"Expanding the Human Economy through Off-Planet Resources"

Moon Miners' Manifesto

& Moon Society Journal

MMM Classics

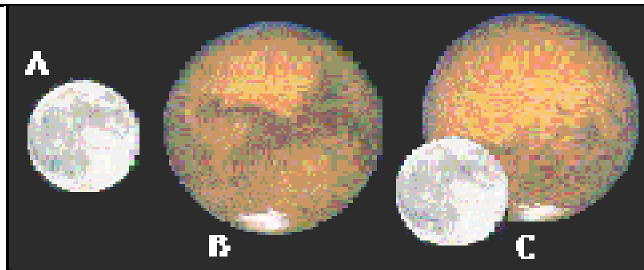
Year 18: MMM #s171-180

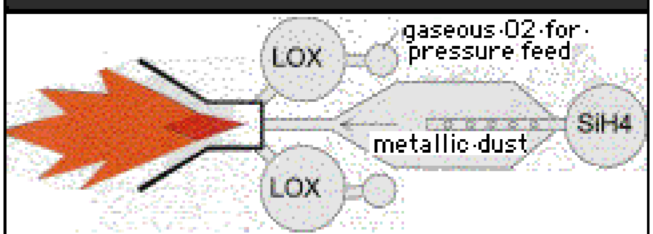
December 2003 - November 2004

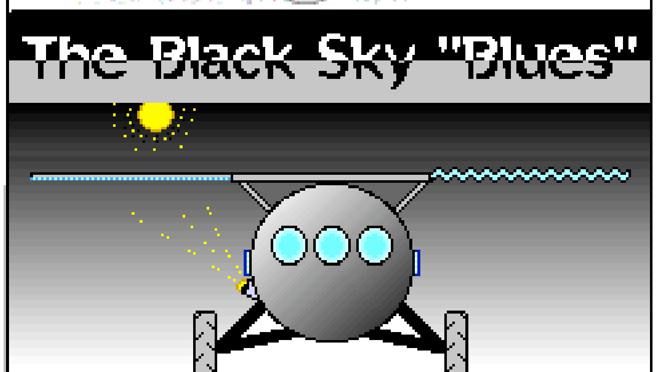
This year, as always, we covered a wide range of topics. One of these was the need to approach the Moon and/or Mars with both frontiers in mind. Both worlds have more in common than either has with Earth. The advantages tof **going to Mars "by way of" an effort to open the Moon** are shown to be considerable. Tom Gangale contributed an impassioned list of reasons why humans should go to Mars, while we wrote about the advantages of dune fields as Mars settlement sites, and ways to play up its Arizona-like views. We even added a page out of the "MarsPort Yellow Pages."

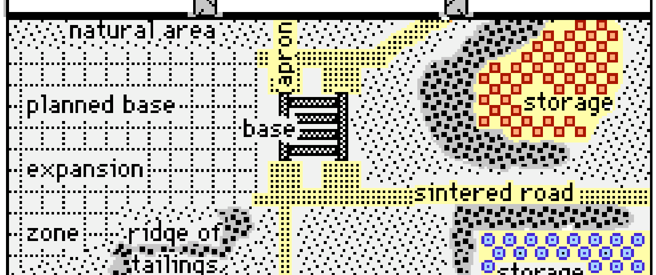
Continuing to expand on our vision for the future were "MMM's Platform for the Moon" in MMM #171 nd in the next issue, a Space Frontier Foundation Vision for the Moon.

Dave Dietzler contributed many articles this year. One was a proposal for **silane/ powdered metal lunar rockets**. He also shared with us his ideas on processing elements out of the Lunar Regolith by "zone refining" and wrote about Lunar production of nuclear fuels, and much much more. Looking far forward, he gave us "A prospector's Tour of the Solar System." and a Grand Tour by Solar Sail.









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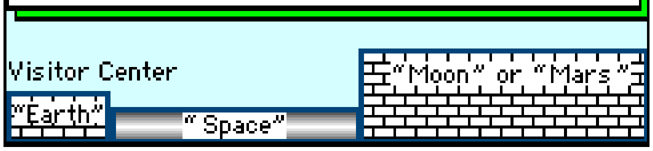


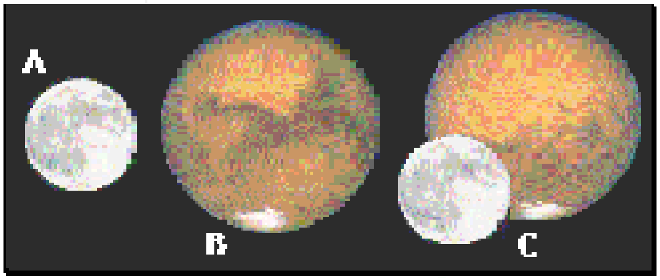
A perennial favorite MMM topic is how pioneers can learn to be "at home" on the Moon. Included are our 2nd and 3rd "**Black Sky Blues**" essays on looking at skylights, and **how we can create an illusion of a bright blue sky** for cross-lunar-travel. Landscaping tips, Lunar National Parks, Nature Trails, and homegrown bever-ages were topics of new original articles. Another page from the "Lunar City Yellow Pages" enterprise ads was published.

Another frequently revisited topic is how to expand out of a first lunar base. "Passing from Outpost to Set-tlement," an easy way of road building by use of "Marsten Matting," modular "container factories" sent from Earth and ready to hook up and run, and different kinds of storage needs we will have to consider in laying out the outpost periphery "ware-housing" area were explored.

A Lunar economy built on dedicated reuse of used products and waste byproducts, reusing both materials and energy will be much more efficient and lead to greater diversification. Attitude is vital.

And we talked about easy ways to simulate moon/mars bases for kids whose imagination can fill in the detals. #

MMM #171 - DEC 2003



Where next is a critical decision. We must get it right!

The Bush Administration is considering which path to take in a NASA rededicated to going somewhere. The Moon first, say some. Mars first, say others. We all stand to lose if the answer is not "to Mars by way of the Moon," with needed equipment optimized for commonality on both worlds. Read "MMM's Platform for the Moon," and "The Moon as a Stepping Stone to Mars," below.

MMM's Platform for the Moon

We start another year of Moon Miners' Manifesto with a comprehensive look at where we should be going, and what projects (government, private enterprise, and societal) we should be supporting to advance the realization of our vision of integrating the Moon into Earth's Economy.

Government funded missions are appropriate to answer questions about the Moon's

- Origin and evolution, Geology and typography, Composition and mineralogy

Economically significant resources (Sudbury analogs)
Priority government/agency-funded Missions include:

- South Pole-Aitken basin [SPA] farside sample return
- Nearside central peak sample return (mantle material)
- Polar cold trap "ground truth" sampling missions (ice?)
- Orbital & impact lavatube detection & mapping
- Optical Wide-array telescopes
- Farside Radio Telescope installations

Industry/enterprise-funded missions are appropriate to:

- Map, quantify and qualify resources with near-term development potential
- Do on site teleoperated demonstrations of element production, building materials manufacturing, and other near-term product and technology development
- Up close high resolution photography for use in film and other audiovisual productions
- Test transport equipment for near-term tourism use

Industry and Enterprise-funded efforts are appropriate for: pre-development, for the sake of profitable terrestrial applications, of technologies that will be needed to open the space frontier (Spin-Up.) See MMM 132 pp 1-4

- "Poor ore" mining technologies
- Novel building materials (glass-glass composites, alternative alloys, cast basalt, etc.)
- Synthetic chemical feed stocks
- Hybrid hydroponic/geoponic food production systems
- Mini-biospheric technologies

Industry/Enterprise-funded efforts are also appropriate for on location (on the Moon) demonstrations of:

- Helium-3 Harvesting methods
- Illmenite Oxygen, Iron, Titanium Production methods
- Glass-glass composites manufacturing systems
- Cast Basalt products manufacturing
- Sintered iron product manufacturing
- Gas scavenging and separation methods
- Silicon solar cell production
- Site grading methods
- Shielding emplacement methods
- Dayspan/nightspan energy management systems
- and more!

Space Organization-funded efforts are appropriate to:

- Outline potential Spin-up" business plan opportunities and publicize them to would-be entrepreneurs
- Found an Institute of Lunar-appropriate industrial design and/as-part-of a University of Luna-Earthside
- Define and list potential masters and doctoral Theses Topics in various fields that could advance our state of knowledge and preparedness to open the lunar frontier
- Define (and pre-design) Return Moonbase Improvements over the Apollo Lunar Module (room to sleep prone, walk, lounge, exercise; capacity to overnight (full-sunth mission capability, missions long enough to grow plants to harvest); recycling of human wastes (directly or indirectly); demonstration plant design; design of experiment tinkering labs; etc.;
- Hold contests to design and develop best teleoperated shielding methods, etc.; moonbase outfitting & layout, etc.,; the time-delay limits of teleoperation, etc.

Individually undertaken and funded efforts [MMM #105 pp 1-2 The "Man in the Mirror" Strategy for Opening Space] are appropriate for:

- writing theses on various topics that advance our state of knowledge and preparedness to open the Moon
- writing books about the Moon and about the prospects of lunar development and life on a future lunar frontier to help broaden the base of public support
- help pre-develop lunar-appropriate art & craft media

Joint Projects for Moon-focused & Mars-focused Societies:

Moon-supporters should realize that it is in their greater interest to maximize the design of any facilities and equipment that would also be useful on Mars, for commonalities of parts and systems.

Mars-enthusiasts should realize that any systems needed on Mars that would also be needed on the Moon, if designed and developed to maximize commonalities of parts and systems, if deployed, tested, and debugged on the Moon first, would greatly reduce the risks of failure, setback, tragedy and catastrophe in the opening of Mars.

Given these shared interests, Moon-focused and Mars-focused societies should do what they can, jointly, within their budgets and abilities to raise special project funds, to insure that any government/agency designed systems, whether meant for the Moon, Mars, or both worlds, are optimized for commonalities of parts, systems, etc.

Further, Moon-focused societies should work on identifying early lunar industrial products that might have a market on the Mars frontier. Any effort to make the lunar frontier pay for its own expansion will have a better chance of succeeding if the potential market is expanded beyond Earth-based and Earth-orbit based consumers.

This is MMM's Platform for the Moon. It is not an impossible plan. It does demand swallowing of pride and a cessation of the "let George (government) do it" mentality.

NRA-03-OBPR-07: Research Opportunities for Ground-Based Research in

Space Radiation Biology and Space Radiation Shielding Materials

by Gordon Haverland, P.Eng., Matter Realisations
< ghaverla@materialisations.com > Nov 19, 2003

The above is the proper title for a NASA program that I learned of on 2003/11/04.

Background

Cosmic rays are a particle radiation from space. In terms of number, the largest component are protons, such as from the solar wind. In terms of effect (and especially biological effect), the most worrisome component are the highly charged, heavy ions. These heavy ions with very high kinetic energies, can travel quite far in matter. A few inches in aluminum for example.

If we say we want shielding for cosmic rays, most people would immediately think of lead (Pb). Lead is really only great for X-rays, for things like cosmic rays it is actually worse than no shielding at all (for any practical thickness of lead). The best material we have at this time is polyethylene, and it is they hydrogen atoms that are the important factor in shielding cosmic rays (without generating high secondary radiation fields).

- Polyethylene is the current best material. It is 14.4% hydrogen by mass, densities below that of water.
- Some suggested shielding materials have included a solid wall of hydrogen (which would need cooling to stay as solid hydrogen) and tanks of water. Water is "only" 11.2% hydrogen by mass.
- Liquid hydrogen has a density of 0.07 g/cm_3. This is much less hydrogen per unit volume, than is found in polyethylene.

Hydrogen Storage Materials

We want a lot of hydrogen per unit volume. The hydrogen economy industry (hydrogen powered cars, fuel cells, etc.) has an interest in storing large amounts of hydrogen per unit volume, and with little "parasitic" mass (non-hydrogen mass). Cryogenic and pressure vessels are possible storage systems, but the better systems are hydrogen storage materials. These special materials can reversibly store hydrogen a number of times within the material.

The first solid-state, hydrogen storage material I forced myself to remember is $LaNi_5$. It could hold more hydrogen per unit volume, than was found in liquid hydrogen. But on a mass fraction basis, this material stores very little hydrogen. (Since liquid hydrogen and solid hydrogen have about the same density, it doesn't really matter which we compare it to. Liquid just happens to be more convenient.) This material started research into hydrogen storage materials.

Hydrogen Storage Materials – 2002/2003

There are now many different families of materials which are being investigated as hydrogen storage materials. For the hydrogen economy, you would like for it to be easy to get them to release the hydrogen as well as having large capacity. For shielding, we would just as soon have the release of hydrogen be restricted.

Lithium Nitride

The latest information I have on these materials, is that the current record holder is Li3N (lithium nitride) at 11.4%. Lithium nitride has a density of 1.38 g/cm3, so if you filled it with hydrogen you should have about 0.171 grams of hydrogen per cubic centimeter. Which is 20% better than a polyethylene having a bulk density the same as water.

When hydrogen is absorbed into lithium nitride, a chemical reaction takes place, much like a battery. Lithium amide and lithium hydride are produced. These two compounds will react at temperatures above 200C and low hydrogen pressures to release the hydrogen.

Lithium nitride, whether loaded with hydrogen or not, is not a nice compound to work with. It is reactive, easily reacting with water to produce ammonia. It may be explosive, or violently decompose, under certain circumstances. Not something one wants to see in radiation shielding.

Lithium

If you have worked with radiation shielding before, you probably immediately remembered something. Lithium (Li-6 in particular) is good at absorbing neutrons, and some neutron shielding materials are polyethylene loaded with lithium compounds (boron compounds are also common).

So, not only is lithium nitride a potentially useful shielding material on the basis of hydrogen density, it should also be quite effective at reducing secondary neutron fields. One downside of using lithium for absorbing neutrons, is that the radioactive form of hydrogen (tritium) is evolved. I suspect that Lithium (either Li-6 or Li-7) might have a "large" cross section for reacting with incoming cosmic rays, which would be another negative factor. Nitrogen is mostly N-14, which is known to react with high energy protons (like those found in cosmic rays) to produce C-14. The production of C-14 shouldn't pose as much of a problem as H-3, but lithium carbide is not known as a hydrogen storage compound. Transmutation of nitrogen to carbon would reduce the hydrogen sotage capability with time.

Offgassing

When polyethylene absorbs particle radiation, on the average some hydrogen will be evolved and lost. One potential advantage to using a hydrogen storage material, is that it might be better at reabsorbing this evolved hydrogen, if it is sealed inside something. And since lithiu nitride might be evolving tritium as it absorbs neutrons as well, we probably should attempt to seal our lithium nitride. How long it will stay sealed is open to speculation, since micrometeroids like to poke holes in things.

Conclusions

Hydrogen storage materials, and lithium nitride in particular, should be considered as cosmic ray shielding materials. The hydrogen economy people are looking for compounds which will easily release hydrogen, and the release rate is probably effected by alloying and doping. For shielding, we want to decrease the release of hydrogen. The "matrix" may participate in positive or negative ways, so we will want to consider all the possible nuclear reactions and radiation physics. It might be worthwile sealing the shielding materials, to lower the rate of hydrogen loss.

‹ GH ›

Colonizing a Bone Dry Moon: Transporting the Seed of Industry

by Dave Dietzler ‹ Dietz37@msn.com ›

No plume of water was detected by Earth-side telescopes when Lunar Prospector was crashed into the Moon. Recent radar studies that only covered about 20% of the south polar region to a depth of 20 feet did not detect slabs of ice. In either case, crystals of ice dispersed throughout the Moondust would not have been detected. A lunar polar lander is badly needed to sample the Moondust and tell us exactly what and how much hydrogen bearing substance is there. Until then, our plans to use lunar polar ice for rocket fuel just long enough to get a foothold on the Moon are almost baseless. However, if the Moon is bone dry we can still do the job.

If we are to land 20,000 tons of equipment, as in O'Neill's original scenario, on the Moon to build a base and a mass driver that then provides millions of tons of materials for more development on the Moon and in outer space, we are going to need quite a bit of rocket fuel. With 330 second space storable hydrazine and nitrogen tetroxide powered rockets we will need 14,680 tons of propellant and 2935 tons of tankage and motors (about 20% of propellant mass) to land all this from lunar orbit. The total mass in lunar orbit will be 37,615 tons. For efficiency, the landing vehicles will be cannibalized to get aluminum, steel and plastics.

It may be possible to fly by WSB orbits to capture into lunar orbit without retro-rocketing, as did the Japanese Hiten spacecraft, but this might not be the "free lunch" that's hoped for. We will need 11,157 tons of hydrazine and N2O4 to brake all this into lunar orbit and about 2230 tons of tankage and motors which will be discarded after use or recovered in lunar orbit someday and cannibalized. The total mass of payload to be accelerated out of LEO to escape velocity will be 51,000 tons. The mass of LH2 and LOX to propel all this out of Earth orbit will be 69,100 tons and the tankage plus motors will be 13,820 tons. That 13,280 tons of rocket stages will be discarded into space or crashed into the Moon after use. The total mass for this project in LEO is then 133,920 tons. At $1000 per kilogram to LEO, less than one tenth today's price, it will cost $133 billion to boost all this to Earth orbit. There will have to be orbital fuel depots to store water that will be converted to LH2 and LOX when ships are ready to depart for the Moon and a substantial robotic and manned presence in LEO to prepare all the rockets and cargo. I have not allowed any margin, but this discussion is for comparison of lunar transportation systems rather than actual specifications. At more than $133 billion it seems that this project is going to have trouble getting funded. Only 15% of the mass launched is actual lunar payload and the rest is propellant, tankage and motors.

Confidently presuming the presence of six billion tons of lunar polar ice, it would be possible to mine the ice with a small number of robotic devices, fuel up a reusable nuclear thermal rocket powered freighter with water and use it to stock up a fuel depot at L1. From there, a tiny chemical rocket burn sends the water down to LEO in reusable aerobraking carriers. In LEO, the water is decomposed with solar powered electrolysis cells to get rocket propellant for reusable rockets that move cargo from LEO to L1 where cargo is transferred to nuclear steam rockets and landed. Presuming that this can be done economically, we hardly have to send any propellant up to LEO and costs are slashed. This demonstrates the value of in-situ resource utilization once again. But what if the water isn't there? Or it exists in quantities too low to mine practically?

At this point we have to be clever. Solar electric propulsion like that used on the ESA's SMART-1 becomes attractive. If we are going to deliver 20,000 tons of payload, 14,680 tons of hydrazine plus N2O4, and 2935 tons of landers to lunar orbit with 6000 second ISP ion drives, we will need only 2650 tons of propellants. The "fuel" could be zero boil-off lithium. The drive itself won't be too massive and the solar panels would be recruited for other purposes (thereby making them part of the useful payload mass), so we can fudge a little and ignore the mass of the ion drive and solar panels. Now we have about 41,000 tons to LEO and that would cost about $41 billion at $1,000 per kilo. That's a substantial reduction. With 20,000 tons of equipment on the Moon, most of it teleoperated and some of it using AI and capable of self replication, we can build habitations on the Moon anticipating humans, dig mines, refine moondust and build mass drivers to launch millions of tons of material into space for construction.

Our labors are not finished. Solar electric propulsion is very slow. It will take months, even a year or more, to spiral out of LEO and then brake into lunar orbit. That's just fine for cargo, but it will not suffice for humans. This is unappealing not only because of our impatient nature, but months spent spiraling out through the Van Allen Belts will be deadly unless the ship is shielded to an absurd degree. What we need are high thrust rockets in order to race through the VABs and reduce radiation exposure. In the absence of water ice for liquid hydrogen and LUNOX, the only substances on the Moon that can be used for high thrust rocket fuel are aluminum, magnesium and oxygen. These might be mixed up to form a monopropellant slurry as demonstrated by Wickman. It might also be possible to take beads of magnesium or aluminum and sinter them in a form to make a solid fuel for a hybrid rocket that uses LOX, something that has yet to be shown. Extracting metals and oxygen from regolith is more complex than simply roasting out water, but it can be done. We will need more than just a few ice miners and nuclear thermal steam rockets, but the day would come when we had to stop using precious lunar polar ice for rocket fuel and switch to aluminum, magnesium and LUNOX anyway. With 20,000 tons of cargo on the Moon it should be possible to build a mass driver and launch moondust (or preferably, alumina and magnesia) carrying modules to lunar orbit where they will then rendezvous with solar electric or nuclear electric powered freighters that load up and haul the moondust over to L1. From L1 the modules will be shot down to LEO with a small chemical rocket burn and aerobraking carriers. The ion driven freighters will go back to lunar orbit to collect more modules launched via lunar surface mass drivers. The material will be smelted in LEO to get rocket propellants. Small manned rockets will race from LEO to L1. Material will also be smelted at the L1 depot to get Al and LUNOX for landers that convey humans to and from the lunar surface. Interlunar rockets will reload with Al and LUNOX at L1 and fly back to LEO, perhaps making use of aerobraking for efficiency.

There are a couple of worthwhile refinements to think about also. What if the first one or two thousand tons of cargo sent to the Moon consist of equipment expressly designed to manufacture Al and LUNOX along with some rocket vehicles? It would not be necessary to convey landers, hydrazine and N2O4 with the next 18,000 to 19,000 tons of cargo. Rockets fueled with indigenous lunar propellants could land this remaining cargo and billions of dollars could be saved that otherwise would be squandered launching lunar landers and their propellants to LEO. What if we build an Earth-Moon cycling station out of some Shuttle ETs accessed by Al/LUNOX powered taxis? Astronauts could travel in greater comfort and that would improve morale. A station at L2 would be necessary for such a cycling station, but it would probably be worth it. see:

http://groups.msn.com/DaveDietzler/spacesmelting.msnw

‹ DD ›

The Moon as a Stepping Stone to Mars

by Peter Kokh

"A serious project of going to Mars will include the Moon in some manner."
James Lovell, December 17, 2003

A decision to return to the Moon before mounting a manned expedition to Mars is the nightmare that has haunted Mars Society founder Robert Zubrin for many years. Yet it seems clear to all less emotionally involved that the pluses, for real and lasting success on Mars, of establishing an outpost on the Moon first could be enormous.

