, and selection of winners prior to construction and competitive testing.

The switch to real competition between commercial companies should help to reduce costs and improve equipment by a substantial margin. The NASA-Contractor monopoly has had its chance and given us space transportation systems impossible to continue financing.

In the next few years we will see real competition between a variety of crew reentry vehicles and space planes. Some will be best for this use, others for that. And all will be significantly less expensive thanks to real competition.

Crews: the cost of training and support

The NASA Astronaut Corps is rightly held in very high esteem. There will always be some individuals with problems. That's neither here nor there. But there has been significant criticism of the cost of the program.

> An "excess of astronauts — and what they do with their non-flying time — costs the space program far more than money. Their influence throughout the agency contributes to a NASA culture that is artificially enthusiastic, overconfident, contemptuous of outside advice and excessively obedient to short-term goals (as defined by the pilots) — often at the price of sound engineering."
>
> www.usatoday.com/news/opinion/editorials/2003-07-30-oberg_x.htm

How much does such a system add to the cost of missions to the International Space Station? How much would it have added to now-cancelled Moon Missions? We don't pretend to know.

But if we are going to switch to commercial providers of hardware, how about also switching to commercial suppliers of trained astronaut crews? We need both, commercial equipment and commercial crews to break out of the amazingly non-American paradigm of "socialized space," which, as much as we are all proud of NASA, is what it is has been, from day one.

Beyond Commercial Crews

Providers of commercial crews must factor the cost of personnel training, and attrition into the price for their service. While this cost could prove to be a fraction of what it costs N

ASA to train astronauts and to maintain an oversized astronaut corps, it would seem that there is a way to do even better, in fact,

> a way to zero out the cost of crew training and support, so that the cost of a mission reflects only the cost of purchasing competitive space transport systems, and tools and equipment that crews will need.

Zeroing out Crew Training and Service Costs

We are all now familiar with the "Space Tourism Industry." It began with Space Adventures arranging to bring Dennis Tito to the International Space Station. "Tito joined Soyuz TM-32 on April 28, 2001, spending 7 days, 22 hours, 4 minutes in space and orbiting Earth 128 times.[8] Tito performed several scientific experiments in orbit that he said would be useful for his company and business. Tito paid a reported $20 million for his trip."

http://en.wikipedia.org/wiki/Dennis_Tito

Tito paid for his training as part of the price for his ticket, and also was required to make himself useful while onboard ISS, and all space "tourists" to ISS since have done likewise.

The "Space Experience Industry"

Right now, we are approaching the dawn of commercial flights to the edge of space. Perhaps it is time to junk the term "Space Tourism" in favor of "Space Experience." The future of the Space Experience Industry seems to us unlimited. Thanks to John Spencer, the president of The Space Tourism Society, for this term!

Now in the near future where the focus will first be on prolonged zero-g flights to the edge of space, then orbital flights, finally commercial space hotels and resorts, we will be talking primarily about people on "the vacation of a lifetime." They will do this to enjoy, not to work! Yet crews and staff catering to their needs will also benefit. While flight crews will most certainly be paid as these will be steady occupations, some "staff" – for space hotels, for example – could be paying volunteers, paying a bit less than tourists, for the privilege of staying in space longer, in trade for working assignments.

The pay-to-work Paradigm already exists

For some time now, individuals have volunteered, and some even paid, for the privilege of participating in archeological and paleontological "digs." Something quite similar is common on "Windjammer Cruises" where tourist crews man the sails and do other jobs – everyone works, and they do so with enthusiasm for the privilege of a vacation experience otherwise out of reach.

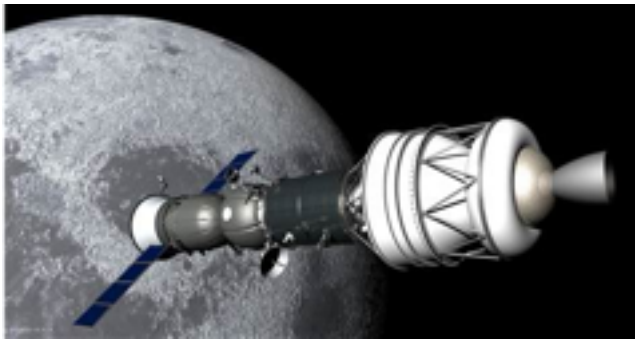
Paying to work in Space

Now most of us need to "get paid" for work, and are hardly in a position to "pay for the privilege of working." But make no mistake. Those who pay to work do get paid! Their pay is an unforgettable experience! Yes, of course, this is an option available only to those with enough income or resources to pay for the privilege. That this is not an option open to most of us is quite irrelevant. The point is that there is a population class growing in size that has begun fueling a "pay-to-work" sector of the economy that is growing year by year.