The recent failure of the UK's **Beagle** Marslander mission to survive planetfall on Mars in a functional state, in the wake of so many previous Mars lander probe failures is ample evidence of the high technological threshold of Mars missions in general. Mars is some 150 (min.) to 1,040 (max.) times as far from Earth as the Moon. One immediate consequence is that while probes and facilities on the Moon can be teleoperated from Earth or Earth orbit with less than 3 *seconds* time delay, remote control is all but impossible on Mars at time delays of 6 to 44 *minutes.*

Trip times to Mars of 6-9 months with currently available chemical rockets, compare poorly with 3 day ones to the Moon, a factor of 20-30 times shorter. For cargo (unmanned) craft, this may not be a problem. For humans this will mean that much more exposure and vulnerability to cosmic radiation and solar flares. It will also mean much more consumables brought along - just for the trip.

More importantly, while optimal windows to the Moon occur monthly -in a pinch, we can go there *anytime.* In contrast, windows to Mars are tightly constrained by orbital mechanics to a period of a couple of months every 2 plus years. The significance is that while an outpost on the Moon can be *resupplied regularly and rather quickly,* a Mars outpost would have to *bring along enough supplies and* *replacement parts to survive without outside help, resupply, or rescue for periods of two or more years.* The Moon can be done via an "umbilical cord" if you will, whereas Mars will require a presupplied 'yolk sac' for growth and nourishment.

It should be clear even to the shallow-thinking "been there, done that (the Moon)" crowd that a Mars outpost will be significantly more of a logistical challenge, and, if involving equipment that has not been pretested in an analogous "field," will involve considerable and unnecessary risk of unrecoverable disaster at unrepeatable expense. If it is important to open Mars, then it is important to reduce these considerable risks to a minimum. As the age old maxim has it, "anything worth doing, is worth doing well." So let's indeed go to Mars, the right way, using a lunar outpost to make sure we have everything right.

Advantages of a prior outpost on the Moon

1. Field testing equipment

New untested and nondebugged equipment on Mars had better work, or be fixable by the crew on hand with tools and parts on hand. Pretesting on Mars "analog" sites on Earth will hardly be adequate. The conditions are not sufficiently similar. Equipment can be field-tested and debugged with far less risk to life on the Moon, where resupply, rebuilding, reconfiguration, overhaul - and, if necessary, rescue - will be significantly easier, safer, faster, and cheaper. An equipment failure on the Moon will be survivable, with recovery relatively swift. Failure on Mars could be crippling and quite possibly catastrophic. Equipment needed in common on Moon and Mars will include:

- regolith shielding emplacement equipment
- other earth-moving equipment
- mining equipment
- construction equipment
- manufacturing equipment
- life support / biosphere maintenance equipment
- farming/agriculture/food production equipment
- power generation equipment
- ground transport equipment
- communications equipment

2. Human Factors Engineering

In this area of concern, enthusiasts in the Mars Society have made great strides. Analog stations on Devon Island (Canada) and in Utah, have proved their value in testing the effects of isolation on human crews. We have learned much. But despite efforts to "observe simulation," not going "outside" without "spacesuits" and only via an "airlock," we could gain much more confidence in an environment whose unforgiving hostility guaranteed compliance, in which the weight and cumbersomeness of space suits was accurately modeled, etc. No one has spent more than a few days at a time on the Moon. Lunar missions of "Mars Mission length" would have a better chance of exposing any critical problem points.

3. Frontier Health Care

NASA has been brainstorming a compact medical complex able to handle most emergencies from trauma to appendicitis. Field testing this complex in real lunar frontier situations would guarantee an improved version for Mars, where emergency return to Earth is not an option.

4. Long Range Applications

If the lunar and Martian frontiers are opened in step, Moon first, down the road, a lunar settlement could produce some of the heavy equipment needed on Mars at shipping cost savings. The lunar frontier would also be the premier source of field-tested settlers for Mars.. **< PK >**

Mail For MMM

Major Findings of 30 years of Apollo Science as reasons to return to the Moon

11/15/03 December's Scientific American has a long feature article by Paul Spudis, on scientific reasons (geological mostly) for a return to the Moon. The first few paragraphs are online: "The New Moon" -

http://www.sciam.com/article.cfm?chanID=sa006&colID=1&articleID=0006DD04-865B-1FA2-85B083414B7F0103

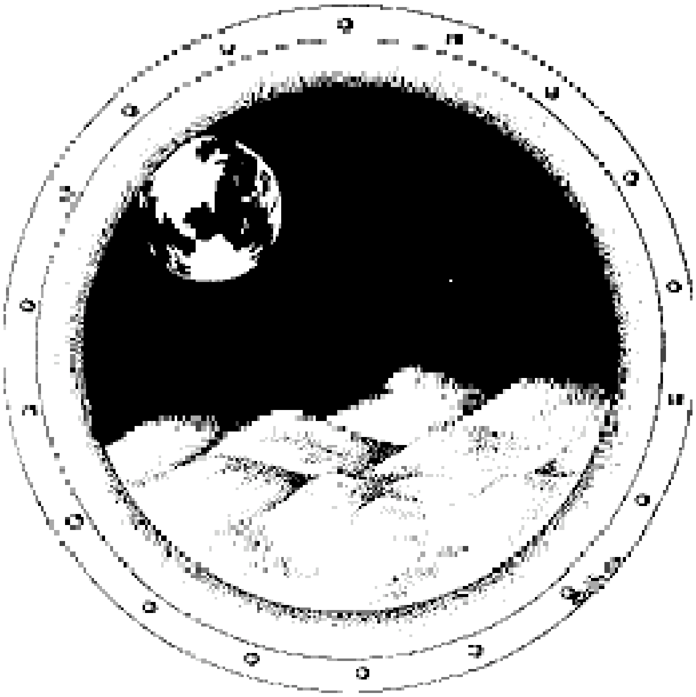
Several interesting tidbits about minerals and properties of the Moon that have been figured out in the last 30 years:

- **High titanium** content found in mare rocks by Apollo 11 **may be an anomaly**; it doesn't seem to be that high anywhere else.
- "**KREE**P" (potassium, rare earth, phosphorus) **concentrations seem to be all in Oceanus Procellarum** - from analysis of thorium abundance on the Moon by Lunar Prospector, since thorium is one of the KREEP elements. This indicates that, during the period the Moon's crust was solidifying, the Procellarum area was the last part to stay liquid. Other geological processes from that era may have led to other mineral concentrations.
- The **South Pole-Aitken basin** has altitude differences of 16 km from nearby crater rim to the bottom of the basin. It **appears to be the oldest lunar basin**, but it would be very interesting to the history of the early solar system to figure out whether it is closer to 4.3 B years old (when the lunar crust solidified) or to 3.8 B years (when the oldest basin on the near side formed).
- Some of the "highland" areas actually have mixed content, and seem to be where there once was a basin and mare, which was since broken up and buried by debris from big impacts.

Anyway, some hope for differentiated mineral deposits for the Moon miners among us :-)

Arthur P. Smith < apsmith@aps.org >

MMM #172 - FEB 2004



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A Vision for the Moon

From "The Lunar Declaration"

In 1999, at the first annual Lunar Development Conference in Houston, Texas, the Space Frontier Foundation presented the Lunar Declaration, written by Foundation president Rick N. Tumlinson, which was signed by many of the conference's attendees [including the MMM Editor].

Selected paragraphs quoted below - full text at: www.space-frontier.org/Projects/Moon/lunarpolicy.html

" ... it is the destiny and responsibility of our species to expand our civilization and the biosphere of our home world outward into space.

" ... it is our duty to assure that this movement is safe, supportable, sustainable and unstoppable.

" ... the Moon represents the next and most vital step for humanity as we expand beyond Earth orbit. "Be it as a training base for future human explorers of Mars and other worlds, a supplier of precious materials for the development of clean energy on Earth and construction in the space between planets, a home to observatories that will probe the cosmos, a location for commercial enterprise including hotels, or simply as land to be settled and owned by individuals who are willing to stake their lives and fortunes to open its bounties; the Moon represents a new opportunity for an unprecedented partnership between the public and private sectors that will results in savings to taxpayers and profits to those willing to take the financial risks." **<SFF>**

Using "Marsten Matting" to build Frontier Roads on Moon & Mars

WWII Instant Runway Technology to the Rescue?

by Peter Kokh

Recently (January 25, '04), in cable TV channel hopping, I chanced upon a History Channel "Mail Call" episode that described an ingenious World War II technology used to provide stabilized runways on the quick in newly conquered territory. Bulldozing and grading are the first steps, of course, but these measures alone did not guarantee runways that could stand up, without rutting, multiple landings of heavier aircraft.

To the rescue, a soil-stabilization technology using open-grid matting invented in Marsten, North Dakota, hence the name "Marsten Matting." You won't find a dedicated article on this on the web, though there are hundreds of references to it. So our source remains what we saw in the History Channel episode.

"Marsten Matting" in its first iteration, consisted of open grid steel panels on the order of a foot and a half wide and 12-15 feet long. They interlocked to provide a continuous mat that could be beat into the loose soil, so as to support landing aircraft and aircraft taking off.

Eventually, long runs of such matting would arrive on scene, pre-interlocked and folded, so that it could be just pulled off a flat bed of a truck and put into place, instead of each panel being carried by a pair of GI's. The design of the mats changed over time, becoming ever more strong and stable. Lighter Aluminum mats, were tried also.

Sorry, but we have no pictures to offer you. Our best advice is to try to catch a rerun of that "Mail Call" episode. But if you do find a website with more information, please let us know at kokhmmm@aol.com.

Translating Marsten Matting technology to the Moon & Mars

In our recent article on the construction of early lunar roads, MMM #169 , OCT '03, we described a vehicle which in one operation would shove aside surface boulders, and grade the soil, then compact it with a trailing weighted roller. The compacted surface could be further stabilized by microwave fusion of the surface powder. This might be enough to support light vehicles and light traffic.

But it would seem prudent to construct lunar roads to be able to handle heavy equipment traffic from the outset. Paving them with "lunacrete" - lunar regolith with added made on Luna Portland cement - presupposes an industrial ability to make that additive in quantity. And the operation of paving roads in this way could be time consuming. Could there be an easier way?

Perhaps the use of "Marsten Matting" open-grid panels made locally on the Moon, along with microwave sintering of the regolith fines filling the grid openings, would do the job. A lot would depend on how the grid was designed and the materials of which it was made. What are the options - realistic options for an early frontier outpost wanna-be-settlement - options appropriate to an early frontier not so diversified industry?

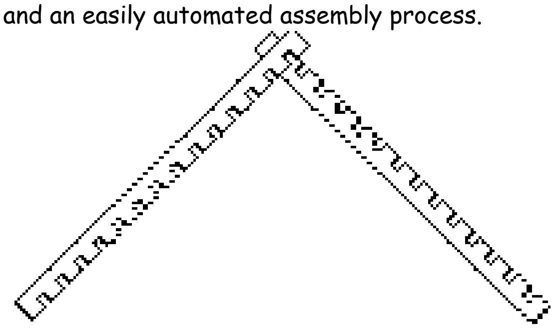
Steel seems desirable, at first blush, but a plant to make steel out of the iron fines in the regolith would seem to be a very ambitious undertaking for a small outpost. You'd want to first produce iron-enriched or beneficiated soil, then extract the iron, add the needed alloying ingredients, then pour the molten steel into the needed molds, then combine them into the desired mats.

We can make objects out of iron more simply, just by sintering free iron fines, small particles extracted from the regolith with a magnet and then sifted. But while "powdered metal" technology is good enough for some "low performance" items, this method could only produce brittle and friable mats that would disintegrate under the passage of the first vehicle.

Aluminum? The plant and equipment necessary to produce aluminum would also be prohibitively extensive and expensive for an early outpost. Magnesium or Titanium? As with aluminum and steel, we'd have to have the prior capacity to extract and isolate the needed alloy ingredients.

Glass would seem to be an unlikely candidate. But mid-eighties experiments by Goldsworthy-Alcoa funded by grants from Space Studies Institute, showed that glass fibers, made from crude lunar highlands regolith (with a relatively high melting point) and embedded in a glass matrix made from crude mare regolith (with a relatively lower melting point, lowered further still with a lead dopant brought from Earth) would produce a hardy composite with "twice the strength" of common steel. (Our advice has been to forget about imported lead as a dopant and to use readily producible lunar sodium and phosphorous which would lower the matrix melting point almost as much.)

A follow-on SSI study showed that a highlyautomated plant to produce glass composites on the Moon need weigh only a few tons, making it ripe for a lunar startup industry. Open grid mats could be designed tailor made for the fabrication methods that prove most workable for lunar glass-glass composites. Square mats of criss-crossed interlocking identical spars would require only one mold and an easily automated assembly process.



Larger glass-glass composite grids of similar design could be used to stabilize steep shielding berms. **‹MMM›**

Moon & Mars Surface "Landscaping" Tips
from Winter Snow Gardens & Japanese Zen Gardens

by Peter Kokh

Settlers, whether on the Moon or Mars, will live in cozy "Hobbit Burrows," their homesteads comfortably shielded and sheltered by an overburden blanket of local regolith (meteorite-pulverized rock powder). When they visit their neighbors, or go to school or work or shopping, they will make their sorties in the "middoors" environment of shielded and sheltered passageways and thoroughfares.

What would they care about the out-on-thesurface appearance of their shielding mounds and their contiguous surface perimeters? Surface landscaping might seem to be of little concern. This may be the case for many of them, even those whose homesteads have separate airlock access to the surface, probably an upscale luxury.

Yet "keeping up with the Joneses" is a hard habit to break, and one which many pioneers may take along with them. We spoke about ways to give special decorative treatments to shielding mounds in MMM #55 MAY '92, p 7. "MOON ROOFS." Once someone does something special and it receives a spotlight moment in the evening TV news or in the Luna City Home & Gardens magazine, the race will be on for ways to do likewise, if not better.

In truth, out-vac appearances are more likely to be a civic concern relative to the approaches to the settlement airlocks, to the settlement spaceport, etc. But once there are multiple settlements some distance apart, roadside "inns" are likely to arise, and if there are more than one, a competition of appearances is sure to rise. Similarly, the approaches to the offices of industrial park factories and enterprises are sure to be a budget line item in their design and construction.

So how would an out-vac or surface "landscaper" go about enhancing the scapes that nature has provided? That's our topic

Moonscape and Marsscape givens

On the Moon and Mars, any exposed bedrock and any given rocks and boulders already on site will become the starting point for landscapers who may choose either to leave them in place and add more scavenged from elsewhere, or to rearrange them in more artful clusters. The same goes with the natural shape of the terrain: flat, rolling, cratered, etc. The landscaper may like what nature provides or to add a hill here and a dale there.

All these features provide the "bones" of the landscape to which the frontier landscaper can choose to add carefully placed color-contrast* sculpture accents - or, of course, to leave untouched save for a few gentle tweaks. After all, some moonscape and marsscape scenes need no help and beg to be left untouched. Others may be rather blah, devoid of interest, and from the settler's point of view, in need of a little "tender loving makeover."

* On the Moon, colors that stand out in contrast to the monochrome light to dark graytones: yellow, orange, red, green, blue - bright greens predicted to stand out best. On Mars, colors that are opposite or next to opposite on the color wheel from the ochres, rusts, salmons, and yellow-beiges of the terrain - bright greens and blues especially.

Tips from Winter Snow Gardens

As I write this article from a friend's home in the countryside south of Milwaukee, there is not quite a foot of snow on the ground, refreshed yesterday, and the view out the south window-wall is spectacular. True, no signs of life - except for fresh tracks of rabbits and other hardy critters - but then, of course, I am referring to plant life. It must seem to most southerners (and many a maladjusted northerner, alas) that "winter" and "garden" are two concepts that together, just don't "compute." But I have another friend who makes his living by landscaping for whom the two concepts fit hand in glove. Some of his ideas suggest approaches future surface landscapers on the Lunar and Martian frontiers might take to heart,

Even in winter, the "bones" of trees, shrubs, and some perennials still stand proud, even above blanketing layers of snow. If we have taken care to arrange those plants in a pleasing fashion, that beauty still shows in silhouette. Included are any landscaping rocks and boulders we may have added to the mix. Gardeners should think of "how it will look in the winter" when making garden and landscape improvement decisions.

To these "bones" we may have taken care to add color accents here and there. Apart from green evergreens and the yellows of tall grasses and the reds of dogwood twigs, there are garden "grazing balls" and other sculpture accents in eye-catching colors, made of metal, glass, ceramic, cement, wood, and plastic. They will be even more appreciated in winter settings.

Analogy to Ice Sculptures

In Milwaukee, St. Paul, and Quebec City, (and perhaps many other northern cities where winter revelry is not uncommon) there are annual winter ice-sculpture and snow-sculpture competitions. Like the monochrome landscapes of the Moon and Mars, northern snowscapes can be magnificent desolations of a narrowed family of related shades. We can predict that frontier artists will make sculptures out of the surface rocks and regolith soils of the Moon and Mars. To the artist and sculptor, nothing is so tempting as free raw material in abundance! [In MMM #22 Feb '89, "First Souvenirs" we wrote of the imaginative creativity that arose in abundance after Mt. St. Helens scattered ash all over Washington State in 1981.]

To sculptures made of raw regolith and rock, the pioneer landscaper can add sculptures of cast basalt, concrete, glass and glass composite, and metal. Crude sintered powdered iron sculptures will hold up well as an early choice. before lunar industry has developed to the point where steel and other alloys can be produced.

Tips from Japanese Zen Gardens of Sand, Rock, & Stone

In Japan, gardens frequently include a Zen area of careful, spiritual compositions of sand, stone, and rock. These inanimate garden spaces demonstrate that we do not need trees, shrubs and other plants with which to landscape our sterile and barren moonscapes and marscapes in ways that please the eye and uplift the soul. For the zen gardener, it is all about composition, order, peace, and simple minimalism. Frontier surface landscapers are likely to turn to these Zen gardens for further inspiration.

Tips from unlikely scene: disco ballrooms & the 60s & 70s

On the Moon's nearside, where perhaps the bulk of the lunar settler population will live, even the nightspans are bright. The Sun may be "down" for two weeks at a time; but meanwhile, Earth will phase from first half to full to second half. And phase for phase, the Earth taking up thirteen times as much area in the sky and with more than four times the reflectivity, thanks to clouds, snow, and ice, shines some sixty times (read 60 X) as bright on the Moon as the Moon does on Earth. The nearside nightspan will be quite bright by our standards, like an urban area under cloudy conditions, streetlights reflecting off the clouds.

But on the Moon's Farside, the Earth will always be "down, out-of-sight and out-of-mind." So when the Sun is also down it will truly be dark. Just the stars, so many stars, and the Milky Way in undreamt of brilliance and glory. This darkness presents a hip opportunity. Breccias and other moon rocks collected during road construction and other activities can be cut and polished, to reveal, under blacklight, iridescent, fluorescent spots and streaks.

The out-vac surface landscaper can arrange such cut rocks artistically, providing nightspan black-lighting from hidden viewpoints to create a fantasy scene out one's habitat periscopic picture windows. To this, farside sculptors working in glass, glass composite, and ceramic may find a way to had blacklight sensitive texture to their creations.

Perhaps the first installations to be so landscaped will be tourist resorts in the "limb regions" of the Moon, where, thanks to orbital "libration," Earth is sometimes just over, sometimes just under the horizon. The attraction of such locations is the opportunity to experience in one place Earth rise, preceded at times by the city-lit hemisphere that happens to be in darkness, then Earth hovering just over the horizon, Earth-set, and the glory of truly dark star-spangled skies. Think a combination of Niagara Falls and Las Vegas. Blacklight fantasy gardens would be a natural, to be copied in miniature by some farside homesteaders and hotels and roadside inns etc.

Imagination is not only fun. It gets things moving. Take a cue and take heart. **</MMM>**

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The Earth and Space Foundation

http://www.earthandspace.org

**"The Earth as an Oasis,
cared for by a space-faring civilization"**

The Earth and Space Foundation is an interna-tional charity that funds scientific exploration that helps us both understand the Earth's environment and explore the frontier of space, bringing the environmental and space exploration communities together to address the challenges facing society.

Vision Statement - "The Earth as an Oasis, cared for by a space-faring civilization".

Mission Statement - "Society now faces the dual challenge of the environmental preservation of the Earth and the exploration of space. Both are essential to our quality of life and our future. Neither goal can exclude the other and success in either requires boldly advancing on both. By supporting and encouraging exploration that bridges these complementary goals, the Earth and Space Foundation seeks to promote and fulfil the vision of Earth as an oasis, cared for by a space-faring civilization."

The above is the mission statement of the Earth and Space Foundation. From remote sensing of endangered habitats using satellites to the study of microorganisms and human performance in extreme environments to understand the potential for life on other planets and assist in the human expansion to these new worlds, there are universal ties between space exploration and environmentalism. Since its establishment in 1994 the Foundation has helped support over 40 projects around the world. This work includes field research that uses space technology and information to help protect and understand Earth's environment and field research that applies environmental knowledge to help us to explore other planets.

The Earth & Space Foundation, originally founded as the Twenty-one Eleven Foundation for Exploration in 1994, forges links between the space exploration and environmental communities. It does this by helping to fund innovative field work around the world that either uses the environments and resources of the Earth to help understand extraterrestrial environments and assist in the exploration of space or uses space technologies and information to understand and care for the Earth's biosphere. By doing this it seeks to bring the environmental and space exploration communities together to address the challenges now facing human society.

Through its work the Foundation seeks to fulfil the vision of "the Earth as an Oasis, cared for by a space faring civilization".

Categories of Expeditions Supported

The Foundation funds expeditions that either use Earth's resources and environments to help us understand other worlds and assist in the exploration of space or expeditions that use space technology and data to help us understand and care for the Earth's environment. Typical categories of expedition that are supported include:

1) Using Space to Help Maintain the Earth as an Oasis

- Environmental projects using technologies resulting from space exploration. Includes the novel use of satellite communications, GPS, remote sensing, advanced materials and power sources.
- Use of data from extraterrestrial expeditions to help further our understanding of the Earth's environments and the biosphere. Includes samples and data returned from missions in Earth orbit and beyond.
- Effects of the space environment and space exploration on the Earth. Includes expeditions studying impact craters, environmental surveys of launch complexes, approved meteorite collection expeditions.

2) Using the Earth to help Understand Other Worlds and to Create a Spacefaring Civilization

- Astro- and exobiology related fieldwork. Includes field research in Earth's extreme environments that assist in the search for life off the Earth and the study of the survival of life in extreme environments.
- Field research applying the Earth's environmental and biological resources toward the human exploration and settlement of space. Includes the use of extraterrestrial 'analog' environments on Earth to test space technologies and human physiological and psychological studies in extreme environments.
- Astronomy at the interface between Earth and space exploration / astroarchaeology. Includes expeditions making astronomical observations from remote, difficult to access, Earth locations, archaeological field projects studying the development of early civilizations that made significant contributions to astronomy and space sciences, field expeditions studying the way in which views of the astronomical environment shaped the nature of past civilizations.

3) Fostering Appreication of the Links Between Environmentalism and Space Exploration

- Educational fieldtrips and projects that improve public understanding of the links between environmentalism and space exploration.

Past Awards: In 1998, the Foundation awarded $1000 to the Haughton-Mars Project on Devon Island. The Foundation has also supported research to perfect radar detection and mapping methods of ice, for eventual use on Mars.

NOTE: Earth and Space Foundation is *not a membership organization,* but depends on donations to fund its awards program.

</MMM>

Lavatubes

By 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, 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

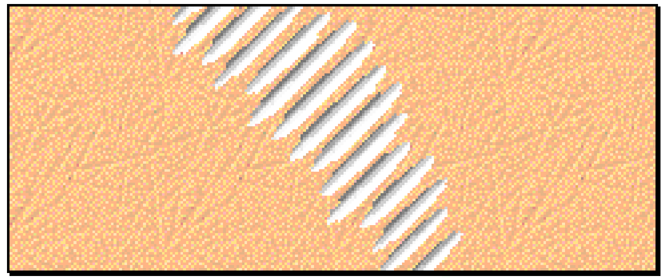
If the surfaces of lunar lavatubes prove to be sensitive to blacklight, a host of practical questions remain before installation of a blacklight system can become a technically and financially feasible project. The tubes are vast in size and a lot of power, lamps, and wiring would be needed. For "dayspan-only" 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 sculputes, 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>**

NOTE: for more on fluorescence in rocks, visit:

Tozour Family's Fluorescent Rocks Links and Updates Page
http://mywebpages.comcast.net/jtozour/links/links.html

MMM #173 - MAR 2004



The Sand Dune Fields of Mars

There would seem to be photographic indications as well as geological reasons that Mars might well have a thinner regolith (rock powder) blanket than the Moon. If we want to use regolith to shield our outposts from cosmic radiation, we may have to look for areas where wind has accumulated dunes of regolith dust. Fortunately dune fields seem to be common on Mars. See below.

Guest Editorial: " Why Should We Send Humans to Mars? "

© 2004 by **Thomas Gangale** <marcus@martiana.org>

In September 2003, as I prepared to leave the San Francisco Bay Area to deliver a presentation at an aerospace conference in Long Beach, one of my professors in International Relations asked, "Why do you want to send people to Mars? Isn't better to focus on robotics for now?"

It is cheaper to explore with robots, but not necessarily better. Despite the advance of technology, there remain tasks that humans can better accomplish using machines in situ than via remote presence.

In 1969, NASA presented a plan to the Nixon Administration to send humans on Mars 12 years later. The report by President Richard Nixon's Space Task Group concluded, "NASA has the demonstrated organizational competence and technology base, by virtue of the Apollo success and other achievements, to carry out a successful program to land man on Mars within 15 years." Since that time, there have been no insurmountable barriers to landing humans on Mars... except the societal will. With each robotic mission to Mars, with each new advance in technology, the technical problem of sending humans to Mars becomes easier. What once were "known unknowns" become "knowns," and "unknown unknowns" become "known unknowns." Once we know that we don't know something, we can research the problem and master it.

This is not to say that it will not be a difficult, dangerous, and expensive endeavor. It will be. However, at this point, we are far better prepared to send humans to Mars than we were to send humans to the Moon when John Kennedy made the decision to do so in 1961. At the time that Kennedy issued his stirring challenge to the nation, America had only 15 minutes of experience in human spaceflight--none of it actually in orbit around the Earth--yet eight years later humans walked on the Moon. In 1961, we had not sent a single successful robotic mission to the Moon--much less to any planet--yet eight years later humans walked on the Moon. In 1961, we had launch vehicles capable of putting only a couple of thousand pounds into orbit around the Earth--yet eight years later humans walked on the Moon.

In the 35 years that it has been feasible to launch a humans to Mars program, we have chosen not to. We will do so when the necessary social and political forces align, and that is something that is difficult to predict. It could happen tomorrow, or it might not happen for generations.

Perhaps the desire to go to Mars can be explained in part as a cultural afterimage of Lowellian Mars. Victorian civilization was convinced that it was on the verge of making "Contact." It was an age when the New York Times reported Nikola Tesla's plans to send radio waves to Mars and communicate with its inhabitants. As we better acquainted ourselves with Mars in the scientific sense in the course of the 20th century, there came, as H. G. Wells wrote, "the great disillusionment." We came to realize that in terms of sentient species, we are alone in the solar system. Yet a faded echo of Lowellian Mars remains. We cling to the hope of a neighboring planet that harbors, if not canals and an advanced civilization, at least some primitive forms of life. If Mars contains even nano-bacteria--or indisputable evidence of past life of the simplest forms--this will profoundly change our conception of our place in the universe. If there is--or was--another Genesis here in our own solar system, then life must be common throughout the universe, and "Contact" with another civilization is therefore inevitable.

Do we need to send humans to Mars to discover this? No, not necessarily. It is possible that robotic missions to Mars could make such a starting discovery. But machines alone are not as capable as humans and machines working together in situ. So, if robots do not find life on Mars, the question remains open, even if just a crack. Eventually, we humans must go to Mars ourselves to definitively satisfy our curiosity.

As forbidding an environment as we have come to know Mars to be in the past few decades, it is nevertheless the most Earth-like planet in the solar system, the most readily accessible from Earth, and given sufficient technology and infrastructure, it will be able to support human life. It is true that Mars is a far cry from our own abundant, life-giving world. The photographs returned by the first robotic fly-by probes in the 1960s should have erased forever the previously held romantic, softer, mental images of Mars, but perhaps they have not erased them entirely. Perhaps these are the true "ghosts of Mars," the spirits of our own past imaginings, and perhaps this is because we want to have neighbors on another world, because we do not want to be alone. Perhaps this is because, even if we cannot make "Contact" with the Other, the Alien, in our own solar system, we do not want to be confined to this Earth.

Is it worth spending tens , possibly hundreds of billions of dollars, to send humans to Mars? In considering this prospective question, it is useful to ask a retrospective one: was it worth it to send humans to the Moon?

There are certain indelible images of the age of photography: Battleship Row in Pearl Harbor on December 7, 1941, the Zapruder film of Dealey Plaza on November 22, 1963, the twin towers of the World Trade Center on Sept. 11, 2001. These not only capture specific events, but also define the specific locales and eras in which they occurred. But the images of the Earth that we brought back from the Moon are timeless and universal, because they are the first images of all of us. Ever since then, because of those images, we have looked at ourselves, each other, and the Earth in a new way. The image of the full Earth brought back by the last crew to return from the Moon is an enduring icon of environmental responsibility and human unity. Was it worth going to the Moon to bring back even one of those photographs of Earth? I believe that it was.

The most important thing that we discovered on the Moon was part of ourselves. In the few hours that a few of us spent on the Moon between 1969 and 1972, we became better Earthlings. As the poet Archibald MacLeish, wrote, we were "riders on the Earth together." We realized that we were our brother's keeper, and we remembered that God had appointed us stewards of the Earth. And yet, a third of a century later, we must reflect on how pitifully less we have done with that revelation than we should have. It is high time that we journeyed outward to that distant perspective, to see again how close we really are to each other, and to relearn those lessons that have faded with the passing of a generation. There are new lessons to be learned on Mars. There are new poems waiting for us on Mars.

If Mars is dead now, but was once alive, understanding how Mars died may give us a crucial understanding of how close we are coming to killing the Earth. Just as no one could have foreseen the transformation of human consciousness that going to the Moon would bring about, no one can predict the further transformative experiences of going to Mars. However, history suggests that this will be the case.

How we go to Mars is as important as whether we go. In the 20th century, a single nation went to the Moon on a Cold War double dare. In the 21st century, let it be a united Earth that goes to Mars. Going to Mars, then pushing outward to the stars, will be a parallel process with other human developments in a push-pull relationship. Going to Mars together will go hand in hand with coming together here on Earth. Bringing life to Mars will go hand in hand with assuming responsibility for the competent stewardship of life on Earth. Bridging the gulf of space to meet and understand the Alien will go hand in hand with tearing down the obstacles of greed and prejudice that are the source of alienation on Earth.

The science fiction novelist Robert A. Heinlein wrote that "the Moon is a harsh mistress." All of the new worlds will be harsh. We will live close to the edge of extinction out there, and learning to survive on those other worlds will bring us closer to immortality. We will learn to depend on each other for our very lives as never before--Africans, Americans, Asians, Australians, Europeans, all of us. The New Frontier will be punctuated by tiny habitat modules, not sprawling with the wide-open spaces of the American Old West. We will live in enclosed places, in each other's faces. All the pretentious barriers that we erect here on Earth will melt away in space. We will come to know each other--and ourselves--as we have never done before. We will push the outside of the envelope of what it means to be human. Living together so closely, so inti-mately, so inescapably, will tear down social and psycholo-gical walls that we need not and dare not consider here on our comfortable, capacious, suburbanized, subdivided Earth. There will be new challenges to human dignity, privacy, individuality, intimacy, and polity. One wonders whether Kennedy grasped the full import of his own words: "We set sail on this new sea because there is new knowledge to be gained and new rights to be won."

I am an engineer, and I am studying to be a social scientist. I am supposed to be dispassionate and logical. But after pondering my professor's question for four months, and indeed, pondering it for most of my life, I find that I come up short. Exploration is always to some degree a leap of faith into the unknown; it touches the human heart, which cannot be weighed on a double-entry ledger of risk and profit. As many are the rationales that can be offered in favor of exploration, as many can be counter-posed. Faith cannot be explained or defended rationally. Bounded only by the ever-expanding limits of the possible, the greater the challenge, the greater the human appeal for the endeavor.

Our parents' generation went to the Moon. Now it is our time. Will we go to Mars? Will we let our children dance among the stars? Will we take the leap?

< http://www.martiana.org/ > < tgangale@jps.net >

The Sundial – First Artwork on Mars?

Bill Nye, the popular "Science Guy" of PBS fame who took the small square and post used as a test pattern to calibrate Mars Polar Lander's color panoramic camera got a second chance after that mission failed. Two duplicate sundials landed safely on Mars on the **Spirit** and **Opportunity** rovers. Kudos to Bill Nye and the Planetary Society! This is one piece of art that has millions of kids excited.

Roadblocks to an Open Mars Frontier

by Peter Kokh

While many Mars enthusiasts are encouraged by what President Bush has called for, what is omitted from his remarks show need for a more sober appraisal.

- There is currently no commitment to more than one exploratory mission, and that only to a pointless "flyby"
- Any commitment to a permanent outpost is far behind
- A commitment to an outpost with real growth potential is further off yet
- Any agreement to open Mars to settlers is beyond the horizon

How do we tackle this?

- Let government do what it will; it is a start and its money otherwise hard to come by
- *But also* try to get government to do *things we can build upon* to get to the next step. Each step must be a pregnant one, an enabling one. This is a strategy of "industrious patience"
- Lobby to get governments to allow tag-along industry/ enterprise initiatives
- Meanwhile, work hard to get a lunar outpost off on the right foot, each step enabling the next, with industry and enterprise involved, developing local resources, self manufacture of many needs, and development of income-earning exports. This will create a model for the Mars Initiative to follow. - PK

Moon – Mars Project Commonalities

by Peter Kokh

Mars enthusiasts are quick to point out the "positive" differences that, in comparison with the Moon, make Mars "special." Mars has an atmosphere and plenty of volatiles: hydrogen, carbon, and nitrogen that, on the Moon, are orders of magnitude more scarce. Mars also has a more manageable day-night cycle. All true, but in many practical respects, irrelevant.

The atmosphere is thin, below 1% of Earth normal pressure. We'll need very similar pressurized habitats and facilities on both worlds. More, Mars thin atmosphere offers little protection from cosmic rays, solar ultraviolet, and solar flares. Habitats on Mars will have to have as much shielding as those on the Moon.

On both worlds we will expand first with hybrid rigid inflatable modules, then by modules produced out of locally processed materials.

Life support systems, food production, medical systems, recycling systems will all be the same.

Transport systems to Mars and to the Moon can have many elements in common.

Power? We" need nuclear back-up on both. **<PK>**

Martian Sand Dune Rows

May make ideal Settlement Sites

by Peter Kokh

A different situation than on the Moon:

The Moon's surface is covered with a regolith layer of pulverized rock and rock powder, varying in depth from 2-5 meters, 6-16 feet. This blanket is the result of eons of meteorite bombardment. It comes in handy. Mineralogically it is representative of the crust in general and forms a "pre-mined" sample, making unnecessary either tunnel mines or strip mining. The fine powder effectively traps volatile atoms and particles from the solar wind, a gift of great economic importance. And for human outposts and settlements, regolith is an effective shield against cosmic rays and solar flares, when piled up 2-4 meters over all pressurized modules and structures.

On Mars, however, there is a thin atmosphere. While this is slim protection against larger meteorites, it is enough to protect against smaller incoming debris, which burns up in Mars' atmosphere as it does in Earth's. The result is that Mars' regolith blanket may well be thinner than the Moon's. That in places, the feeble Martian winds have been able to uncover unpulverized bedrock, as is apparent in the area being explored by the Opportunity rover, is anecdotal evidence that the regolith may be thin.

Another question concerns the presence of perma-frost and how close to the surface it may be. In short, it may be quite a bit more difficult to scoop up regolith to use as shielding on Mars, as compared with the Moon. To be sure, this is all no more than speculation, on the author's part. But if found to be true., We may have to rethink our options for providing radiation shielding on Mars. This is an important issue, for Mars' atmosphere is not thick enough to offer significant protection from cosmic rays and solar flares. Signing a waiver not to hold the government respon-sible for radiation damage to one's body or systems, is not the answer. This is nothing to be cavalier about.

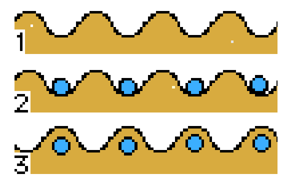
In MMM # 42 FEB '91, p4 Atmosphere Derived Shielding for Lo-REM Martian Shelters, we explored the idea of "mining" Mars' atmosphere for shielding materials. In the article, we suggested dinitrogen pentoxide which is a powder through out the entire thermal range to be found on Mars. It would extract nitrogen and oxygen from Mars air for this purpose. Geoffrey Landis objected, pointing out that this is an explosively unstable compound. But another option is simply to use the carbon, extracted from Mars atmosphere, 97% carbon dioxide, 3% nitrogen by weight, to make graphite powder. In the process, signifi-cant amounts of water, other useful compounds and impor-tant chemical feed stocks would be by-produced. A major advantage, as pointed out in that article, would be to leave the terrain surrounding the outpost pristine, undisturbed.

On Mars, as on the Moon, we will eventually build settlements, industrial parks, and warehouses in lavatubes which provide built-in structural shielding. But here we are talking about surface outpost options.

On the Moon where regolith covers just about everything, an outpost could be built in the bottom of a rille valley, and regolith pulled down on top of it by raking the valley sides. We might do the same in smaller craters. On Mars, if the regolith layer is thin in comparison, this may be a less attractive option. What can we do?

The dune fields of Mars: a unique structual opportunity:

Mars Global Surveyor has found many dune fields on Mars, areas in which there are neat rows of dunes. [See http://www.msss.com/moc_gallery/m19_m23/full_jpg_map/M20/M2001660.jpg] Some of these dune rows are in large crater bottoms and in inter-crater valleys. Most interesting are the long narrow rows of dunes extending many miles down the bottom of winding valleys or rilles. Whether these valleys were carved by water or lava is immaterial to the point we wish to make. The point is that each dune in a handy pile of regolith powder or sand, and the troughs between each pare of dunes, a logical place to put a habitat row. To cover the havitat with shielding, just pull down one of the dunes on top of it. To expand the outpost, put another habitat row in the next trough, and pull the intervening dune down on top of that one, and so on.



Of course, we will need to use dunefields where the dunes are of useful height and volume to cover what we put in each trough with a layer 2-4 meeters thick. The dune fields found on Mars so far, include some that are of just the right range of heights to make this a practical idea.

Questions of stability and preservation:

It is only natural that on Mars, feeble winds will have concentrated most sandy powder in basins and valleys and that dune fields in such terrain are common. Stability, however, is a legitimate question. Dunes on Earth migrate over time. But Mars winds are feeble, and dunes there may migrate much more slowly than on Earth, possibly making them suitable for human use as outlined above.

But quite another question, and a legitimate one, is whether dune fields should be preserved as "geologically special," giving them protection as "national monuments or parks." Clearly we will want to preserve the most outstan-ding dune fields. But there may be enough such fields, that the use of a few "prosaic" dune fields of "commonplace" character, could be used as settlement sites.

Some areas of Mars, notably the great shield volcanoes, should be laced with lavatubes. Other areas on Mars may not be so blessed. Dunefields may provide a pracitcal shelter option. <MMM>

Being Playful on Mars

Arizonesque Burlesques on Mars?

by Peter Kokh

Where comparisons end

While much of the crater-pocked southern hemisphere of Mars seems rather "Moon-like," other areas of Mars bear comparison to places many of us have visited in movies, if not in person, in Arizona, Utah and other desert locations of the American southwest. But try going outside on Mars in a short sleeve shirt and pair of blue jeans, and it will become painfully (if not fatally) clear in a matter of seconds, that Mars is not Arizona or Utah.

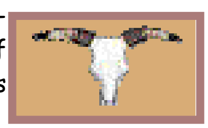
Not only is the air unbreathable and way too thin, but the temperatures range from a high of"cool" down to "cold well-beyond bitter." But there is more about Mars to shatter the tourist poster image. No life anywhere! At least none visible to the naked eye; no tumbleweeds, no lizards, no scorpions -- not even a sun-bleached old steer skull.

Nor will we any relic of a previous wave of human (or alien) pioneers. No ghost towns with empty saloons and doors swinging in the wind. No broken down wagons or even wagon trail ruts. No signs pointing to watering holes.

Yes it is desert. Yes there are canyons and arroyos in the midst of a never-ending dry season - and sand dunes galore. You may see a dust devil now and then. The sun will be mercifully only half as bright. But the color of the sky will tell you at once - if all else has failed to make you take note - that this is not any desert on Earth

Why not do something about that?

So what if Mars is not a desert like any on Earth? In a respectful effort to put a "welcome home" touch on their homestead and roadway horizons, future pioneers could add playful elements to the scenes out their habitat windows to enhance similarities and reminiscences: wagon ruts, broken down old wagons, sun-dried steer skulls, dead trees, tumbleweeds, etc. None of these would be the real thing, imported from Earth at an exorbitant expense. They would be creations of frontier artists, made of craft mater-ials processed from the elements on hand.



"Out-of-place?" Strictly speaking, perhaps. But Mars will no longer be a "virgin world." Such objects would be a promise of a more humanized Mars to come. No can we underestimate the importance of "let's pretend" humor to the morale of immigrants displaced from comforts they had always taken for granted. Inserting allusions to familiar Earth frontier life and scenes is one good way to soften the intimidating power of the bleak and unforgiving landscapes of Mars.

To those outraged and horrified that we would desecrate Mars in this fashion, we say "get a life!" To be human is to have a sense of humor. Desecrate it for whom? The pioneers would honor Mars by recasting it as a marginally livable place, implying that its sterile barrenness can be corrected, that Mars too can be a mother to life. As the Mars Society motto goes, "bringing life to Mars, and Mars to life." And such "additions" could be forbidden in scenic and geological "nature preserves" or "parks."

Using Made-on-Mars Art/craft materials.

When humans come to Mars, it is only natural that they will bring many cultural artifacts and habits with them to help make themselves feel at home. On the other hand, the new pioneers will never truly be comfortable with their newly adopted homeworld until they have learned to express themselves creatively with native raw materials. In time, the carryovers from Old Earth will be overshadowed by original art creations that arise from their frontier experience on Mars. The culture that will emerge will be a blend of Old Earth and this old but virginal planet. Homesteaders may take much inspiration from the rich old American West and Australian outback memories and legends.

While fake trees fully leafed out in a profusion of green, fields of fake wildflowers, with browsing deer etc. would be too absurd a contrast, the relics of dead life such as mentioned above will seem less absurd, less out of place, an admission that Mars may now be dead, put also a belief that it my have been once alive, and may come to bloom again through humanity and the earth-life humans will bring with them to support their mini-biospheres.

Clues from Mars on Earth

Last week (February 26, 2004) I had a chance to visit Mars. No, not M.A.R.S. on Devon Island, nor .M.D.R.S. in Utah - Mars on Maui - the rimcrest of the great Haleakala volcano! The caldera, about 10 miles wide, was an alien landscape of lava rock, cinder cones, rubble, and dust in various shades of rust to black. No sign whatsoever of life - except right on the rim - the peaceful silvery green shrub-size plant known as "silversword." They grew each alone without any other plants around, happily thriving on shallow roots in the "martian" soil, at 10,000 feet. The contrast of the silver greens with the host mars tones of the amazing landscape was anything but jarring, much less obscene. Faux silverswords on Mars would symbolize our hope for a rejuvenation of Mars, making Mars not like Earth, but more like it once was, an oasis of early life.

Enter the wind

One thing Mars has in common with Earth is wind. Yes, with the atmosphere on the shy side of 1% as dense as our own, that wind does not carry much oomph. The dust devils are just that, dust, not sand or grit. The so-called sand storms are dust storms, and the sand dunes are likely gravity-compacted dust dunes. Yet, the wind adds an element on pre-biological "life" to the landscapes of Mars, and that is a factor that begs to be used by frontier artists and craftsmen, in adding humanizing touches.

In William K. Hartmann's science fiction mystery novel "Mars Underground" page 253 (paperback edition) one of the characters, Phillippe Brach, the resident artist, creates a tree of aluminum branches and delicate foil leaves that, like an aspen, quakes in the Martian breezes. His purpose is to symbolize the hope that the citizens of Mars City have in their future. Why not also faux "tumble weeds" of gossamer construction? Set them out and let the winds take care of their "natural" arrangement!