Fast forward a bit: we foresee the emergence of commercial companies that supply personnel who have paid for their own training, and who are ready to pay for the privilege of using that training on actual assignments – in space. Some will staff budget space hotels and resorts. And beyond that?

Space Adventures' 1st Private Moon Expedition

"Make history as the world's first private lunar explorer.
"Witness Earth rise as you emerge from the far side of the moon.
"Become a catalyst for humankind's expansion into space."
"Space Adventures invites you to join us for the most significant private expedition of our time – launching the first private mission to circumnavigate the moon."



Space Adventures, working with Russian providers of the vehicle and service module needed, has already signed up one of the two tourists, who, with a Russian astronaut pilot, will make the first commercial Apollo 13 type loop-the-Moon trip. (Apollo 8 made several orbits about the Moon before returning.) A second customer is said to be ready to sign. **Watch this Space Adventures Video:**

http://www.spaceadventures.com/videos/LunarMission_no_ZG_msg_300kbps_480x270.mov

This flight could occur within the next to years, and will be the first presence of humans near the Moon in forty years, many years before any national space agency.

What next for the Space Experience Industry?

Once this flight is history, or perhaps even before out of anticipation, there will be a growing interest and demand among "experience-seekers" willing to pay the price for lunar landing excursions. Now there will be no on site facilities to cater to them. So what would be the cheapest way to provide such facilities? You got it! The ideal site for an ever-growing tourist complex having been identified in advance, the first paying experience seekers will plot out the site, photograph the site in detail and do additional investigation to supply architects on Earth with the information they need to draw up plans for the first structures, and a game plan for additional expansion. Perhaps this first crew could also leave a robonaut behind to be telepresence-operated by persons back on Earth to continue making site improvements in advance of the arrival of a second private crew again paying not only for their own training, but for the priviledge of working on arrival at the selected site.

For an ideal site location idea, read **"An 'All-in-One' Moon Resort"** pp. 82-85, **MMM Classic Themes - Lunar Tourism**, a free download at: http://www.moonsociety.org/publications/mmm_themes/mmmt_tourism.pdf

Because "pay for the experience" tourists will be taking on serious work assignments, and have even paid for the training to allow them to do so, their tickets to the Moon (resort) will be cheaper than those of purely passive tourists. Those willing and able will pay-to-prepare, pay-to-build, pay-to-explore, pay-to-prospect, and pay-to-deliver services.

Yes, these people will come from the wealthy, as few of the rest of us will be able to compete for these positions. But the point is that in this manner, lunar surface facilities including not just tourist resorts but science outposts, even initial factories, will get built sooner and at far less taxpayer expense (translate that to freedom from political veto power).

As we have suggested, pay-for-experience tourists will be accompanied by and work with robonauts who will do the boring, repetitive, and dangerous tasks. They need no life support, no rest or recreation, and no need to return to Earth. They also require less room aboard the craft that bring pay-to-work tourists to the Moon. Thus robonauts promise to greatly multiply the cost-effectiveness of this approach, and bring down all costs even more. So we can add to the "pay-to" list, pay to teleoperate, and pay to maintain equipment.

This scheme can serve to expand science on the Moon as well as tourism. "Pay-to" personnel can also go to the Moon for the privilege of collecting specimens, of prospecting, and doing all sorts of scientific research. The can also pay for the privilege of testing equipment to turn moondust into usable materials - "ISRU" - "in situ" [on location for those of you not

familiar with Latin] resource utilization. Thus people may “pay-to” develop building materials with which to expand habitat and outpost complexes with far less “upports” from Earth.

We do not pretend that this scenario is certain to develop. The World Economy is too near implosion, and that could put off all plans, commercial as well as tax-supported inefficient government programs.