Wind and Sound

The wind may blow but you won't hear it howl. The air on Mars is probably to thin to carry sound that unaided human ears can hear. So? Supply the hearing aids that will do the trick. Piezoelectronic devices are sufficiently lightweight to transmit a signal to devices within the homestead or other pressurized place that will be amplified into the range of human hearing. You might be able to hear those faux aspen leaves rustle.

So why not also create sufficiently lightweight wind chimes? As with wind chimes on Earth, anything that works, no matter what it looks like, should do the trick. And again piezoelectronics will make it possible for outpost personnel and future settlers to hear and enjoy those pleasant chime sounds, varying with the force of the winds, from within the comfort of their pressurized living spaces.

Mars of Yore, and Lore

If young Mars did bloom with life, the odds are that it was microbial. Yet that doesn't preclude visible microbe colonies or mats as have been found in fossil form on Earth. If we find any, we might "recreate" more of them, detectable in the mars scapes by their texture and perhaps color.

But more inspiration is to be found in imagination of Percival Lowell of a dying Mars still clinging to life through the engineering feats of its brave and wise inhabi-tants. Wide corridors of vegetation hugging thousands of miles of canals a network extending from the poles to the water starved temperate and tropical regions of the planet. Landscape architects could playfully create "ruin sections" of canals, now tastefully dry, of course.

And then there are the images, indelible in the minds of those of us who grew up with "Tarzan" legends of the creatures and other denizens of "Barsoom" in the illustrated "John Carter on Mars" series of 11 novels (1911-41) and comic book of Edgar Rice Burroughs, the man also behind the pre-Hollywood Tarzan stories. "Replicas" of the giant six-legged thoat steeds, fierce cat-like calots and other critters might someday be found on a Mars in process of humanization. After all,some of us indulge in pink plastic flamingos! And in addition to the creatures of Barsoom, why not some "wrecked" fliers and other vehicles?

Other science fiction novels of Mars may supply further sources of artistic inspiration. Who can tell?

Tourist attractions

How many of all these possibilities will be pursued by individual homesteaders is anyone's guess. Tastes and humor both vary widely in any population, witness the great variety and amount of home gardenscaping and lawn sculptures in our various communities on Earth. But owners and proprietors of commercial properties, while they may also vary greatly, are more likely to have the money to pursue such embellishments in abandon, both as customer draws and as recognizable brand trademarks.

Roadside Inns and resorts may lead the way in both directions, transplanting relics of desert areas of Earth and pioneering fresh arts and crafts creativity inspired by the new frontier. Both fake allusions to fami-liar and vaguely similar frontiers, and fresh expressions of native inspiration will be draws for travelers and tourist. Businesses may also be more likely to field replicas of Barsoomian beasts and vehicles. One can foresee theme parks or indoor gardens à la Barsoom. See MMM #41 DEC '90, p6 "To Inject a Unique Flavor into Martian Settlement Culture, add the Romantic Touch of Old Barsoom"

Earthside Deserts will continue to inspire

One attraction popular for immigrants and their children would be a museum featuring displays of various terrains and cultures of Earth. Those that will strike a chord of familiarity will be portrayals of desert and other extreme environments on the homeworld. The children may find rain forest and maritime displays too unbelievable to be of interest, too irrelevant to their own experience.

In Milwaukee, there is a trio of geodesic domes housing tropical, desert, and temperate zone plants. I once had imagined that on the Moon and Mars, a recreation of the tropical rain forest area would be most fascinating for the pioneers. But as a lets-pretend pioneer, on each visit, I am drawn not to the rich tropic dome, nor to the temperate plants I grew up with, but to the desert home, as probably more in synch with the pioneer experience.

While some will be horrified by the prospects foreseen in this article, most pioneers will need to "hang loose" (old Hawaiian advice) as a matter of psychological survival. What can it hurt? **<MMM>**

A Barsoom Glossary – Illustrated

People - Places - Things - Culture - Technology
http://www.erblist.com/abg/

Do maps of Barsoom and Mars line up?

1440x721 pixel map of Edgar Rice Burrough's Barsoomhttp://www.geocities.com/area51/dreamworld/6532/barsoom/maps/barsoom_large.gif

Jetan – Barsoomian Chess

http://www.erblist.com/abg/jetan.html

Instruction: Materials Science, Usage, and Mastery

University of MarsPort

Manufacturing Materials Program [MMM]
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marsport.edu.mars/materials_masters.html
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678-8337

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You may be qualified for a Guild Apprenticeship in Exo-Materials Mastery. If so, you can apply for available apprenticeships to learn your chosen trade under Masters proficient in various art, craft, and sculpture materials processed here on Mars.

To find out more, visit us online at:

www.mars_acguild.org/apprentice.html

627-8377

Materials Producers, Exposed

Ares Exoplastics

We are producers of synthetic materials from MarsAir-derived chemical feedstocks, formulated to withstand prolonged UV and cosmic ray exposure.

We also manufacture **Faux Desert Creations®**, our own line of limited warrantee test products, sold to alleviate the cost of our continued experimentation and research, in our effort to develop fully exposable exoplastics able to serve as surface building materials.

For a catalog of available materials and their properties, or a catalog of ready to purchase artifacts, or to inquire about employment opportunities in research, testing, production, and sales, visit us at:
online: www.ares-exoplastics.com.mars
phone: 273-7396 -- email: info@ares-exoplastics.com
showroom: 880 Aaanthor Way SE, MarsPort

Tourist Attractions, MarsPort

A Piece of Old Barsoom

E.R. Burroughs Outdoor Museum

The real Mars is not the Barsoom of novelist Edgar Rice Burroughs. But what can it hurt to pretend!

Transport yourself back to that fictional yesteryear on ancient Mars, to a time of survival and chivalry and heroism. Visit the Avenue of the Quays in ancient Aaanthor and the Avenue of the Ancestors in Greater Helium. Behold our recreations of apts, thoats, calots, and other creatures encountered by that first visitor from Earth, John Carter, related in Burroughs novels . published way back in 1911-1941 common Earth era.

The Travel Channel (Earthside cable and satellite service) has called us "the only 5-star tourist trap on Mars." and we're only too proud of that rating, with plans to make our exhibit bigger and better.

Open daily, one hour after sunrise to one hour before sunset
2500 Spaceport Bypass Road, MarsPort
Photo Gallery: www.barsoomonmars.com.mars
More information, Group Visits: **227-7666**

The Dejah Thoris Hotel

Designed inside and out in Barsoomian fashion by famed Mars architect, Tars Carter. Our courteous staff is in full period costume. Our halls are punctuated with niches featuring characters from ERB's novels: green and red men, four-armed tharks, heroes, heroines, villains. Enjoy Barsoom indoors in shirtsleeve comfort.

Open to hotel guests and casual visitors alike.

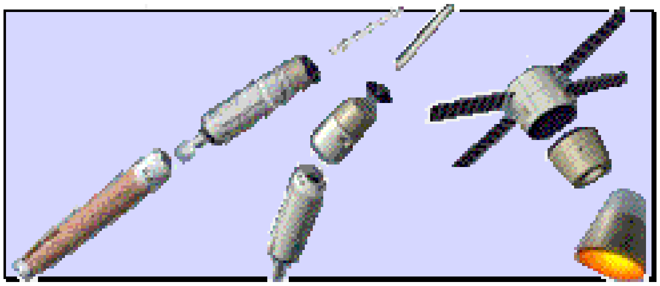
www.marsport.com.mars/hotels/dejahthoris/
100 Pioneer Square, MarsPort
Information & Reservations: **384-6747**

New Old Tucson

A domed "must see" museum of the Old Desert South West, complete with a Ghost Town, and a circular nature walk along the edge of the dome with living Earth desert plants on the inside, faux dead plant and animal life and abandoned wagons just outside. Enjoy our one hour guided tour and visit our souvenir shop.

Just across from the MarsPort Botanical Park
1500 Spaceport Bypass Road
www.newoldtucson.com.mars
Visitor Information & Events Hot Line: **682-7663**

MMM #174 - APR 2004



The Proposed Crewed Exploration Vehicle

Lockheed-Martin's Crew Exploration Vehicle will include a Crew Cabin with no attached payload space - cargo would fly separately. The wingless capsule would return to Earth much as did the Apollo Program's Mercury, Gemini, and Apollo capsules, using a ballistic trajectory, simple replaceable ablative heat shields, and parachutes for at-sea landings. Well-proven technology.

In FOCUS: Crew Exploration Vehicle Modularity Brings Opportunities

When NASA designed the Space Shuttle Transportation system, It was an integrated package that left little room for private enterprise to offer competing components that would plug into the system at various points. Only SpaceHab, which designed and built an "extra pressurizable space" module that could fit inside the Orbiter's payload bay, was successfully able to piggyback on the System.

Yes, there have been many designs for "shuttle-derived" vehicles, the new parts of which might have been provided by private enterprise, but despite a host of suggested uses and applications, no company succeeded in coming up with a business plan that was workable enough to attract the necessary venture capital.

The Shuttle was supposed to be reusable and economical. After it went through the political meddling and design by committee, we had neither. It was "overhaul-able" and extremely expensive to fly and turn around.

Bow that a decision has been made to replace the aging shuttle fleet with a "Crewed Space Exploration Vehicle, the CEV, we have the unique opportunity to design the CEV infrastrucure in a way that would invite private enterprise to plug in at verious points with new and improved designs for the various CEV modules..These include the two stages of the expendable launch vehicle, and the modular parts of the Crew Vehicle itself. To make this possible, NASA must:

- **carefully design the interfaces** between the various components to make it easy to substitute, new and improved modules at evry point
- **publish the specifications** of this interface infrastructure so that any company capable of designing and building alternative vehicles with greater capacities, and more attractive design features, could do so.

What are the possiblities? More powerful launch boosters, enabling larger and heavier Crew Cabin modules for more ambitious missions. Bigger Crew Cabins could carry larger crews and/or more supplies and provisions for longer deep space msisions. Such developments would lead to for-profit missions with vehicles configured with fully compatbile hardware, something essential for repairs, rescue, and salvage. By this design route and strategy, a CEV common infrastructure could lead to for-profit missions to the Moon and nearby asteroids. - Editor

Sub-Selene Aesthetics
and Lunar Resource Usage

by Dave Dietzler < Dietz37@msn.com >

[**selene:** Greek equivalent of Latin Luna]
[**sub-selene:** below the lunar surface, as in lavatubes or regolith-shielded habitats]

Finding the elements in the regolith to perk up habitats

Having studied the element abundances reported in the moon rocks sampled from several locations explored by the Apollo Astonauts, I have the utmost confidence that we can get volatiles (Hydrogen, Carbon, Nitrogen, Sulfur, Helium, Neon) and iron [Fe], Titanium, ceramics (titania, cast basalt), glass, cement, Calcium metal, Aluminum, Magnesium, Manganese, Chromium, sodium [Na], potassium [K], Phos-phorus, and traces of Zinc, fluorine, Chlorine and a few other elements from regolith using processes that I and others have described. We can make steel from iron, magnesium, chromium and carbon extracted on the Moon.

Polished steel can be shiny, but most of these materials are rather gray. What about materials that are pleasing to the eye? We can use the Mond process to get traces of nickel and cobalt from iron fines. We must have cobalt to tint glass blue and make sodium silicate based azure paint for artworks. If there are Sudbury [Ontario] type impact sites on Luna we can get copper [Cu], gold [Au], Platinum, Selenium, Nickel, etc. Many of these metals can be used to tint glass and serve as paint pigments. Copper and gold have a beauty of their own.

The problem we might run into is a shortage of hydrocarbons to make chemicals and paint. Many decades after our first outposts, we will build sub-selene towns in lava tubes with bricks and cement blocks, pour concrete floors, make glass walls and windows (some of tinted glass), glass and metal doors, glass fiber cloth drapes tinted with metals, sheetrock and plaster walls.

Our need for a good range of colors

But what about color? We don't want the place to look like an underground prison or hospital. Peter Kokh has suggested flowers, green plants, birds, small fruit trees, goldfish ponds, aquariums, etc. He has also experimented with sodium silicate ("waterglass") based paintings done on glass. [see MMM #s 77, 80 - July, Nov. 1994 "Waterglazing" - www.lunar-reclamation.org/art/painting_exp.htm] These and some tinted glass could really brighten the place up. Just a little bit of tinted glass is needed to make colored flood lights and light diffuesers, so we should be able to create a variety of color effects covering large areas with lights. Neon signs and lights are also possible. [MMM #43 March '91 "Nightspan"] The world within the Moon might have the flavor of nightlife as well as the energizing effect of bright sunshine funnelled in through light pipes. [MMM #66 June 1993 "Let There Be Light"] (MMM Classic #7)

Brick and cement blockwalls don't need to be so grim. They can be covered with plaster. We all like stucco. We can also take clear glass, aluminize it and make mirror tiles to cover inner and outer walls. Steel and glass skyscrapers, like the Equitable building here in St. Louis, are often made of mirrorized glass and they look terrific. We could build mirrored palaces within the Moon.

We can still produce lates paint with volatiles harvested while Helium-3 mining. From 30 billion tons of regolith, an area about 100 kilometers square mined to a depth of one meter, we can get 300 tons of Helium-3, an fusionable isotope scarce on Earth but relatively abundant on the Moon, enough to power the Earth for a year. As byporducts of that mining process, we can also get 1.2 million tons of hydrogen, 3 million tons of nitrogen and 6 million tons of carbon. That should be enough to make quite a lot of plastic, paint, dyes, and other products.

If we emphasize the use of polished metal, stucco, mirrors, tinted glass, colored lights and living things to add color and make attractive interiors and ("middoor") exteriors), we won't have to make so much paint and we can use our precious H, C, and N for more important purposes. Latex paints formulated with a high percentage of volatile organic compounds (VOCs) for fast druying, cause many indoor pollution problems. Fortunately, in the past decade, Low-VOC paints have become available everywhere from the web to your local paint or hardware retailer. Manufacturers of low-VOC paint include Benjamin Moore, Sherwin Williams, Martha Stewart, Dutch Boy, and many more. Such paints might be used in lunar habitat interiors where others would pose major headaches, literally and figuratively.

We could use colored ceramic tiles on walls and floors as well as previously described ways of adding color. {see MMM #76 June 1994 -- MMM Classics #8) As a clue to what elements we would need for metal oxide-based ceramic glazes, see:

http://digitalfire.com/oxide/oxprops.htm

We may not want to go overboard with color and become gaudy. Overall, blocks, mortar, concrete, sheet metal and glass will create a sort of industrial decor like that found in pricey loft apartments built in old warehouses and factories. [MMM #s 146, 147 (June, August 2001 "Urban Lofts & Settlement Style") both republished in MMM Classic #15, a pdf file you can download from either location given at the end of this article.

Until we return to the Moon and explore some subselene lava tubes, we won't know what charms nature has in store for us that will help us make things interesting. But we already know enough to be rather optimistic.. <DD>

From Back Issues of MMM

Back in 1994, we took up many of these topics in MMM #s 74, 75, 76, 77 - April, May, June, August..

#74 Visual & Solar Access
#75 Modular Hab Architecture
#76 Interior Walls and Surfaces (available materials & treatments) & "Trimwork" (substitutes for woodwork)
#77 Upholstery fabrics, what to hang on walls

These articles are republished in MMM Classic #8, a pdf file you can download from either of these locations.

www.lunar-reclamation.org/mmm_classics/
www.moonsociety.org/publications/mmm_classics/

A Pause for Inspiration:

Quotes worth Pondering

"When you are inspired by some great purpose, some extraordinary project, all your thoughts break their bounds. Your mind transcends limitations, your consciousness expands in every direction, and you find yourself in a new, great and wonderful world. Dormant forces, faculties and talents come alive, and you discover yourself to be a greater person by far than you ever dreamt yourself to be."

- Maharishi Patanjali, India, c. 500 BC

"**Clarke's Law"**

New ideas pass through three stages:

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

"You can take a man out of the Earth, but you can't take the Earth out of a man."

The Earth receives only one-half of one billionth of the Sun's radiant energy.

Always listen to experts.
They'll tell you what can't be done
and why.
Then do it. - Robert A. Heinlein

Experimental Lunar Rockets

by Dave Dietzler < Dietz37@msn.com >

Burning Lunar Alunminum in Liquid Lunar Oxygen

Several ways to burn lunar aluminum and LOX in rocket motors have been proposed. Some have suggested a roll of sheet aluminum or foil, wire mesh or a hexagonal array of aluminum bars in a hybrid motor. Aluminum dust and LOX have been mixed up to form a monopropellant.

My suggestions have been aluminum beads fused together at the edges or aluminum dust in a binder of metallic calcium in a hybrid motor. The calcium makes the aluminum more "friable" - able to remain in powder form.

Real situation testing is needed

All these ideas need extensive testing not only here on Earth but in the vacuum and weightlessness of space and in the low gravity of the Moon. Fire burns differently in microgravity. Solid fuels that might slog out of the rocket nozzle on Earth might stay in place in low lunar gravity or in space. LOX / aluminum mixtures might separate in a gravita-tional field but remain suspended in "zero-G."

Rocket motors using aluminum dust suspended in crystalized sulfur, molten sulfur and LOX or molten sulfur and aluminum dust slurry are also worth investigating. A number of small experimental rockets should be tested at the ISS and at the future lunar outpost. Model rocket enthusiasts should get a thrill out of that!

Hydrogen assisted aluminum / oxygen combinations

Also of interest are rockets that burn a slurry of liquid hydrogen and aluminum and/or magnesium powder. A slurry of silane [SiH_4, a liquid quasi analog of Methane CH_4, silane could serve as a "hydrogen-extender"] and aluminum and/or magnesium is also of great interest.

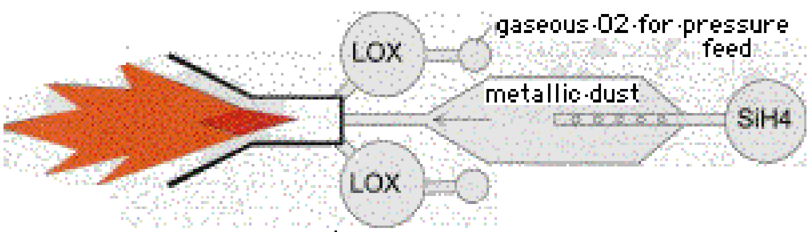
We need hydrogen to make silane and there isn't much of it in regolith. From 100 million tons of regolith, enough to get one ton of 3he, we could get 4,000 tons of hydrogen. That's enough to make 32,000 tons of silane which would be burned with 64,000 tons of LOX. That's plenty for an early mining base, but it won't be enough for tourism! If we can make a slurry of SiH4, Al and Mg that is perhaps 25% to 30% silane by mass, we could greatly extend our hydrogen resources. If you compare two rockets, one using LH2+LOX at 450 seconds and the other using SiH4+LOX at 340 seconds you will find that the silane rocket uses as little as half as much hydrogen.

If there really is six billion tons of water at the lunar poles we don't have to worry about a hydrogen shortage for a long time, but it would be wise to extend our hydrogen resources by making silane anyway. If we could make a slurry of silane and metal based fuels we could slash hydrogen demands even more. Silane has a much higher boiling point than LH2 (-112 C. versus -253 C.) and is much denser (0.7 g/cc versus 0.07 g/cc), so it will be easier to handle, liquefy and store. Rockets running SiH4 will have smaller fuel tanks than rockets on LH2 and this will allow a better mass ratio.

I wonder about the reliability of Al+LUNOX burning hybrid motors. The aluminum fuel could literally fall apart and that would be catastrophic. If we use alloys of aluminum and magnesium which have much lower melting points than either of the two metals they are composed of, things will be entirely different. Since there is so much magnesium in regolith we want to burn it if we can.

Iron, silicon ,and other fuel options

Iron is plentiful and available in powdered form. But it has a very low heat of combustion and the exhaust product is very heavy so iron may not make a good rocket fuel for space vehicles. But powdered iron has been proposed by several investigators as rocket fuel for lunar "hoppers" shuttling in ballistic hops from one location on the Moon to another. Iron oxide powder is the rocket exhaust from such an engine.



Silane carrier gas/powdered metal base fuel rocket motor

Silicon is abundant and it burns with as much heat as aluminum but is harder to ignite and keep burning. Alloys of magnesium, aluminum and silicon must be investigated. So we have a variety of substances to experiment with.

The silane plus LUNOX rocket should be reliable even in a gravitational field. The SiH4, Al, Mg slurry might sludge out in the Moon's gravity. It might do the same thing under acceleration in space. Maybe an in-tank agitation system could prevent that. Perhaps a system using metallic powders flushed into the motor by gaseous silane rather than a slurry fuel would be superior.

Time fordown and dirty homework

The rocket jocks have a lot of research ahead to keep them busy in the future. Perhaps some of these fuel combinations could be safely investigated as part of sciene projects, certianly in College and University Engineering Departments. Now if only we could come up with an X-Prize type incentive for the most promising demonstration! Availability of all lunar fuels minimizing hydrogen would advance the attainment of economic breakeven . **< DD >**

Back Reading from MMM issues past:

"Bootsrap Rockets" MMM #6, June 1987

http://www.asi.org/adb/06/09/03/02/004/bootstrap.html

Modular Container Factories to Industrialize Early Lunar Settlements

by Peter Kokh

[Thanks to Bryce Walden, Oregon L5 for the heads-up lead]

A fairly new project in aimed at Third World Development offers a model for systematic and relatively painless industrialization of early lunar settlements: mini-production plants in mobile containers, transportable anywhere, and ready to go once hooked up to the necessary utilities. This makes time consuming construction of production plants on location unnecessary, along with the inevitable delays in getting all the needed parts, and shaking down the system operations. It also obviates the expense of time-consuming custom plant design. Most importantly, it saves labor time from plant construction and speeds up availability of product production both for the local (lunar settlement) market and for income-earning export, in the case of products in demand at other in space locations (low Earth orbit, Mars-bound freighters, etc.)

The plants use tested fully debugged designs, can be test-operated before shipment, and are modular. If you need to double production, you just gang another module alongside or in series. And they are sized just right for adaptation for shipment to the Moon and other space locations: 40 feet (13 meters) in length, and on wheels - just right for a shuttle-sized payload bay or cargo hold. Worldwide Partners SN World Foundation is the outfit responsible - www.world-foundation.org.

We'd want to do some brainstorming to get our priorities right in designing the plants needed first, i.e which are prerequisites for others. But the whole container plant idea seems quite versatile given the list of those already being manufactured for Third World use. There are an amazing 700 different portable units currently in use.

Just a few of the many varied container factories

Give an idea of the great versatility of this system:

Biosphere & Prepared Foods - Water purification
Bakeries - Dehydrated food - Fruit juice preparation

Construction Materials - Aluminum Buckets
Reinforcement Bar Bending for Construction Framework
Steel Nails - Sheeting for Roofing - Ceilings and Façades
Construction Electrically Welded Mesh - Plated Drums

Synthetics - Injected Polypropylene Housewares
Pressed Melamine Items (Glasses, Cups, Plates, Mugs, etc.)
Plastic Bags and Packaging

Vehicular Equipment - Tire Retreading - Mufflers

Medical & Heath Equipment
Medical assistance mobile units - Sanitary Material
Hypodermic Syringes - Hemostatic Clamps, etc.

Adapting the Container Plant Concept for the Lunar Frontier

What seems especially appropriate about these mobile modular container factories are these two features:

- a uniform compact size, one that would fit in a shuttle orbiter payload bay or could ride to space in a faring atop many of today's expendable launch vehicles.
- that you need only plug it into the needed utilities, feed in the needed raw materials, and start producing

Lunar Industrial Parks Made for Container Factories

That the plant comes in a container is logical, as the walls are attachment points and support for equipment. For lunar adaptation, you could provide a pressurizable container, but on reflection there seems a better idea: use the containers as they come, but place them in a host pressurized industrial park volume, outfitted with utilities and stalls and aisles for service vehicles, supply of materials and removal of products. If we take this approach, some of these mobile container factories might be usable on the Moon as they are. After all, it is clearly inefficient to duplicate systems that can easily be shared.

Situating these container factories within such a host complex offers additional advantages:

- Container Factories requiring the same raw materials can be clustered together
- Clusters could also be based on similar by-products that need to be stored separately for recycling / reuse
- Clusters could be based on a thermal cascade with the plants running at the highest temperatures at one end, the coolest at the other, so that waste heat from one can be used in the next.

The host "industrial parks" could be modular in themselves. As the settlements diversify their industrial capacities, there will be need for more such parks.

Shielding these sizable and expandable industrial parks could be a challenge. If the settlement was placed with foresight near an intact lavatube, that would be ideal. Such a volume could easily house inflatable and other "less-fortified" structures safely, as well as the supply infra-structure needed to keep everything running, plus, and this is a big plus, all the sheltered warehouse space for products waiting shipment to market, whether that be for domestic settlement use or somewhere off the Moon.

A supporting consideration is that lavatubes are most frequent near mare/highland coasts where both the most common suites of lunar materials are readily found. Locating a settlement at one of the poles would almost certainly squelch any chances for industrialization and thus for export-import breakeven, the key to permanence.

What Container Factories should come first?

There are several guidelines here in developing a plan for quick and timely industrialization of the lunar settlements - and timely is the operative word. Until the frontier economy reaches a point where the pioneers can earn enough from exports to Earth (other than energy products and souvenirs, not much) and to other "in-space" markets (low Earth orbit space stations, industrial parks, and tourist clusters - and the early Mars frontier) to pay for the importation of those essential goods and materials that they cannot yet produce for themselves, the lunar settlements will remain "tentative" and vulnerable to the vagaries of economics and politics on Earth. The longer that "permanent human presence" remains subject to such outside irrationalities, the more likely it is that something will develop to force an end to the dream.

The guiding considerations would seem to be these, and *they do not neatly coincide:*

- those products needed for domestic lunar use in the largest per capita total mass, will be most helpful in reducing the cost burden of importing them.
- some products / capacities are prerequisites for the production development of other products / capacities
- products that help build habitat space and utility infrastructure should have priority over those that supply only creature comfort.
- tools production is more important than product
- arts & crafts tools and materials are essential for overall morale because of their capacity to generate a feeling of being "at home" on this challenging world.

The lunar industries dependent on the pulverized regolith surface blanket for raw material that seem easiest to jump start are sintered powdered iron products and cast basalt production parts some of which will find immediate service in materials handling systems. Earliest possible oxygen production is also essential. Beneficiation systems that produce "regolith extracts" enriched in various needed elements will have to be right up there. Surely, glass-glass composites industries requiring less refined raw materials will be an early mainstay. Beyond that, the paths of industrial diversification merit big time ongoing brainstorming by diverse teams of exports.

Humans do not live by Processing & Manufacturing alone

We can also make immediate use of Container Water Recycling & Purification "factories." And to supplement early garden to mouth menus, container factories that produce bread and other basic prepared menu and recipe products will be in demand as soon as the number of people in the settlement is large enough to benefit.

Early domestic products will include glass, glass composite, cast basalt and ceramic tableware and furniture items to furnish new homesteads and make them livable. And this is not a trivial goal. Everything that can be used domestically, can probably be exported at a profit and at a competitive cost advantage to space markets such as LEO and elsewhere, especially if it is well and tastefully designed..

Other early products will be spare parts for vehicles and equipment in common use - certainly those parts that are not complex or sophisticated and do not have critical tolerances - dust fenders, to give one example.

Container Factories and Manpower Needs

While for their original purpose, industrializing Third World communities, automation would certainly be a low priority, for use on the lunar frontier, the opposite is true. On all frontiers in human experience, there has always been more work to do than people available to do it. Any of this container operations that can be automated will free pioneers to work that cannot be so easily disposed of.

Container Factories and Energy Needs

Some operations - cast basalt products, glass and glass composite products, ceramic products, and metal alloy production - require a lot of heat. Heat can efficiently be produced in dayspan by using solar concentrators. All operations will require some electricity, and the amount will vary greatly. Operations that are highly energy-intensive may have to be reserved for dayspan when more total energy is available whether the settlement has a nuclear plant or not. Those operations that have a labor-intensive element that can be conveniently separated out, can run in dual mode throughout the sunth, energy-intensive tasks done during dayspan, labor-intensive ones, such as routine maintenance, changeouts, packaging, inventory, etc. can be done during nightspan. Of course, not all operations will lend themselves so neatly to such an alteration of tasks.

Container Factories and Water Usage

If the settlement is located where the greatest percentage, tonnage-wise, of needed materials can easily be sourced, it will be along a mare-highland coast. Water can be produced by solar wind gas scavenging performed religiously as a part of all regolith handling operations: road construction, site grading and preparation, gathering material for processing plants, transforming regolith into soil for those crops that do better with soil buffering, etc. The regolith would be heated and the gas, mostly hydrogen but appreciable amounts of carbon, nitrogen, helium, neon and argon would be collected and separated. This operation is called ":primage" and it sets the settlement up with resources it would not otherwise have.

If the settlement was placed as close as possible to the nearest polar permashade areas (craters over 20 km in diameter as far as 30° from the pole will do, such as the north coast of Mare Frigoris, it will be situated well for earliest possible start of those operations that there is no other way to do than with intensive water usage.

Summing up

It is clear that the Container Factory concept brightens the prospects for lunar settlements. We need to study this existing model, factory by factory, for adapatability to lunar settlement conditions. **‹MMM›**

A Return to the Moon the Right Way: to Set up a Self-Sustaining Settlement

by Bill Avery < avery6709@comcast.net >

t's all about Financing

A lunar civilization will be financed through the work of the individuals living there. Initially, a self-sustaining settlement must be able to survive and grow utilizing 90% of the labor available from the inhabitants. The remaining 10% will provide labor for products and materials to be exported in exchange for Earth specific items and materials.

Preparing the way for success

Creating this type of settlement will require some preparation work. First there needs to be an infrastructure created that will allow for self-sufficiency. A private industry or a government industry can create this infrastructure. Until a clear profit motive is realized, the private industry probably will not fund such an endeavor. The government, on the other hand, has deep pockets to create such an infrastructure. In fact, NASA's new direc-tive by President Bush should lead to the development of this initial infrastructure.

The infrastructure needed includes transportation to and from the Moon as well as on the surface. Pressurized and unpressurized living and work areas need to be constructed along with regenerative life support systems for the settlers. An assortment of tools and manufacturing equipment would be needed to repair and create all of the required machinery. Finally, a means to utilize raw lunar materials in the expansion of the settlement will be required.

A Critical mass of pioneers

My estimate is self-sufficiency will be practical with as few as 150 individuals. These people would be highly trained and motivated. From a financial viewpoint, people are the ultimate currency. They are the ones creating the products and services civilizations operate on. Money is something you need when you cannot create the products or services on your own. Given the skills, tools and raw materials any settlement can be self-sufficient and grow.

Details can be worked out with settler input

The details of the settlement buildings, the life support, the work areas, the tools, etc. are not discussed at this time. These details are not needed to discuss the 'why' of going to the Moon. They provide the 'how' of going to the Moon. In my life as an engineer, project manager and reactor operator, I could spend years on these types of details. However, concentrating only on these details will not get humanity to the Moon. This article answers some questions regarding the funding of such an endeavor.

When the initial infrastructure is in place and the settlers can maintain a good life style on the lunar surface, the settlement can then begin to grow and prosper. Remember that people create wealth through the application of knowledge to resources. To maximize the use of the established infrastructure, operations need to be conducted around the clock. This results in five (5) crews being dedicated to a specific activity working 40 hours per Earth week. This will allow the settlers 128 hours per week for personal time, which may include the creation of personal wealth through moneymaking projects.

The settlement will utilize a small percentage of service personnel to maintain the life support, facilities, and general infrastructure. Working around the clock in 8 hour shifts will require 5 crews of 3 people each, or 15 Engineers/Technicians. Generally, power production and life support will be highly automated. The technicians will provide troubleshooting and repair with little operational duties.

Manufacturing and construction will require the lion's share of the personnel. A crew of 10 individuals can produce building materials in a small steel/glass/aluminum mill. Another crew of 5 individual would turn these materials into products needed by the settlement or for sale to other parties. These two groups would add 75 settlers to the lunar settlement population.

The addition of a staff of 10 administrative personnel would round out the settlement to an even 100 people. To perform science on the Moon, explore for new resources, and create an export aspect to the settlement, I propose an additional 50 settlers. These 150 highly trained and motivated people will provide a large labor pool to draw on to ensure the success of the settlement. Individuals can be diverted to emergent issues as needed to ensure the survival of the settlement. In worse case situations, the entire settlement could work 12-hour days for several weeks to address emergency conditions. This would provide 12,600 person-hours per week, per shift to address any problems.

From Survival to Prosperity through Enterprise

After the maintenance of the settlement and the expansion of lunar infrastructure are addressed, there is the opportunity to create wealth in Earth terms. By this, I mean provide goods and services to the people of the Earth. An example of this would be to create a hotel for visiting scientists, explorers, government officials, and yes even tourists. The creation of additional infrastructure to support specific science projects for governments and private industry would also bring in Earth currency. The credit earned by these activities would be used to purchase items only available from Earth. An example of this might be electronics.

On the Moon, any type of industry could be set up. Many dangerous or undesirable manufacturing processes could be moved to the Moon. These could include genetic, chemical, biological, and weapons research, manufacturing and testing. As the settlement grows, the construction of spacecraft and support equipment could also become a major industry. The settlers would use the ships for expansion on the Moon, resource retrieval and travel to Mars. They could also sell the ships to governments and private industries.

An additional source of income would be in the form of electronic information. Discoveries on the Moon could be patented and beamed back to Earth. Internet connections could be easily established between the Earth and Moon providing a number of services to both the settlers and Earth. On their own time, settlers could use the Internet to 'work from home' on the Moon and provide services to Earth bound industries.

The creation of products for sale on Earth is a real possibility. The discovery of resources not easily found on earth could provide a justification to ship products to earth for profit. Products could be packaged into a container and sent to earth by using an O'Neil mass driver.

As a final note, the Moon could become the retirement paradise of the solar system. At 1/6th Earth's gravity, elderly people could find a new life in settlement building. Their bodies would no longer be a hindrance in maneuvering around and contributing to the expansion of human civilization.

The Facilitating Role of Governments

The creation of the initial infrastructure is the key to the development of the first permanent human settlement on the Moon. The governments of the world should provide the initial transportation system, habitats, manufacturing equipment, tools and talented settlers for this great endeavor! The return to the world will be beyond expectations as humanity moves out into the solar system.

I urge you to contact your political representative and ask them to support this new goal oriented mission for NASA as set forth by President Bush. If we do not push for a lunar settlement now, we may not get the chance again in our lifetimes. Remember, humans have not been to the Moon for 32 years. There is no guarantee we will ever make it there again. We must make our own future.

You can contact your President, Vice-President, Senator and Us Representative at the following web sites:

http://www.house.gov/
http://www.senate.gov/
http://www.whitehouse.gov/

About Bill Avery:

Bill is a registered Professional Engineer in the State of Ohio and has supported space development most of his life. He is also one of the founders of the Midwest Space Development Corporation (MSDC), The Cuyahoga Valley Space Society (CVSS), and EXITUS, Inc.

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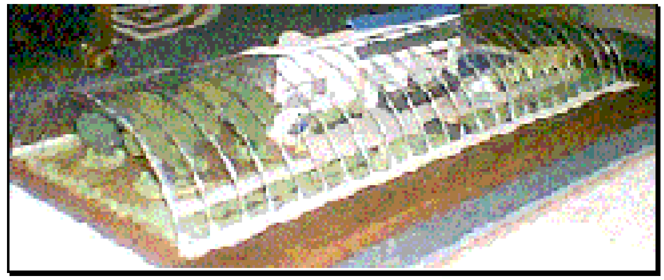


House-scale Biospherics Testbed in Indiana

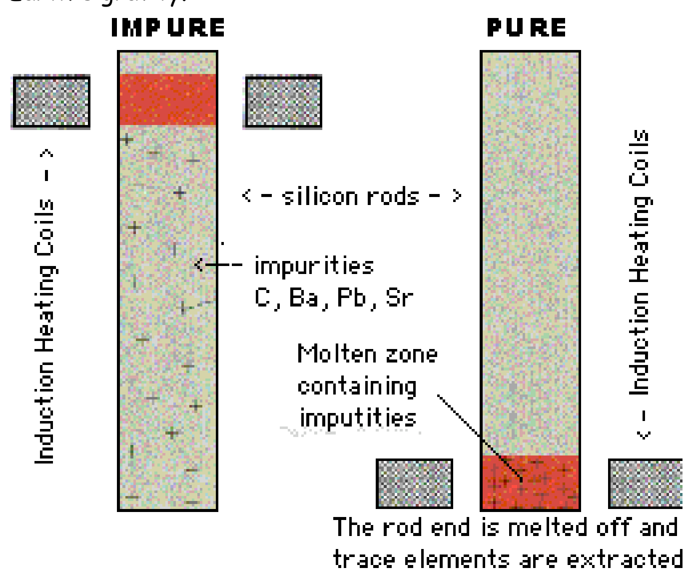
Terry Ryan Kok has been doing biospherics experiments in SW Central Indiana (Needmore/Bedford area) for more than a decade. At right is his door-top model for a "home scale total recycling for self-sufficient living" that he calls the **TerraVita - Ecoark Prototype**.

Zone Refining in Space and on the Moon:

Extracting pure metals and other elements from the Moon's pulverized surface blanket.

by Dave Dietzler <Dietz37@msn.com>

On Earth, ultra-pure silicon is obtained by zone refining. Basically, a silicon rod is lowered through an electric heating coil. As the red hot molten zone moves along the rod impurities that are more soluble in the molten zone are swept along. Surface tension holds the rod together. This must be done in an inert gas filled container or the red hot molten zone will start to oxidize. Only small four inch long rods are purified this way. Huge rods would fall apart in Earth's gravity.



Above:Left: induction coils start to move down along the rod Above Right: The coils have reached the bottom and all the impurities have traveled to the bottom in the melt zone.

What about Zone Refining in Space, or on the Moon?

In space, such limitations do not exist. We could zone refine metal rods amassing tons and do it in the pure vacuum without the necessity of an inert gas filled container. It might even be possible to focus the Sun's rays on the rods instead of using electric heating coils. Any metal can be purified this way in space, including metals that would fall apart in Earth's gravity or catch fire easily.

Zone refining is also advantageous because it does not require any chemical reagents or water which is so precious on the Moon and it concentrates impurities in the molten end of the rod after refining is accomplished. It will be easier to extract trace elements that compose the impurities once they are concentrated.

To build Solar Power Satellites, we need lots of pure silicon. We could go with aluminum foil reflectors and turbo-generators, but those need more maintenance and a larger crew than thin film silicon panel powersats will. Silicon can be extracted directly from moondust with fluorine gas. The silicon tetrafluoride gas that forms can be decomposed with heat and the silicon can then be zone refined.

We can also produce silicon in other ways. If roasted and magnetically beneficiated moondust that has had all the iron removed is leached in sulfuric acid (the most produced industrial chemical also called the "bread of chemistry") a solution of magnesium and aluminum sulfate with trace sulfates will result that can be filtered off and then refined to get magnesium, aluminum and other metals. Silica ($SiO2$), calcium sulfate and some calcium trisilicate slag will remain. These could be separated with washing and/or electrostatic separation (needs some investigation).

Since barium, lead and strontium, present only in traces in lunar soil, do not form soluble sulfate salts they will be present as impurities in the silica and $CaSO4$. There could also be some insoluble chromic sulfate salts in there. This won't make much difference for the $CaSO4$ because that is going to be used for plaster or calcined to get lime, the active ingredient in cement and an ingredient in soda-lime glass.

The silica (silicon dioxide) can be reduced to silicon in a solar furnace with carbon at about 1700 deg. C. This avoids corrosive fluorine gas and is the conventional way to make lots of silicon. Now we have silicon contaminated with carbon and a little lead, strontium and barium. All we have to do is take our multi-ton rods of silicon and zone refine them until we get pure silicon in huge quantities to make giant powersats.

The carbon which is rare on the Moon must be recycled. Carbon monoxide generated during reduction will be shifted to methane and water which are more easily decomposed. Carbon in the rod ends, along with lead, strontium, barium and perhaps some chromium will be concentrated. [See illustration at left.] Some hydrofluoric acid and not very exotic chemistry could get all those separated. There is only about 3 ppm of lead in regolith, so we won't be rich with the stuff, but all we want it for is to tint glass red. After refining millions of tons of moondust we could have a couple of tons of lead, and that should make plenty of red glass.

Magnesium and aluminum-silicon alloys obtained by solar silicothermic and carbothermic reduction of magnesia and alumina obtained from the sulfates obtained during sulfuric acid leaching could also be zone refined to get tonnages of pure metals on the Moon or in free space. Zone refining will concentrate trace elements and make them easier to extract.

As a rule, it is easier to extract more concentrated elements than it is to extract traces. Chromium and manganese, present in raw moondust at about 2000 ppm each, will be present in the Al/Si alloy obtained by solar smelting. Vanadium, zirconium and yttrium, present at about 114 ppm, 311 ppm and 84 ppm respectively in raw regolith, will also be present. If these can be concentrated into the rod ends and then extracted and separated, we will do well. Vanadium is used for titanium alloys, making tool steels and as a sulfuric acid making catalyst in the form of vanadium pentoxide. Zirconium is used in magnesium alloys and nuclear fuel cladding in fission reactors. Yttrium can strengthen magnesium and aluminum alloys, and that is of great importance on the Moon where copper, a major aluminum alloying ingredient, and zinc which is used to alloy magnesium, are rare. If we find lunar Sudbury type impacts this might not be such a problem. We keep our fingers crossed.

Zone refining in space needs to be investigated on the ISS. We must show the way to the future. We could also use a centrifuge on the ISS with white mice in it to see what happens to mammals in lunar 1/6th and Martian 3/8ths gravity fields for long periods of time also, because it looks like we are going to be working up there.

Summary: If my hunch is right, and we can zone refine in space and on the Moon in larger batches (using larger rods) then can get super pure materials with a simple process that doesn't require any reagents. In the process, we zone refine and melt off the end containing impurties. Then we zone refine in turn a rod made of those concentrated impurities. The end result -- a highly enriched concentrate of moodust trace elements.

Since zirconium and vanadium are trace elements at around 100-300 ppm, we might get some decent amounts of these. Zr can give magnesium higher temp. strength and resistance to combusion, although Zr itself is highly combustible. V can be used in tool steels and Ti alloys.

Implications for providing badly needed color.

It didn't dawn on me that we could concentrate lead by zone refining, until I started to write this piece. Lead is present in lunar regolith only in parts per billion, and so is not otherwise economically producible Now we have some red glass to go with the cobalt blue glass and the white washes. This is one patriotic Moon city. Add all that polished metal, pyrite coated iron, rusty stone, shiny black basalt and what have you including some green plants and flowers and this place is becoming livable. Hell, we're living there already in our imaginations. Some people would think we was crazy. What do you think of prisms to cast rainbows of color around?? And birds of many colors. <DD>

Editor's note: Lead is also essntial for high gloss ceramic glazes and without it, we will only be able to produce matte finishes. Lead would also be the "dopant of choice" in making low temperature glass matrix for glass-glass composites. But we can do almost as well with sodium and phosphorus.

Lead is an alloy ingredient of pewter, and has many industrial applications. The only other suggestion to provide lead in desirable abundance that seems viable (besides importation and zone refining) is biological processing, using microbial cultures with an affinity to lead to help concentrate it to the point where it can be economically isolated.

Coloring the Moon – anything but Gray!

A February 16, 2004 email exchange between Dave Dietzler <Dietz37@msn.co> (Moon Society St. Louis) and MMM Editor, Peter Kokh <KokhMMM@aol.com>

PK To build of brick and mortar in lavatubes we'll need some sort of pressurized envelope. We've talked about self-sealing tubes via water vapor freezing in the cracks. Works as long as there is no freeze-thaw cycling going on. Could be tricky. I think we need to find a tube, secure the entrances, generate water vapor and then simulate the kind of fluctu-ating heat-flow that would come from expected human activities of all kinds, and do this for a couple of years as a test. What do you think?

DD Yes. If we are lucky, those lava tubes won't even be that porous. Also, the sub-selene temp. is a fairly constant minus four Fahrenheit. Might not have a freeze-thaw cycle. More investigation is called for. One more job for the early research base!

PK I also suggested use of colored lights and/or colored glass lamp diffusers for casting color shades on whitewash surfaces etc.

DD that's a good idea. One little piece of colored glass and many, many square meters of colored area, and you can change it as you like much easier than if it was painted. Have you ever been to a commercial cave where they use colored lights to decorate within? Meramec Caverns about 60 miles from here [St. Louis, MO] which was also Jesse James hideout is decorated that way. A purist might shudder, but I think they achieve beautiful effects with colored lights there. I haven't been there in years and I suppose they still use colored lights and have not become purists.....