> Wikipedia “**Extreme tourism** or **shock tourism** is a type of niche tourism involving travel to dangerous places (mountains, jungles, deserts, caves, etc.) or participation in dangerous events. Extreme tourism overlaps with extreme sport. The two share the main attraction, "adrenaline rush" caused by an element of risk,”
> http://en.wikipedia.org/wiki/Extreme_tourism

Yes, there will be space tourists in the traditional sense who want to just enjoy and sightsee and they will pay even more to go into space. But here we talk about those who will pave the way and create places for others to visit. Here we talk about space tourists willing to pay for own training, pay their own insurance etc.; who pay (rather than get paid) for work and assignments.

How do we cover cost of equipment, vehicles, etc.? A first answer would be the commercial companies and consortia who want to operate lunar resorts, and deploy factories on the Moon, mining operations etc. Keep in mind that this is an introductory article aimed at getting further brainstorming in high gear. We offer this article as a contribution to a **Commercial Model for settling the Moon**.

Addenda: Opening the Moon to the less-well-to-do

The overwhelming majority of us would never have the resources to participate in such a scenario. But there could be **lotteries**, with drawings to be held when the combined entry fees exceed the costs to be covered. Winners who did not pass medical and other tests, could sell their rights to the highest bidder. But there could also be limits on those who could enter, to minimize such situations.

When Weight is an Issue

One thing we have not discussed is the simple hard fact that transporting anywhere in space those who are bigger and heavier goes up in proportion. Should otherwise capable midgets, dwarfs, and just smaller individuals pay less? For passage perhaps, but maybe not for training.

We hope you enjoyed this article ant that it sets of a chain of constructive brainstorming.

See you on the Moon! **PK**

MMM # 246 June 2011

Most Popular Souvenir from the Moon?

By Peter Kokh

Now wait a minute!

Bringing home a tray of moon dust with one's boot print sintered in to keep the shape forever is going to be expensive. While it would cost much less fuel to bring such a thing back home than to bring something of equivalent mass to the Moon, it will still cost extra fuel and something this large might not be part of your "allowance." (Unless you earn points by being "underweight" in the first place! Hmmm?)

As proud a specimen and souvenir as a real boot print would be over someone's mantle, few will be able to fork up the cash. And a photograph won't quite do it.

Here is a compromise idea.

- **A boot print, yours, is scanned** in 3-Dimensions on the spot, along with its surroundings, say a 1 foot by 2 foot area. Y
- **You take the scan home** with you on a CD (or its successor medium) or have it sent home to you by email.
- **On Earth, a company takes the scan and faithfully reproduces your boot print** in your choice of media, some more expensive and realistic than others, and you have this as a faithful copy, fixed dimensionally so that it can't be disturbed or lose the fidelity of shape and detail in any way. Now you can hang it over your fireplace or plasma screen without any dust coming off, as the trophy it is.

Here is one way companies on Earth can cash in on early lunar tourism, perhaps offering a variety of moon dust simulant for the cast. And that day is coming sooner than you think. If Space Adventures doesn't sign up a $150 million dollar tourist for the second seat on the Russian Soyuz first loop-the-Moon tour, Space-X might beat them to it with lower prices.

Of course, you will come home with photos and videos as well! But your recreated 3-dimensonal boot print would be special. **PK**

How to go for a nice Walk on the Moon And not get lost!

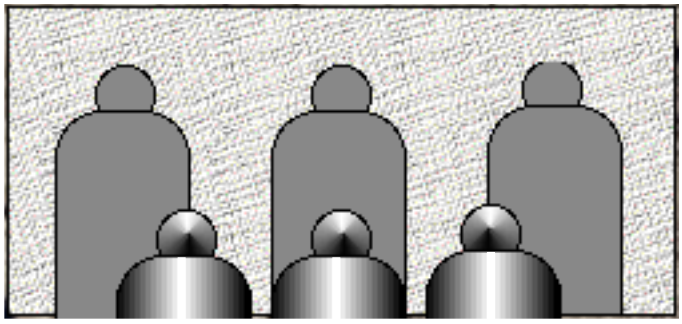
By Peter Kokh, Wisconsin Northwoodsman

May 17, 2011 outside Florence, WI – This morning my 9-year old "alley" shepherd Nessa and I went for a long walk along a dead end country road, facing east towards the sun, but then **returning through the woods** westbound. While we were walking back through the woods

(Spring is best, before the trees are too leafed out, so that the sun gets through), it occurred to me that my Northwoods instincts might work on the Moon.