PK Remember the early recycled plastics with swirls of variegated colors within a narrow range of shades? I think we could do naturally variegated gray tones with ceramics, raw glass, and cast basalt products.

DD I don't remember, but we can certainly do grays and black. They can make biodegradable plastic from corn these days. I think they can from soybean also. Don't know much about the colors.

PK Next easiest would be to steam the free iron content and make all sorts of ochre-hued regolith products. We could do this before we have the ability to separate out the elements needed to make metal oxide pigment powders.

DD Could we tint the lava tube walls that way???

PK Paints: have you noticed that some stores now sell special latex paints that are environment friendly i.e. low-volatiles? I wonder what is involved in that. If we are going to use paints indoors, with no fresh air exchange, volatile emissions are going to have to be tightly controlled. We may have to paint things in factory conditions and sell only cured painted objects, i.e. no paints for the do-it-yourselfer that are not near zero-emission of troublesome volatiles. **<MMM>**

A Private Enterprise Teleoperation Potpourri could be an Overture to a Return to the Moon

by Peter Kokh

Those of us interested in establishing private/free enterprise on the Moon have realized for quite some time that grandiose "clean energy for Earth with lunar resources" schemes are not the place to start. With horrific amounts of up front capital needed and a decades-long wait for first "returns-on-investment," such plans are currently untouch-able, however attractive.

No, we have to start small, terracing one humble quick-paying business plan on another. Indeed, there have been a number of start-up proposals, most involving "vanity products."

- **sales of land** - rather disreputable, because no one has title to land on the Moon, a prerequisite for selling any
- **crash landing personal items** on the Moon: from business cards to personal archives of text and photos
- **crash landing** of a "pinch" of one's personal "**cremains**"

Applied Space Resources was the first to explore the Archive idea. They concentrated on archive sales but had no vehicle to get the archive to the Moon except one on paper. Now TransOrbital, with an actual vehicle, Trailblazer 1, seems poised for launch. It would do orbital photographic surveys at unprecedented resolution, and at the end of its mission, crash into the Moon's surface bearing an impact-surviving canister of archival materials.

Popular interest in such archives, planned to survive for thousands of years, has been light. MMM's first article will be aboard the Trailblazer canister, however. It is time to ramp up to the next step, costing more money, but probably also guaranteed to spark more interest:

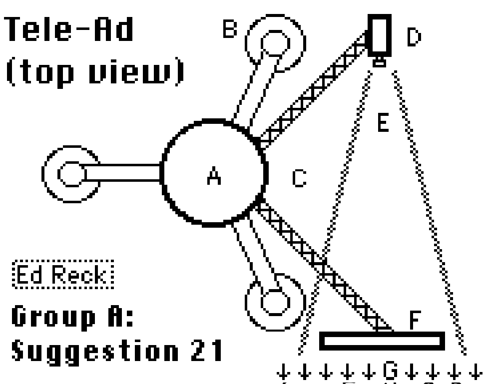
Teleoperable Landers & Lander-Rovers Racers, Message Boards, and More

Applied Space Resources, Luna Corp, and Carnegie Mellon University have all had detailed blueprints for lunar landers. Alas, without viable business plans, none of these efforts are still alive. The dust-gathering plans are a place to start, however, for anyone who would take up the challenge anew. With 22 start-up companies in the race for the X-Prize, which may be won yet this year, interest in private enterprise space ventures is vigorous and growing.

So we dust off those plans, taking the best of each and put together a teleoperable lander or lander-rover. Whatventures could be built on such a platform? Plenty!

Several Moon-soft-landed teleoperable for-profit ventures have already been suggested. In one scheme, two identical teleoperable rovers would be available for tele-driven races, with the Earthside drivers selected by lottery or highest bid. If the racing rovers survived the event, they could be raced repeatedly, as long as public interest was high enough to generate good money.

The 1995 First Contact Science/Science-Fiction Convention in Milwaukee featured a "Commercial Moonbase Brainstorming Workshop." [See MMM # 91 DEC '95, p 14. Commercial Moonbase Brainstorm Workshop] at which perhaps the most interesting suggestion was that of artist Ed Reck who proposed a lander with a power and communications package [illustration below]



A. lander core B. One of three landing pads C. retractable booms; D. videocam E. Videocam's field of view F. Electronic message board tele-changed from Earth. G. Background scenery.

Ed's idea was simple. Earth-bound romantics could send greetings messages ("I love you, please marry me"; "Honey, please forgive me"; Happy Birthday, Happy Anniversary, Happy Valentines Day) or product/service advertisements to be displayed on the electronic message board against a real live moonscape background. This idea is simple and could be accomplished with highly miniaturized equipment, and thus a smaller power pack and landing vehicle.

As for investors, this enterprise would appeal to many: Hallmark, E-cards, AT&T, and new entrepreneurs. The message board would include Earth-time (Universal or in the time-zone of the sender or targeted recipient. It could include local Moon time (day of the sunth) and even an inset window onto a tag-along lunar sundial. Messages could be public, or private (costlier?) As to background moonscape, this could be static or panned. Of course, you would want your Lunar Messenger to land in a scenic location!

If the Message Board was high resolution, it could showcase photographs and pieces of art as well as simple messages. Advertisements could incorporate logos and pictures of products or service providers or customers.

Another idea would be to land a server or an Internet relay on the Moon, for "Moon-based Chat Rooms" and Moon-relayed email messages. This might not be an independently viable venture, but it seems to be one that could be piggybacked on the Lunar Messenger above, for added income. Indeed, any such business plan should brainstorm a wide variety of piggyback-worthy ventures that could be supported on the Messenger Lander without adding significantly to its weight or power demands.

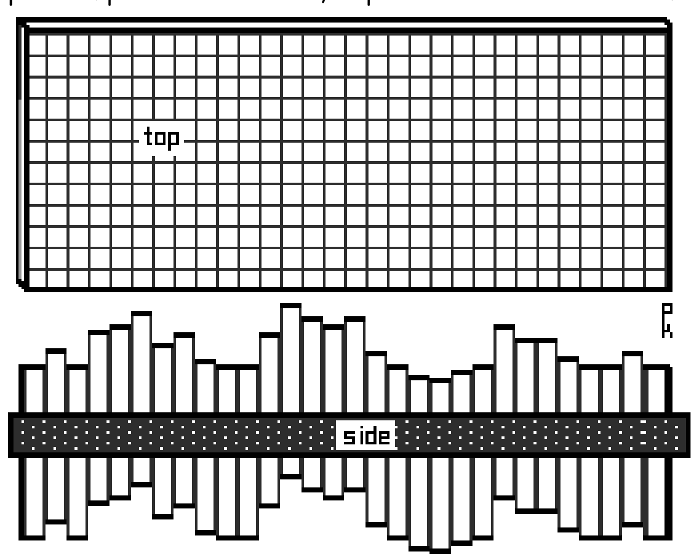
Tele-Crafted Art Objects

The nest step beyond Moon-relayed messages and advertisements could be tele-art. We are still in the realm of products delivered to Earth-bound customers electronically, no physical objects shipped. What more could teleoperable landers and lander rovers do or produce for telesales on Earth? As with video games, progression from the first ping-pong games to todays multi-megabyte games played on high definition screens, the potential for progress from first humble offerings to sophisitcated products is great. And what better prospectus could you have for a tele-operable space enterprise!

The idea is simple. The lander, or lander-rover is equipped to make things in, or out of, the regolith moondust at its location, and relay photos of these creations back to Earth for the enjoyment of their telecreators, gift-recipients, and others. What are the possibilities?

Drawing in the moondust with a "stick" or wand: the moondust is cohesive enough to hold crude shape. The crisp Apollo bootprints are ready proof of that.

Getting beyond the stick, a stamper made of tele-extendible pixel rods or bars could stamp any sort of pattern/picture in the soil, dependent on its "resolution."

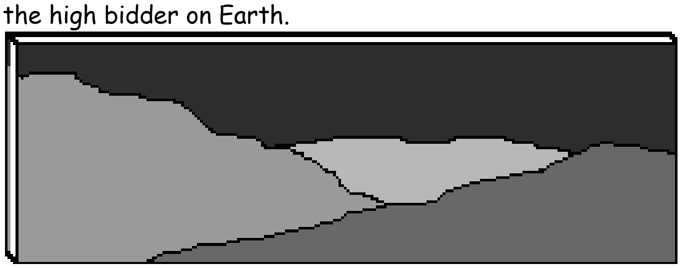


The ability to "fix" the stamping by micro-wave sintering would be an asset. People could order "moon bricks" (to remain on the Moon but with their photos relayed back to the person placing the order) with their own name or the name of a beloved or departed person. The stamping could be a handprint or footprint or bootprint. Or it could be a simple message. The apparent drawbacks of this idea are (at least) these three:

1. the scale would probably have to be large, if keeping with the degree of detail and resolution desired
2. the lander rover would have to keep on the move, as it would quickly run out of stampable terrain within reach of its landing spot.
3. if microwave sintering is used to ensure "permanence" the power requirements of the rover would be greater

The next step beyond simple stamping would involve altering the moondust to telecreate art objects and sculptures out of crude moonglass and ceramics. Once we get beyond simple microwave sintering, the power demands go up along with the temperatures involved. Iron fines gathered by a magnet, could be shaped and sintered (powdered metal technology) into objects of art. Glass making would be more ambitious. A solar concentrator mirrow could supply the high temperature needed. Designing tele-shapable mold aparatus would be the trick. But perhaps someone out there is up to the challenge.

Quite another idea is to sift the moondust and then run it through an apparatus capable of sorting the particles for shade and color. A teleartist on Earth could draw on the bin sorts to create "sand paintings" in twin-paned glass frames open at the top, and webcast to Earth. If these could be preserved somehow, they could be traded on some sort of Art Futures market, against the day further into the future, when they might be retrieved and shipped to the high bidder on Earth.



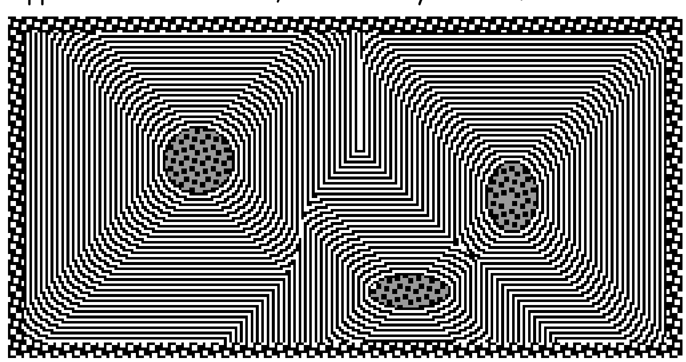
The same sort of thing could be done with glass spherules sorted from the moondust, and again sorted for color. The visual effect and texture of the "painting" would be different and richer. The coarser rock and aggregate bits removed by the sifting process, could always be added back in, sparingly and deliberately placed for the desired accent. Preservation of such art objects could be by microwave sintering. The big trick is to supply, or make, a suitable durable substrate for these fragile creations.

Glass and iron-fine jewelry and coins have been suggested, but again, these ideas are for the next round, when shipment back to Earth is possible and affordable. We are more concerned with objects of art that can be tele-created on the Moon, and enjoyed long-distance via the web or relayed photos, auctioned off in an Art Ftures market against the day when they might be retrieved, or become part of a lunar sculpture garden for future Lunans to enjoy.

A more ambitious idea would require a rover with a manipulator arm that could pick up tele-selected rocks or breccia aggregates and pile them up into interesting sculptures. Without some sort of glue or binder, however, this possibility seem limited to gravity-shaped piles. In that case, the art would be in the choice of rocks and the overall visual "texture." On a grander scale, a sculpture on Earth could create a lunar Stonehenge of sorts. A lunar Stonehenge could even be designed to showcase astronomical events. An installation of this sort along the 90° E or W longitudes, in the middle of the limbs, could be designed to show maximum elevation of Earth above the horizon, i.e. librational extremes. How long it takes for the teleoperated device to create any such grand object is immaterial, if the device is solar-powered. All that is of concern is that the device be strong enough to handle the largest sculpture component that needs to be moved, as opposed to being left in place.

Primitive prehistoric stone works could serve as inspiration. Such larger scale art projects would endure indefinitely, to the delight of the eventual pioneers. And for them too, such rock works would be "prehistoric," tele-made on the Moon before the arrival of first settlers. Perhaps this doesn't conjure up anything of much interest to most readers. But then most of us do not have the unbridled imaginations of artists, and of an artist turned loose in a brand new medium!

Besides Stonehenge-inspired creations, artists on Earth could make serene Zen/Japanese rock gardens with well-selected and carefully placed rocks set in a pool of ripple-racked moondust, bordered by a row of smaller rocks.



Zen gardens can be created around any trio (the desired number) of nice boulders left in place, simply by raking the regolith around them, piling up the rake-removed smaller rocks in a row around the perimeter. That would remove the need to select and move the bigger rocks that are to be the garden's focal points.

All the artistic creations accomplished through a given lander-rover-manipulator would remain in one general area. A sunset task for this teleoperated art machine might be to grade and tamp down, and possibly sinter, a "sculpture garden pathway." Then the rover would make a final video tour complete with documentary script, with the originaol artists making the voice over commentary.

Such sculpture gardens would in time be visitied byactual tourist visitors, from the settlements and from Old Earth itself. Such a park could be named after the lander-rover-sculptor ("Moonsculptor I"), or after the most award-honored individual creation in the park (e.g. Moonhenge III Sculpture Garden), or simply after a prominent nearby geographic feature ("the Taurus-Littrow Prehistoric Sculpture Garden.") The finishing touch of working all these tele-creations in a Garden Park would help counter those who object that we are "defacing" the Moon.

Without the presence of weathering agents other than the light incessant micrometeorite "rain" that should take many of thousands of years to errode the Apollo bootprints, these creations will endure in their exposed setting for a very long time. The more highly-valued can always be relocated within some future settler museum.

Prospects for Tele-art on the Moon

We are not talking about art created by robots - robot art. Real human artists on Earth, their hands inside virtuality teleoperation gloves, would go through the motions of placing, shaping, working moondust and moon rocks into the object conceived in heir heads. For first timers, this will be a learning exprience and preconceived ideas of what they will be able to do may quickly go out the window as they learn hands on what they can and cannot do, both via teleoperation, and with actual moondust and rock. Some will get the hang of it faster than others. And some will produce objects of more widespread appeal than others.

Can we do the same thing on Mars? There is less than a 3-second time delay in the execution of a teleoperated command on the Moon. For Mars thw delay would range from 6 to 40 minutes. The long answer, however, is yes. One could create a teleoperation program and let the computer execute it, removing the artist from the time delay loop.

Outside of contracts for future delivery, money might come from friends of art sponsors and benefactors, or by sale of lottery tickets for the chance to tele-craft, to extend one's artistic abilities virtually to an alien material on an alien shore. A considerable fringe benefit may be from media exposure and publicity.

The precedent of treating the moonscape with artful respect will strengthen the case for prior agreement on environmental protocols. The Moon has no biosphere to pollute, but that does not mean that it can't be visually "trashed." Tele-created art objects may lead to prior set-asides of geological and scenic preserves, and other guidelines that will guarantee the Moon remains beautiful for its future inhabitants. Meanwhile, the expectation that pioneers cannot be far behind, will spread. **<MMM>**

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 desola-tion" 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 distinc-tive 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 whhat 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 fore-ground pops out and monopolizes our awareness. Absent life, the geology becomes 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 differ-ences between this view and that, between this location and that. In the absence 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.

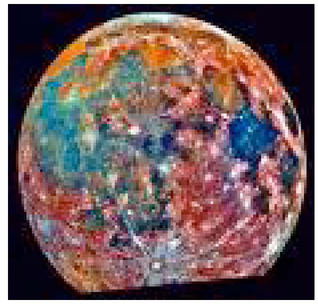
In the near and not to distant future

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 wrap-around 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 video-taping, 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>**

Galileo's Colorful Moon

The Moon is a mono-color sphere - shades of grey, chromatically bounded by some whitish glare and black shadows. The problem is that our eyes, so wonderfully sensitive to faint light and subtle hues aren't good enough.



But spacecraft can use filters to image in wave-lengths that are sensitive to particular elements, and then computers can exaggerate the colors so that our humble Moon looks like a gaudy Christmas ornament.

Such colorized views are good because they help us understand the differences in composition and sometimes age of different parts of the Moon. And we can carry that knowledge back to the eyepiece when observing.

The colors show, as we know from black and white views, that there are two major types of lunar materials. The cratered highlands are made largely of iron-poor rocks which show up red in this 3-filtered image.

You can see though that not all highlands are the same - an orangish area near Schickard (bottom left), and near the north pole must have some compositional differences. And the maria also have differ shades of blue and even some golden hues, showing that they are not all identical. The brightest blue in Tranquillitatis is due to titanium-rich lavas, and the orange mare (parts of Imbrium, Frigoris and Serenitatis) are lower titanium lavas.

Patches of purple blue (SE of Copernicus) are due to pyroclastic (ashy, sort of) rocks. The brightest areas are the freshly (well, in the last billion years or so) crushed and exposed surfaces of young impact craters. Tycho and its rays are clear, but so are Aristarchus, Copernicus, Proclus, and various smaller craters west of Nectaris, near the north pole, and even just west of Plato. Take a look.

Technical Details: Imaged December 8, 1992 by Galileo Solid State Imaging CCD Camera. **<LPOD.org>**

Editor's Comments: Note that the maria, in fact the major low elevation basins on the Moon, are suggestively blue, as if to confirm their nature as "seas" - and they are indeed seas, but of frozen lava rather than liquid water.

This exageration of the Moon's subtle colors gives us a challenge. As is, the magnificent moonscapes will be sources of "color deprivation" for settlers, and we'll have to make that up in our habitat interiors, our vehicle and space suit colors, and other ways. Perhaps we can come up with a form of lunar sunglasses that enhance the subtle color differences already there, much as Galileo's filters did..

Outward bound to Jupiter, Galileo snapped the Moon's colors on its 2nd lunar flyby on Dec.ember 7, 1992

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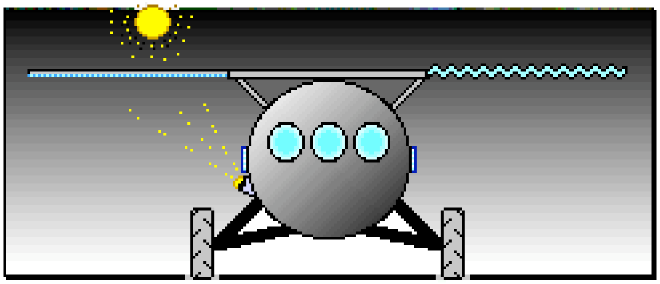


Coach with Special Micrometeorite Shield

During dayspan, travelers on the Moon will have to deal with the very black sky and its high contrast to the glare of the sun off the surface. The Lunar Greyhound Coach at right has a micrometeorite shield testing two eye-relief options,. At left, a spotlight below the window shines upward on a matte sky-blue surface. At right the sun shines through a translucent shield. More, below.

The Exotic Moon:

In Search of Color & Beauty

Available Media will Challenge Frontier Artisans

by Dave Dietzler <Dietz37@msn.com>

Recently, I went to an art gallery here in St. Louis called Macro-Sun International to listen to a sitar player and see some belly dancers. There were plenty of statues of the Buddha, Siva, Ganesh, dragons, elephants, Krishna and lots of fine furniture, clothing, jewelry and incense on sale. Some of the statuary was made of carved stone, but most of it was made of wood or copper.

Once again our limited stable of lunar materials raises its dragon's head to challenge us. We can forget about wooden carvings on the Moon except for the most wealthy men and women alive. Given the geological reality of the Moon, unless we find that Sudbury type impact we dream about we can forget about copper, zinc, tin, brass, bronze, gold and silver. Lunar artisans will have plenty of stone, cast basalt and iron to work with, but not much of the traditional materials.

I guess the bright side is that there won't be any competition with plastic on the hydrocarbon poor Moon, if anybody wants a plastic Siva!! Imagine artisans casting and hammering aluminum, magnesium and titanium in solar furnaces with the use of free lunar vacuum. Red hot magnesium, a fairly soft metal, will catch fire in air but our lunar artisans may do some original work in the vacuum with it. We could have plenty of shiny grayish or silvery statues of these metals. We might even chrome plate them. A chrome plated aluminum Ganesh will truly be a creation of the 21st century!

For the want of yellowish metals we can work with pure iron and then expose it to hot sulfur vapors to form a pyrite finish, a coating of fool's gold. We could put pure iron statues in hot oxygen baths to form a rusty red coating.

But what about glass? I noticed a dearth of glass items in this gallery. Has glass never enjoyed the popularity in Asia that it has in the West? Besides glass flowers and cut glass work, how about a glass Buddha or eight armed Vishnu riding a lion? On sandy silicate covered Luna, we will have plenty of glass and our oriental artisans may find lots uses for it. I can see clear, frosted, iron tinted green and brown glass elephants as well as shiny black cast basalt elephants and dragons. I am sure that it will be more affordable to transport artisans to the Moon and put them to work using local materials than it will be to ship kilotons of finished copper, gold, wood and ivory times to the Moon! I hope they enjoy the challenge of working with lunar available materials as much as we do (at least Peter Kokh and I).

We have discussed neon signs, red and cobalt blue glass filters over spotlights, prisms to cast rainbows of color (some prism fiber-optic light pipe systems will be large enough to illuminate stages with selected colors), plants, flowers, tropical fish and birds to add color to our lunar dwellings.

As I watched the girls belly dancing, I realized that there were other colorful creatures to jazz up those steel and underground lava tube enclosed lunar cities we intend to build someday -- human women with all their finery. Colorful silks, jewelry, cosmetics and such don't amass too much and the girls will be bringing luggage with them anyway.

Going to the Moon is *not* going to be like going to a hospital and being forced to give up your clothes and wear those humiliating hospital pajamas nor will it be like joining the army and being dressed up in a uniform or going to jail with all us cowards. Travelers will have their own clothes, although they might have to wear a G-suit to keep from passing out or getting sick during rocket ascent to LEO.

The fairer sex will have their feathers and dance for us. That will add color to the exotic Moon. Perhaps we can sell them some cobalt blue tinted glass jewelry while they are up there too. <DD>

Relevant Articles in MMM Issues Past

#2 FEB '87 "Moon Garden" *online at:*
www.lunar-reclamation.org/art/painting_experiment.htm
#13 MAR '88 "APPAREL"
#16 JUN '88 Jewelryy
#26 JUN '89 "Thermoplastic"
#43 MAR '91 p4 DAYSPAN; NIGHTSPAN
#63 MAR '93 p 10. Color the Moon anything but 'gray'
#76 JUN '94 p 5. WALL Surfaces & Trimwork
#77 JUL '94 p 4. Inside Mare Manor: "Cinderella Style"

Musing about Space Elevators: Drawbacks & Advantages

by Dave Dietzler <Dietz37@msn.com>

I've been reading up about space elevators. I'll concede that they are possible, but only if we can mass produce C60 carbon nanofiber cables and do it cheap, and only if we have rockets big enough to send the reel of cable plus its electric motors and solar panels up to GEO.

It will take a lot of horsepower to haul things up 22,400 miles so we will need big solar panels array. As David Heck and I agreed way back in December, I believe, space elevators will be slow. If you climb the cable at 1,000 miles per hour, which will take a lot of energy (just consider fuel gulping jets that travel at this speed), it will take almost a day to reach orbit!! A rocket or jet/rocket spaceplane can get you to LEO in ten minutes. This is an important consideration.

And what if the cable snaps? Can you parachute down? You can parachute back or glide back in rocket propelled vehicles if there is an engine failure. The bright side is that space elevators won't explode.

Another drawback is that a space elevator only touches one place on Earth. A rocket can take off from anywhere on the globe. And space elevators can only take you to GEO or fling you off the counterweighted end into space. Rockets can ascend to any orbit and any altitude and any inclination to Earth's equator. So space elevators are not a free lunch and rockets will be with us for a long time.

I do see one great use for near term space elevators - cargo. Humans can fly up in rockets. Cargo can be hauled up slowly to GEO. So what if cargo takes its time or the cable snaps? Cargo is what costs. Humans aren't that heavy. Ten humans with luggage only weigh a metric ton if we estimate 100 kg. (220 pounds) per person and luggage. With an early space elevator consisting merely of a cable and a reel we can send thousands of tons of cargo to GEO. From there it will either be flung off the end of the counter balancing cable at about 44,000 miles up or use ion drives to go to lunar orbit or a Lagrange point station or even Mars. In this way, we can have our cakes and eat them too. We can fly humans via our VTOLs and HOTOLs to LEO space hotels and haul cargo up by cable to save a fortune. Whether it will be economical to send loads of rocket fuel up to GEO and then send it down to LEO via ion drives to fuel up taxis in LEO that they fly to higher orbits, cycling stations or escape velocity i do not know. Making sure all this does not crash into the cable will be tricky.

In Arthur C. Clarke's FOUNTAINS OF PARADISE a 44,000 mile high tower was built. If we just have a big station at GEO and lower a ribbon of C60 nanofiber to Earth's surface and extend a counterbalancing ribbon another 22,000 miles this should be much more practical that a solid tower, and this is something we will be less likely to crash into as it can be reeled up and out of the way with advanced warning!! More to think about. <DD>

Editor's own musing: Hey Dave, what if we have a cable passenger car that rides up the elevator à la maglev? Once the car cleared the atmosphere, it should be able to build up some real speed without heat from air drag or friction from contact with the cable.

But what about power demands? If the power were generated in space by a solar power satellite network, the amount of power needed might not be a problem.

Personally, while I believe a space elevator could work, I am a "doubting Thomas" about finding a way to build it. It is going to be one very tricky engineering proposition, and I'll have returned to stardust long before it becomes more than science-fantasy.

Launchtracks, an alternative to Elevators

As to cargo, let's not forget the other long-talked-about option: launch tracks up the side of equatorial mountain massifs. In essence, a launch track is a grid-powered "first stage" that remains on the ground. We highlighted a set of candidate mountains in MMM # 99 Oct. '96; p 4. "Mountains Made for Launchtracks" - which identified four special merit peaks:

- ☑ **Mt. Cayambe**, Ecuador, 19,160 ft., 0°, 40 m. NE of Quito
- ☑ **Mt. Kenya**, Kenya, 17,040 ft., 0°, 100 mi. NNE of Nairobi
- ☐ **Mt. Cameroon**, Cameroon 4+°N, 13,353 ft., 60 miles from the Nigerian border, 10 mi N of the port of Buea
- ☐ **Mt. Kinabalu**, Sabah, Malaysia, 13,455 ft., 6+°N. Near NE tip of Borneo. About 40 miles ENE of the South China Sea port of Kota Kinabalu, and 80 miles WNW of the Sulu Sea port of Sandakan

All of these are on or near enough to the equator and have reasonable transportation access. The first two are checked for being virtually smack dab on the equator. As such both are candidate mountains for an Earthside terminus of a space elevator, one handy for the Americas, the other handier for Europe, Africa and western Asia. The last, while 6+ ° off the equator, would be handier to Pacific Rim customers.

Lauchtracks have the significant advantage of being deployable from Earth's surface, and involving nothing more exotic than Maglev transportation. Reserved for cargo canisters only, to be delivered to a specified holding area, an orbital ":cargo yard," they could be engineered for massive G-forces and seem significantly more near term. Let's pursue both options, pushing the possibilities as far as they will go, making no premature choices Baloon-launching is another nearer-term option, but one that has met with limited trial success and promises less down the road. **<PK>**.

National Parks on the Moon

by Peter Kokh

World Book: [a] **National park** is an area set aside by a nation's government to protect natural beauty, wildlife, or ... places of cultural, historical, or scientific interest. ... Governments create national parks to guard their natural treasures from the harmful effects of farming, hunting, logging, mining, and other economic development.

The world's first national park, Yellowstone National Park, was established in the United States in 1872. National parks gradually spread throughout the world. Today, about 1,500 national parks ... [exist] in more than 120 countries.

The Moon is "virgin territory," -- well, almost. Intact artifacts left behind by the Apollo manned Moon landings and various robotic missions are destined either to be part of future Frontier Republic historic National Monuments or to be relocated in Lunar museums.

Now is clearly the time to think and act ahead about preserving and protecting some areas of the Moon of especial geological interest or scenic beauty by setting them aside as, for now, International National Parks (to be trans-ferred to the Lunar Frontier Republic as the latter emerges as a de facto civil authority.

There are at least two steps here. The first is the creation by international treaty, provisional classes of lunar "national parks," and a set of "protocols" which would protect them from economic and industrial development, allowing or disallowing road development and commercial "concessions." Of course, once jurisdiction passes to the local frontier authority (a stepped process which should be milestone-driven and established beforehand by treaty to remove it as a political and power-play issue,) that authority would have the right, limited and defined in its own constitu-tion, to review and reset any such protocols.

The second step is the nomination by an international committee of self-selected geologists and other scientists, tourist industry panels, commerce and industry representatives, and interested individuals of specific features or regions to be so protected. This list, to be an "attachment" to the original treaty establishing a Lunar National Park System, could always be added to later on.

For both of these steps, there will be considerable disagreement. Some will want to guarantee the treasured sites on the originally list from any and all human encroachment, while others will seek more pragmatic provisions. A reasonable compromise would be to create classes: class A containing the most protected, class C those only minimally protected. Some will favor only a few original parks, others will want to preserve half the Moon or more. There will be wide differences of opinion on the merits of individual areas to be selected for the original list. But it should be possible to find broad agreement on a starter list, and compromise positions on the protocols governing them.

Mining & Processing Industry Protocols

We have previously pointed out that "Moon mining" is not likely to be an especially "scarring" operation. The elements we need are to be found in the already "pre-mined" impact-pulverized debris blanket of rock and powder, meters-thick, that covers the entire lunar surface: the "regolith." That said, we can split mining operations into those seeking to "produce" elements found just about everywhere or, at least rather widely [oxygen, silicon, iron, aluminum, calcium, titanium, magnesium - all in parts per hundred; others found in parts per ten thousand] and those concentrated only in a few atypical areas. Clearly, any mining activity seeking elements in this first classification, since it can be done most anywhere, can be completely forbidden within the selected park areas and their approaches.

Any rare and strategically needed elements which are especially concentrated in an area nominated for inclusion in the Lunar National Park System, could be mined within the area in question, in a tightly regulated "clean" operation, and then processed elsewhere. What we have in mind is the possibility that we would discover that a protected impact crater area is of the Sudbury (Ontario) type, rich in asteroid-endowed metals otherwise absent on the Moon in economically producible abundances, such as copper, zinc, gold, silver, platinum - all industrially strategic. Lunar geologists have yet to identify any such "heaven-blest" area, it is possible one or more may be identified in the future.

Tourist Industry Protocols

Some areas, chosen for inclusion on the original list for their especial noteworthy geological features, might also be identified as having especial scenic value. Others areas of no unique geological interest, may be nominated for inclusion on the merits of outstanding scenic appeal alone. In either case, if we are not to be left to "tour" them at the end of an Earth-bound telescope or from the porthole of a passing spaceship, we need to consider public access.

Access can be restricted to guided "Eco-tours" aboard "self-contained" excursion coaches, or opened up to do-it-yourself self-guiding tours for individuals in private vehicles. The limited access provisions would apply to especially fragile sites and may include "pack it in, pack it out" regulations to guarantee that human detritus would not accumulate. An option, once traffic merits, would be excursions via suspended monorails or cableways, hugging the high ground where possible.

Once tourist traffic and volume grew to the point where it made sense, could allow and provide for carefully regulated tourist-serving "concessions" within the park area - hotels, restaurants, "general stores," even RV camping grounds. If these operations could be conveniently placed at, or just outside, the park boundaries, that would be preferable.

Transport Corridor Protocols

Roads and trails are an important item to discuss. In some especially delicate areas, we may want to allow only a bare minimum of overland access, keeping the route as "rustic" as possible. For especially scenic craters, rilles, escarpments and other high vantage points, we may want to provide only scenic "rim roads" or scenic overlooks, with no access to the floor or area below other than by specially equipped go-anywhere, off-road vehicles that do not require intrusively bulldozer-graded routes. In a few cases, the Alpine Valley providing access between northern Mare Imbrium and Mare Frigoris for example, we will want to provide for a major highway, a minimum of traveler-serving concessions, and tightly regulated signage.

The merit of transportation access is obvious. How else are we to enjoy these treasures set aside for us? By browsing through a book or watching a DVD documentary? We could provide both, of course, for tourist wannabes and those selecting their itineraries. But for the future Lunans themselves, if not for Earthworms like ourselves, access is clearly in order -- access with thoughtful restrictions.

Some Park-worthy nominations

There are noteworthy areas, features of special scenic interest -- at least form our wrong-end-of-a-telescope vantage point -- in all areas of the Moon's surface: in the nearside highlands and maria; on the farside. As we do not know (although many are prematurely "sure") where the first outpost will be sited, and where early and subsequent industrial settlements will spring up, it will be important to identify candidate sites all around the globe for protection. With my 12" globe of the Moon in hand, I'd like to start the list off with the following short starter-list nominations:

- **nearside craters:** Aristarchus, Plato, Copernicus, Tycho, Theophilus, Proclus - there are equally outstanding craters elsewhere on nearside, that could be added to the list if settlement, transportation, or mining activities were to be considered nearby.
- **other nearside features:** the Alpine Valley, Hadley Rille, the "interruptions" or "bridges" along Hyginus Rille, the Straight Wall, the Altai Scarp, the Rheita Valley
- **nearside historical sites:** the Apollo Moon landing sites, the Lunakhod sites, any intact landers.
- **Farside Craters:** Tsiolkovsky is at the top of my list, Van de Graaf

Once the site of the initial international outpost is agreed open, worthy sites within reach should be identified and protected appropriately. One may argue, of course, that most places on the Moon are already protected by their very remoteness and inaccessibility. But the day may come, when many noteworthy places will no longer be remote and inaccessible. Establishing a Lunar National Park System infrastructure, even without a short list of first inclusions, would be a wise move for these reasons:

- It is easier to establish such a system now, when the threat seems remote, than later, when economic counter-interests may have arisen.
- Early establishment of a Lunar National Park System will be a media coup, thrusting the Moon and its beauty into the public consciousness.
- It will whet the appetite for lunar tourism, thus helping create the justification for development of the vehicles and systems needed for on-location tours.

Extreme Touring

As on Earth, some parks will get the majority of tourist visitors, being "on" the most popular itineraries. But also as on Earth, there will be a tourist market for those who wish to explore "off the beaten path" in remote or usually overlooked areas or in "virgin" territory.

First Robotic Tele-tours

The very act of establishment of a Lunar National Park System by treaty, along with a starter list of included areas, will lay the economic grounds for private enterprise to land robotic "tour guides" on location, to photograph and explore the especially scenic features with maximum "ooh and aah" appeal, to be included in edited tourist documentaries on video and DVD or in NATIONAL GEOGRAPHIC, along with promotions of the sponsor tourist companies, of course. Tourism "pump-primers." A next step would be actual live tours, rehearsed or unrehearsed, exploring especially mysterious areas such as the first lavatube to be entered.

Flora & Fauna Preserves

When *we* think of "National Parks," places of great geological and biological beauty come to mind: Yellowstone, Banff, Great Smokies, etc. Yet we too have preserved areas in which life is sparse, if not all but invisible: the Grand Canyon, Arches, Haleakala, for example. Biological preserves would seem to be out of consideration on the barren and lifeless Moon. But someday, that may not be the case.

In pressurized urban areas, we may set aside and designate as "wilds" areas left to be seeded at random by the birds, insects, squirrels, and ventilator winds, as an experiment and educational project spanning generations. We might also set aside areas to be landscaped and planted with trees and plants and wildlife of no economic importance at all, just for settler enjoyment and appreciation of beauty, and as places for peaceful retreat.

On a larger scale, heavily-traveled inter-settlement routes between neighboring population clusters may one day be relocated into pressurized tubes or rilles with broad fringe areas that can be planted with a mix of crops and purely ornamental plants -- parkways. And there may be small scale "national forests" created in pressurized structures by private enterprise seeking tourist dollars.

A Lunar National Park System will have a profound impact of the way lunar settlement develops, and even on its pace. The time is ripe. Let's get started! **<MMM>**

The Black Sky "Blues"

Revisited

[cf. MMM #138, Sept 2000, pp. 4-5, "The Black Sky Blues"]
by Peter Kokh

In the earlier article four years ago, I wrote:

> "We've all grown up with the night. We don't mind it. Nighttime darkness is only temporary. With dawn comes welcome visual relief. On the Moon, that relief never comes. Our pioneers will be transplanting themselves to 'Black Sky Country.' And that can have long term psychological consequences.
>
> "With the sky black even at 'high noon,' the contrast volume between surface and sky is intense. Shadows are bottomless visual pits. This will cause some eyestrain. Of course, this will be more of a problem for those who spend a lot of time out on the surface - in the 'out-vac'. But it will affect those who spend most of their time in pressurized spaces as well: in what they see through various types of 'windows' (visiscreen, periscopic windows, etc.); it may affect 'skylights' as well."

I suggested that spacesuit helmet visors might have a "differentially reflective coating that would 'brighten'" the sky, even if just a bit, without interfering with clarity of visibility of the moonscape." And that for skylights, perhaps we could "produce some sort of frosted and translucent, but not transparent, glass pane that will not only let in sunlight but appear itself to be bright, giving the illusion of a bright sky beyond."

> "Without real experimentation, we would not pretend to guess what will work best. But we should be trying a lot of things, including foamed glass, aerogel, special coatings or laminate layers, etc."

But I had also brought up the possibility that "electronic images of the surface scene outside offer , for good as well as mischief, the opportunity to be manipulated. The viewer may be able to select a sky color and brightness to his or her liking. The [tele]viewer [device], much like an Internet browser, would then 'interpret' the black areas at the top of the picture accordingly. Pick a light gray to go with the moontones, or a smoky blue. A visiting Martian pioneer, might prefer a dusty salmon. Homesick for Earth? Pick a brilliant blue. The idea is not to deceive oneself but to prevent eyestrain - if it has become a personal problem."

Technology now at hand

When I wrote that, I was making a leap of faith. But since, American Football fans have become familiar with a new computer-assisted TV trick that paves the way: the insertion of an orange line on the screen to show the viewer where the football has to be advanced for a "First Down."

How do we get from *this* "scrimmage line" to *our* first down - the apparition of a blue sky on a visiscreen showing the moonscape outside one's homestead habitat? A smart computer program would scan the scene looking for the "horizon," able to distinguish between the black sky above that line and dark shadows below it. The viewer could control the result, the tint color, contrast, brightness, etc. And, of course, the viewer could turn the program off, preferring reality, however black.

Some years ago (a couple of decades, actually) I bought a pair of "rain glasses" that had the effect of brightening the view and giving it a distinctive yellow cast, creating for a moment the illusion that the sun was shining. They were fun to wear for a while, then I threw them away, preferring reality. Some of us are more affected by cloudy and rainy and otherwise "dreary" days than others. Moi? I have always been able to make my own sunshine.

Some pioneers will handle the black skies well, and need no artificial assistance to "pretend." Others may want to wean themselves of blue skies gradually, and such smart screen moonscape monitors will be available with a "blue skies patch." Software is all we are talking about.

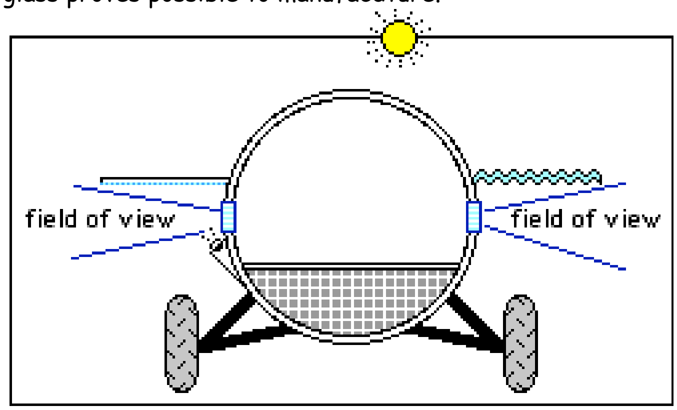
There just might be competition among software providers. The introductory program would just shade the black sky uniformly blue. Improvements would make the sky a deeper below above, and a milkier blue near the horizon. But then comes the fun! Programs that can be set to random insert alien space ship landings, or balloons, or World War I biplanes, or geese flying south in formation, or clouds of various types, even storms, lightning and more. It might amuse the kids, but perhaps most adults would tire of the "let's pretend" games fairly quickly.

Out of the Homestead and into the Rover

Most Lunans, in their every day work and recreation schedules will rarely venture out-vac, beyond the airlock onto the surface, or even through the dockport match-lock into pressurized rover for an excursion or to travel to another settlement. But when they do, they will have much less to distract them from the view out the porthole or visiscreen. If some manage to pay little attention to the out-scapes in their daily routines, once out on the surface, on the way to somewhere else, it'll be harder not to notice.

Yet, with highway rights of way being free for the taking, once traffic volume allows, coaches may be very wide track, to the point of having twin aisles like our wide-body jets. Those who do not care to look out the window will have plenty of opportunity to sit "in the middle."

For those who do want to see where they are going and to appreciate the moonscapes, there are at least two options that would "moderate" the starkness of the view. the black skies in particular. There could be the smart flat screen monitors built into the seat back in front with the sky-effects fully controlled by the passenger. For"window seat passengers," the porthole could sport a sort of "visor" that would project outwards, blocking most of the sky to within perhaps 10-15 degrees of the horizon. Its underside could be a light matte blue, lit from a lamp below the window. Or it could be made of a special light diffusing glass such as we mentioned as an option for skylights, if such a glass proves possible to manufacdture.

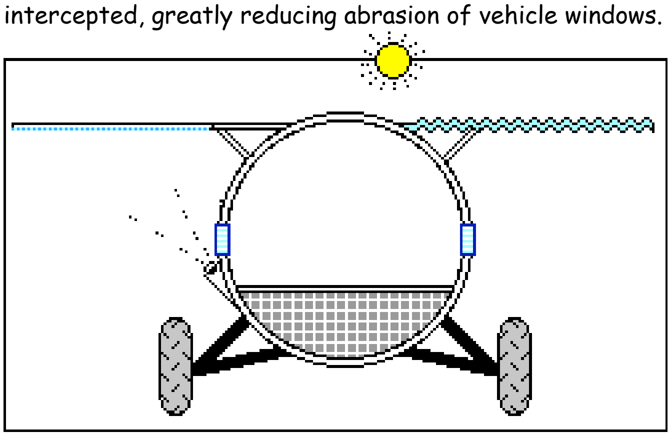


ABOVE: On the left, an uplit visor with a blue matte underside masks much of the black sky at left. At right, a sun light diffusing glass visor does the trick naturally.

How might frequent traveler's react to devices like these? Reactions might run the gamut from "Why should we pretend this is not the Moon?" to "Wonderful!" to "You need to tone it down a bit." to "Junk the fake clouds." We differ in our tastes and tolerances. Market forces will determine what stays and what goes. One coach, on a busy route, might be equipped with several options, to test the market waters.

The convenience of passengers is far less a concern than that of drivers, however. Eye strain can affect safety. So whatever the fate of such passenger window visors, we predict that driver windshields will be visored somehow, or visiscreens, equipped with sky effects programs such as those described above, will replace windshields.

Yet another option is a wide-eave micrometeorite canopy, either underlit or sunlight diffusing that leaves black only the horizon-hugging area of the sky. Such a shield makes sense: while some micro-meteorites will travel in low-angles hugging the horizon, and sneak under any canopies, most of them, coming in at higher angles, would be intercepted, greatly reducing abrasion of vehicle windows.



We will lick those "Black Sky Blues!" ‹MMM›

Music to Watch Moonscapes By

by Peter Kokh

With the new Lockheed/Tom Hanks IMAX film "Magnificent Desolation" featuring the video footage shot on the Apollo Moon Landing Missions due to be released soon, I eagerly anticipate the background music selection (or will the music be specially commissioned?) as much as the promised "put you right there" visual experience. Music can endow lifeless scenes with undefinable significance, affec-ting our impressions far more than we might admit.

Will composers write symphonies, overtures, and theme music with the moonscapes as inspiration? Why not? Should not the pioneers have their own counterparts to Antonin Dvorak's "Symphony from the New World?" or "The Grand Canyon Suite" by Ferde Grofe? While we could look for suitable existing pieces (as was done for 2001: A Space Odyssey) fresh compositions which would be forever identified with the lunar frontier and become part of frontier culture are preferable and will come in time. Some such music could be written now. Certainly the actual pioneers will add to whatever we provide as start.