Always keep the sun to your back
and follow your shadow.
You won't get lost or go far astray!

Now on the Moon, the "Dayspan" is 14 and 3/4 of our 24-hour Earth days long. So my advice is to pick a destination towards the west (WSW-W-WNW) for an early morning walk (1-4 days after sunrise) and towards the east (ESE-E-ENE) for a late afternoon hike (1-4 days before sunset)



Now to return, if you don't want to wait a week or more until the Sun-angle is just right for following your shadow, you can follow your bootprint trail – if – and this is a very big "if" you walked through "virgin" territory, and there are no other boot-prints but yours. But that's risky, as someone may have crossed your path since you made it, and then you could get confused. It is better to wait to follow your own shadow!

Dress for comfort

Don't wear a NASA-Apollo suit designed for maximum fatigue in the minimum amount of time. The traditional "spacesuit" combines two separable functions in one garment: (1) maintaining breathable air pressure, (2) protecting from thermal extremes and punctures from sharp rocks and from the constant dust-particle size micrometeorite rain. Instead, a **mechanical counter-pressure "skinsuit"** will allow you to breathe and yet move your arms and legs much more freely. Then don **a loose outer suit** with the same layers as an Apollo suit, to provide the needed puncture resistance without encumbering motion and tiring you out prematurely. Then with water and air supply, you should be able to walk at ease for many hours, thoroughly enjoying your sense of freedom during your walk on the Moon, "as if you were at home on Earth." What an achievement!

[See **MMM # 238** Sept 2010, pp. 4-5 "**A Fresh Look at the Spacesuit Concept**"]

Now as to bringing your dog along, in an equally comfortable 2-part suit, he or she might get frustrated, as bending down to sniff rocks but unable to sense any odor will disappoint and confuse them. And for a male, trying to lift a leg and mark his territory will only make one leg of his suit very, warm and wet. Maybe in time he would stop trying. Maybe a custom-made fitted urinal bag? Hmmm! I smell a lunar patent!

Yes, there are many areas of the Moon that are very boring, especially out on the maria (Tranquility Base) but areas in the highlands or along highland-mare coasts, or along rilles and scarps could be pleasantly scenic. And just knowing that you are the very first human to pass that way could be especially rewarding (look, ma, no bootprints but mine!) Not all humans enjoy a quiet walk in a nature setting all alone, communing with nature, with themselves, while deep in thought. But perhaps you are one of those like me, for whom there is a special bond with the raw outdoors and nature, best enjoyed alone, even though we may want to share this experience with another on a return trip! **PK**

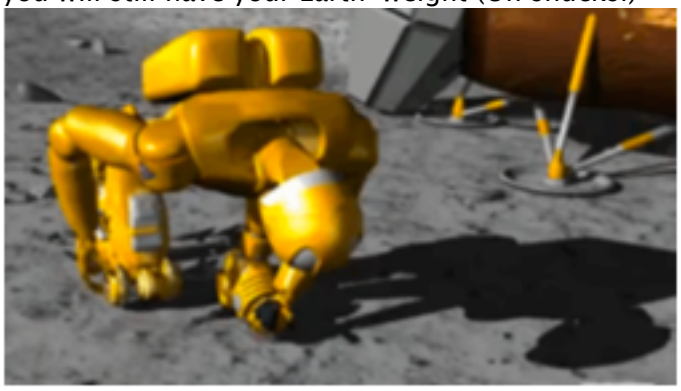
MMM #260 - November 2011

"Telepresence" Tours of the Moon: How Soon?

By Peter Kokh

Scenario: It is July 20, 2019, the 50th Anniversary of the Apollo 11 Moon Landing by Armstrong and Aldrin, and NASA is celebrating big style. At all eight NASA centers around the country, new Moon Telepresence Centers will open up. At each center, you can make reservations for use of a Moon Telepresence Booth, by the quarter hour.

Inside the booth, you are helped to get into a telepresence outfit which includes moon-visors, special moon gloves, and and moon-shoes. On the Moon, at the Apollo 11 site or a number of other interesting sites, "avatars" will walk, bend over and pick up rocks, and look at them, or just scan the horizon, as you wish. You will have all the sensations of being there yourself, except that you will still have your Earth-weight (Oh shucks!)

How  **soon?**

Telepresence equipment is advancing by leaps and bounds, and the six and a half year window may just be enough. Now NASA and a number of commercial firms specializing in robotics are not pushing this technology for you the visitor, but for the sake of science and exploration. For most of the involved parties, the incentive is not public use. But for some, it may be. Indeed some of the breakthroughs needed may be motivated by potential profits from such tele-tourism markets. That's the process of "spin-up" that we had described way back in 1989. Read:

http://www.moonsociety.org/publications/mmm_papers/glass_composites_paper.htm

This development path is just the opposite of "spin-off." Instead of NASA embarking on a crash research program at exorbitant cost and then turning over the resultant technology at no cost to commercial enterprises with the taxpayer footing the bill, in "spin-up," a private enterprise, seeking profits, develops the technology, with the consumer paying the bill. As a result, when the technology is needed on the space frontier, it is already "on-the-shelf" and in need of relatively inexpensive adaptation only.

In a recent article in Space Review(online), there just such a possibility is discussed:

"Is there a way for humans to be on a surface of another planet without actually physically being there? Dan Lester argues that, thanks to the increasing capabilities of robotics and related technologies, telepresence can be the next best thing to actually being there, at considerably less cost and risk." http://www.thespacereview.com/article/2150/1

So what?

For billions of people who cannot afford a multimillion dollar "loop the Moon" tour, this will be a much less expensive opportunity, not to skim over the Moon's surface at an altitude of 5-100 miles, but to have all the experience and sensation (less the lighter gravity) of walking

on the Moon, picking up and feeling a moon rock, and doing a little exploring. Each option will offer different “unforgettable” experiences. This is important because as more and more people take such a telepresence Moon tour, and tell their friends about it, the more public interest in supporting permanent outposts, then tourist centers, on the Moon itself will grow.

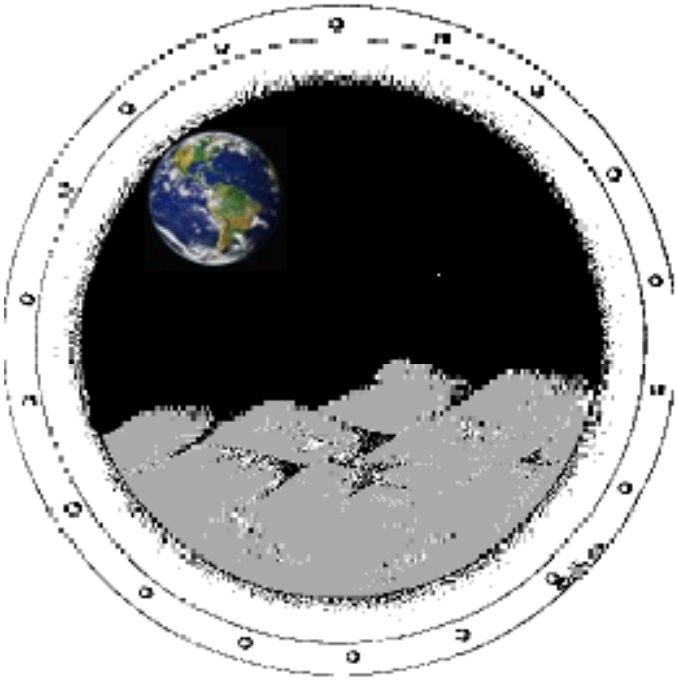
The catch is less in developing the “avatars” through which you will see and feel yourself on the Moon, than in sending enough avatars to the Moon to meet telepresence demand, and in their maintenance. The first such experiences will be expensive. But the cost will come down as demand increases.

What about Mars?

The reaction time delay for command and response in telepresence on the Moon is of the order of three seconds, the time it takes for command signals to get to the Moon, and perceived command execution at the speed of light. For Mars, the delay will be from a 6 to as much as 40 minutes - it is just not practical.

When will lunar telepresence tours come to a NASA Visitors Center near me? The timeline suggested above seems realistic, especially if commercial firms take the lead in the “spin-up” process described. If it is left up to NASA, it becomes a budget item, which we all know will always be at high-risk for cancellation at any stage of the process. In the meantime, do watch this video:

http://www.youtube.com/watch?v=kFPNcWN7QnM MMM



Oh, the wonder of it all !!