A Challenge to Computer Music Composers

Imagine a computer program that would blend a whole range of themes keyed to many different moonscape features: topographic features such as craters, rilles, moun-tains, mare planes, rolling highlands, boulders and shadows; geochemical features such as various types of regolith, and automatically interwove them, each given proper prominence or understated subtlety according to the changing scene outside one's vehicle window? A tall order? Yes! Such a computer program would "read" the passing terrain much as a music box reads the spikes on a rotating drum or disk.

Themes keyed to scene components are not new. Just think of "Peter and the Wolf" by Prokofiev. Yes, from that classical piece to the sort of "Music of the Terrain" readers that translate shapes, colors, textural nuances into music is quite a leap. Surely someone is up to the challenge!.

For this idea, I give credit to William K. Hartmann who wrote in his recent science fiction mystery novel "Mars Underground" page 185 (paperback edition):

> "Flat-lit by the high sun, the plain looked like a giant's sheet of music, with rocks scattered like notes that would play some strange music if only you knew how to read it."

There is more than one solution to this equation. Different composers could use different instruments and different themes for the various types of terrain features and shadings. Listeners would set the relative volume or stress according to which features are of most interest.

At night, there could be a program that keyed in to black lit phosphoresce perhaps. The bottom line is that music can bring the barren desolation to life. ‹MMM›

Discovering Mars on Earth!
MyStay at a Mars Outpost Analog in the Utah Desert

A Personal Journal By Bob McGown < rmcgown@comcast.net>

It was the opportunity of a lifetime! How could I turn down a chance to visit Mars? My good friend Gus Frederick invited me to join him for a weekend as he was in command of a team at the Mars Desert Research Station (MDRS), near Hanksville, Utah (elevation ~4,500). My usual sidekick couldn't make it, so I asked Sean League, owner of Sean's Astronomy Shop, if he wanted some adventure. He enthusiastically agreed, even volunteering to drive his van.

Surviving 16+hour drive from Portland we arrived at MDRS where Commander Gus introduced us to his crew, Team 28. MDRS is part of an ambitious plan of the International Mars Society, which has initiated the Mars Analog Research Station (MARS) project.

This is a global program of Mars exploration operations research which will eventually include four Mars base-like habitats located in deserts in the Canadian Arctic, the American Southwest, the Australian Outback, and Iceland. The MDRS in Utah is well underway in this Mars-like environment. Volunteers conduct a program of extensive long-duration geology and biology field exploration operations done in the same style and under many of the same constraints as they would on the Red Planet.

The main component of the MDRS is the "hab" (Habitat.) There is also a small observatory (the Musk Observatory >>>) and greenhouse near the hab.

Gus had a personal project for this mission, the MDRS "Salad Machine" which was designed to be a semi-automated hydroponics system to test the feasibility of growing fresh vegetables for crews. At last accounts it is still doing well, with some tweaking.

Another project for Gus was to introduce duckweed and water fern into the gray water tanks of the greenhouse. It was an ingenious way to try to reprocess gray water so it could be usable for other purposes.

<<< At about 3 p.m. on April 16th, Sean and I set up the solar H-alpha Coronado telescope and the C-5 telescope with a white light filter. We noticed large solar flares and sun spot activity that afternoon. The wind was gusting up to 45 km//hr and we were skeptical about observing that evening.

However, weather finally cleared up and we set up our Alt?Azimuth 10" Newtonian telescope on the south side of the hab so we could observe with the crew.

At about 10:30 it was getting very dark and there were just a few clouds hanging on. The sky was about 75% clear with very little wind. It was a warm evening, above 60-65 degrees, and occasionally a slight breeze would wiggle the scope. We had two observing chairs and a selection of eyepieces from 13, 25, 32, 40, and 50mm. We tried some spectral filters and diffraction gratings on observing planets & stars. The lower atmosphere seemed to be turbulent, while the upper atmosphere was steady. The wind died down and the seeing conditions improved to about 3-arc seconds seeing. The darkness was excellent on a Bortle scale of 1-10 with a rating of about 3. The seeing ranged from a 5 low on the horizon to about a 7-8 on a 1-10 scale. The transparency ranged from 6 to about 8.5.

We first toured the planets. Our first observation included Venus, which was about 18 degrees above the western horizon. Venus was in a crescent phase and quite interesting. The 6 members of Crew 28 came out to observe in shifts. Mars was low in the atmosphere and unsteady. Saturn was quite striking in a 90-power 13-mm eyepiece. The Cassini division would come and go. Jupiter was very distinctive as usual with clean banding, displaying four moons spread out on the Ecliptic. We were especially interested in Jupiter because of the new blue methane band, which just became visible this month in the Southern Temperate Belt region near where Shoemaker Levy-9 comet hit in 1994.

After our customary planetary tour, we observed a few deep sky northern objects and spent the next 3 hours observing the southern sky. It was a rarity to view the southern sky and observe some of the southern Caldwell Objects, galaxies and globular clusters that included C-66 (globular cluster in Hydra), C-60 & 61 (irregular galaxy - "ring tailed galaxy" in Corvus), C-59 (the "ghost of Jupiter), C-53 (8.0 mag galaxy in Sextans), and C-48 (N2775 - 10.1 mag spiral galaxy). We compared the galaxies for differences in our two-night observation for glimpses of possible super nova. Sean and I also spent some time observing the Virgo Cluster, M-83 (the southern pinwheel) and Leo galaxies. The sky was very black. Over all, the observing was very good despite the occasional cloud. We were able to locate deep sky objects rapidly so the MDRS research team enjoyed a good star party after all.

The next day, Sean and I(went into Hanksville to send out mail from the MDRS team and to pick up a magnet for searching for small possible micrometeorites or magnetic nodules in the hills. On the way back, we stopped at 6 anthills about 4.5 km south of the turn-off at the hematite-strewn field along the Lowell highway. We photographed cactus and hematite deposits - "Martian blue berries." The anthills had some micromagnetic nodules less than 1 mm in size. In some of the anthills, we found a surface layer of magnetic nodules the size of sand grains and some fine grained iron filings. Naturally, we did not disturb the anthills or the ants. The terrain is typical of a sand grain meteoretical strewn field, and analog of the Holbrook site in Arizona.

Bob investigates a red anthill.

On Sunday, the 18th, Sean and I got a chance to actually experience an Extra Vehicular Activity (EVA). We suited up with the assistance at Space Tensder Steve Featherstone of Team 28. The pressurized suit has an air filtering system, which prevented the blowing sand dust, which gusted to 45km/hour during our EVA. We headed southeast about 1.2 km to the center section of Lowell Highway and Sagan Road seeking anthills to look for micro-magnetic nodules. We found an area prolific with nodules. It gave us an eerie feeling looking for specimens that had been collected by the ant colonies. Red ants are able to carry an iron nodule many times their body weight up inside the anthill and stack them in a mound up to 1/2 meter high.

That evening, the crew wrote reports and had dinner while Sean and I set up for the evening's observing. Our hopes for observing dwindled as an electrical storm came through, blowing dust with high winds as well.

Commander Gus Frederick leads an EVA

We placed the 10" Newtonian scope into the green house during the storm. Waiting out the storm, Sean and I counted meteors in the leeward side of the Mars hab between 11-11:30 p.m. We observed 9 meteors in 18 minutes radiating out of Ursa Major or possibly Leo.

The meteors ranged from 6 magnitude to 1st magnitude. We immediately thought they might be coming from Lyra. The Lyra meteor shower is active starting 16 April with a zenith hourly rate of 18 to 90. Sean and I did not see the whole sky since we were observing in the leeward side of the hab. It seemed like the meteors were coming from Leo or Ursa Major instead of Lyra. It appeared as though we might be witnessing an outburst of the meteor shower three weeks after the end of the Delta Leonoid shower in April. I contacted Wes Stone, a member of the IMO international meteor organization, to discuss the possibility of a new minor meteor shower. Wes thought it might be the Tau Draconoids, a minor meteor shower during this time of the year.

When the sky cleared, Sean and I looked in the Uranametria (Northern Edition, page 106) and searched out the super nova in NGC 3786. Ursa Major was now visible, so we set up on the northerly lee side of the hab to avoid the blowing sand and wind gusts up to 40km/hr. The discomfort was worth it to possibly get the chance to observe a 14th magnitude super nova in a 12th magnitude galaxy. We found some averted vision galaxies in the area with our 10'' Newtonian however we did not catch a glimpse of the super nova this time.

A few days earlier I had observed the super nova with colleagues Matt Vartanian and Dareth Murray at the Highgate Farm near Molalla, in a 16'' scope. Sean and I could have observed the supernova manually with the C-14 at the MDRS if the wind gusts had not been so strong. It was not possible to use the C-14 at any time during our visit due to the high wind and dust.

The great thing about the MDRS is that anyone who has an interest or talent can apply and be part of a science team for two weeks. What an experience! The scenery is breathtaking and the weather is like Mars - unpredictable!

An EVA and a Rover Ride!

To learn more, visit

http://www.marssociety.org/mdrs/index.asp

I look forward to another adventure of "Mars on Earth" somet ime in the future **<RMcG>**

MMM #177 - AUG 2004

Can X-, Y-, Z-Prizes Get us to the Moon?

Should the Bush Administration's Moon to Mars Initiative be approved by the incoming Congress and fully funded, *year after year after year,* we have a good chance of seeing a NASA science outpost on the Moon of limited capacity, probably in the polar boondocks. What we need is a private enterprise presence. Carefully "terraced" prize competitions could help make that dream become a reality.

Earth's Mushrooming Power Appetite: a Reality Check

by Dave Dietzler < Dietz37@msn.com >

The Power Generation Situation

From Dr. Robert Zubrin's *Entering Space* we find some interesting figures on energy usage listed in the table below. I've compared this to figures on total world energy consumption in BTUs from other sources and it matches well. The 15 trillion (tera-) watts we generated in 2000 includes electricity from hydro, coal, nuclear, etc. as well as auto and truck fuel, and heating gas. The projected rate of energy use increase is 2.6% based on current growth. So you never know what really will happen given things like the rapid growth in China. Also, the population will probably level off in the mid to late 21st century and so will growth a little later.

YEAR	POWER (TW)
2000	15
2025	28
2050	53
2075	101
2100	192
2125	365

We will have to curtail fossil fuel burning in the next 50 years and get all our energy from electricity generated by other means for heating as well as hydrogen generation for auto and truck fuel. Perhaps small airplanes, motorboats, snowmobiles, motorcycles, lawnmowers and a few other applications will still run fossil fuels as these will not dump much carbon into the air. Let's hope some Mean Green alliance doesn't outlaw backyard barbecues!

Solar Power Satellites to the Rescue?

So how do we get all this electricity? If we want solar power satellites to generate 50 TW by 2050 we will need a thousand 50 GW satellites. I read about solar trough collectors that were 60% efficient; but what about the turbogenerators? At best you get 50% with Brayton cycle turbines so I would guess overall you'd get 30% efficiency or 0.3*1350 watts/square meter=405 w/m2 Thus the satellite must be 11,111 meters on a side!! That's 6.88 or almost 7 miles!

O'Neill designed a 5GW satellite that would amass 80,000 tons. This one will amass 800,000 tons at least. So we are talking about moving 800 million tons of material from the Moon to build 1000 satellites by 2050 AD. If we use thin film silicon cells the SPS must be larger in area but I don't know about its mass.

Anyhow, *it isn't going to happen.* There is no way we can do that much work in 50 years with no previous experience and no infrastructure to support the thousands of workers and robots that would be needed.

When you consider the cost of space launches today and the cost of the ISS program the situation becomes even more difficult. If we develop something like Bob Truax's Sea Dragon that could put 550 tons of payload in orbit for a fraction of the cost of a Saturn V launch and make advances in AI and robotics, then launch tens of thousands of tons of payload to the Moon which grows into an industrial base amassing millions of tons we might just do it, but not by 2050. I'm not that optimistic. Who would dare gamble on this? Experience has proven space travel to be dangerous and expensive. Only some new ways of doing things could change all this.

Other Options

Perhaps orbital tourism over the next few decades will bring about cheap transportation of humans to LEO. With Sea Dragons or a Shuttle Derived Cargo Vehicle we could launch cargo, unless you think we will have a cable dangling from GEO in the next 50 years!

I have no doubt that AI (artificial intelligence) will astound us in coming years. I've read that the real barrier is not hardware but software.

In the meantime, the only realistic power source for the Earth is nuclear fission with breeder reactors to tap the plutonium and thorium/U233 cycles and perhaps even the extraction of uranium and thorium from seawater and other novel sources.

There might be a fusion breakthrough, maybe due to the growing of giant laser crystals in space factories that would fall apart when molten in Earth's gravity. We can't gamble on that either.

Count on these half measures for sure

We are going to see more hybrids, diesels, mass transit, electric cars, clean coal plants, natural gas fired power plants, wind farms, conservation, LEDs, fluorescents, etc. in the near future and higher energy prices.

The age of cheap oil is over with as demand from other countries increases and drives up prices. *We are going to need nuclear fission with breeder reactors or civilization will collapse.* Fission will keep industrial growth going, clean up our air and allow the creation of the hydrogen economy. Even so, we will need thousands of fission power plants and that will cost lots of money when a nuclear power plant costs about $2 B. For that you could buy 4 or 5 shuttle launches. If you could buy 40 or 50 shuttle launches or even 400 to 500 shuttle launches for that price, maybe we could gamble on solar power satellites, but this is not the fact of the matter. *So we are more likely to see trillions of dollars spent on nuclear power plants instead of space development.*

The Bright Side

The bright side is that we can prevent ecological catastrophe and still generate cheap clean energy with nuclear. Economic growth will continue and we might create an economy large enough to afford space travel by wealthy private citizens to LEO in a couple of decades and to the Moon in 50 to 100 years. We've already seen the first rocket plane, Rutan's Spaceship One. Meanwhile, we can build larger more powerful broadcasting stations in space, defense stations, advanced telecommunication stations, manufacturing labs, etc.

How the Moon fits in

The question is, what do we do with the Moon for now? We still need to get the ground truth on the polar ice deposits indicated by the *Lunar Prospector* data, but unconfirmed by radar. We need to search for Sudbury type impact basins that could be rich in copper, nickel, zinc, gold, platinum, etc. We need to develop shelters and long term life support systems for ground crews. We need to develop regolith refining and aluminum/oxygen rocket technology. We need to develop mass drivers.

Perhaps we need to deploy a small satellite amassing 25 tons that sends a microwave beam down to Earth for proof of concept. Experiments in microwave power transmission have been done on the ground and we could probably do more. Can we send a tight beam of microwaves 22,400 miles? Or even 240,000 miles if you like David Criswell's concept of power beams directly from the Moon. We need to work out all the manufacturing details for construction of Moon bases, lunar power plants, mines, refineries, mining machines and mass drivers. Exactly how many and what kinds of machine tools are we going to need to make all this stuff? I don't know if it is humanly possible to work that out in your head. We don't know how things will hold up in the vacuum, low gravity, abrasive dust, radiation and temperature extremes of the Moon so we would be best to test things out at a Moon base.

I think we waste too much money on Mars rovers when we need more lunar rovers and a manned presence on the Moon to do research with the long range intention of building solar power satellites and mining for helium 3 so that we can get an even better, cleaner power source than nuclear fission that cannot meltdown or generate radioactive waste. If we are talking 1000 SPSs rated at 50 GW each to power the world of 2050 AD and we grow to demand 192 TW by 2100 AD we are talking about 2000 SPSs rated at 100 GW. I think we would be more realistic to expect growth to level off at around 200 TW and those satellites to be built in the 22nd century, barring major a fusion breakthrough in which case everything goes fusion and the only reason to go the Moon then is for Helium-3 and tourism as well as creating a "spring board" to Mars and the outer planets (especially Uransus) for future Helium-3 mining.

The Last Word

What it's really going to depend on is costs. *The cheapest form of energy will win,* and nobody can predict that without the God given gift of prophesy orby paying Lucifer a high price for a little bit of knowledge. **< DD >**

Personal Self Reliance on the Frontier

by Dave Dietzler < Dietz37@msn.com >

Prescriptions for Misery (on Earth or Elsewhere!)

Pity the poor person who depends on drugs, alcohol and sex. One's life is one of addiction and slavery, diseases from hepatitis to liver damage and worse (AIDS, brain damage), drug dealers and bars that suck all the money out of one's pocket as well as one's pride. Perhaps the most damaging is an addiction to sex. Partners are chosen for the wrong and shallow reasons. relationships and marriages built on lust alone are headed for personal and family disasters and likely financial ones as well.

Stress Levels for Space Frontier Pioneers

This will all hold just as true on the space frontier, where greater stresses may leave one more vulnerable to the temptations of false diversions and cures. Pioneers will have left behind much that they love and enjoy: open air environments with blue skies; many outdoor sports and kinds of recreation; an endless selection of places to go for get-away-from-it-all vacations and weekends; a vast and infinitely varied selection of consumer goods from clothing, to electronics, to food and more; many places to escape into the faceless, nameless crowd when one feels the need. In early settlements, in contrast, at first everyone will know everyone else. The small town syndrome. The general store will have little to choose from. The list of things to do on a Saturday night will be few. And on and on. If we leave it like that, we are headed for trouble.

Prescriptions for a Healthy Life Style

Self reliance begins with a good ballanced, varied, and nutritious diet. It is so important to feed the body and feed the soul for the sake of maturity and self reliance that it is even permissible to eat animal meat, despite the fears of vegetarians. We will produce enough food on the Moon to feed everybody three square meals a day of meat, milk, fruit, vegetables and grains as well as a couple of snacks. If we don't we might have a bunch of impover-ished weaklings on our hands and they won't make it on the harsh frontier.

We will produce limited amounts of alcohol, only be available on weekends -- during the work week, we'll need as close to full productivity from everyone as we can get. In an environment where survival depends on the mastery of high tech equipment and alertness, intoxication can be deadly, as it is so many times on Earth's highways.

There won't be much tobacco. In confined environments, smoking will quickly lower air quality levels to harmful if not intolerable levels. No windows to open to let in fresh air! There will be nowhere to "step outside" for a puff. A smoking habit will thus be a big negative on any settler applicant's resume or profile. Chewing tobacco? Perhaps for those who don't mind losing a tongue or jaw to cancer.

Lunans will exercise regularly and lift weights to avoid atrophy in the low gravity. Physical strength and muscle tone must not be lost. Ask any astronaut who has to fight the spacesuit. Going outvac in a spacesuit will give Lunans good workouts. Workplace clusters may share gyms.

Exercising one's Spiritual Side

Religious rituals have importance also. I discovered the chanting of the maha-mantra when I was about thirty years old. Others find Christ and get something out of church services. Some find peace through submission to the commands of Allah and prayer five times a day facing Mecca. There are many other spiritual traditions out there. I've become interested in some of the European Pagan observances of the seasonal changes recently through acquaintance with a woman who participates in Wicca. There will be temples and meeting places for religious groups in our lunar cities. Hopefully, they will all learn enough about each other to develop mutual respect and peaceful coexistence.

Lunans will probably be highly educated and highly skilled. Ignorance and bigotry are no more desirable on the High Frontier than are chemical dependency, domestic violence and fractured families. Lunans will be a special, hearty breed of humans who survive by the use of intelligence and common sense. They will set an example to the rest of humanity. If they don't, they will not survive.

The Space Frontier as an Uplifing Vision

Life can be harsh, but humans, being what they are, have developed character through the struggle to survive for millions of years. If we didn't, we'd be extinct, and there would be no galactic civilization of the future. What a pity it would be if our species went extinct when such a glorious future awaits us "out there." By spreading the vision of the High Frontier, we can uplift today's people's spiritually and perhaps put an end to some of their dysfunctional behavior by showing them that there is more to live for than alcoholic and narcotic stupor, legendary sex partners, a miserable home filled with violence, children who go astray and hopeless floundering in financial troubles.

Summing up

Stress-relieving addiction is a very complex subject and psychologists are studying the problem. The important thing is that we can't have dysfunctional behavior on the Moon or in the free floating space colonies, where O'Neill and others including the painter Don Davis have pictured a quasi-utopian existence, or we will end up expending scarce resources and endangering the survival of the colonies.

We must know more about psychology before we can really put people up there for long periods of time. It is sort of like the life support issue. We may have propulsion systems that can send a team to Mars but we do not have the life support systems to sustain them for years.

We may not yet have the spiritual/psychological support systems we need either. Perhaps a study of Antarctic research base personnel is warranted, and maybe we should study colonies in isolated places on Earth today to figure out what is conducive to spiritual/psychological survival in harsh, dangerous environments. Perhaps we need to discuss this some more.

Besides nutrition, exercise, and prayer/ritual, there is also the family support network. This is perhaps the most important part of O'Neill's vision -- normal family life in space rather than some kind of military base that looks like a prison or inside of a nuclear submarine. That's another thing to look at -- how nuclear submarine personnel maintain psychological health while confined together in close quarters for months at a time. The military may have many of these questions answered already. More to learn!!

The need for emotional support is a strong one. At the very least we will need intense psychological screening and character history investigation before we send someone to the Moon. Unfortunately, this won't be possible with tourists, so we're going to need trained persons ready to handle security problems up there! And even if the original settlers are screened, that won't prevent their offspring from developing anti-social behavior. Proactive measures that encourage healthy living and healthy inter-personal relationships are a must. **‹ DD ›**

Editor's Postscript

Read MMM #97 July 1996, p 8. SPIRITUALITY: Effects of the Lunar Environment on Spirituality and on Reinforcement of Personal Religious Sensitivities, P. Kokh

Many MMM articles have addressed the need for morale-lifting, stress-reducing measures such as spacious quarters with real elbow room, abundant color and vegetation, fresh air, "water features", get-away vacation options, job routine variation, arts & crafts & hobby options, music, sports, outvac recreation options, and more.

Articles have also dealt with the need for every citizen to be environmentally conscious, since "living immediately downwind and downstream of ourselves" leaves little room for "carrying" the environmentally insensitive. The burden of those who won't co-operate can be very stressful. Education of frontier children would feature Recycling as "the 4th R" and include chores and "universal service stints" in the systems that keep the settlement alive: farms, water and air refreshening; recycling of scrap materials, etc. On the frontier, it will be truer than ever that *"if you aren't part of the solution, you are part of the problem!"*

On any early frontier, there is always more to do than people to do it. We cannot afford to lose anyone to addictions, nor incarceration. We must find other "corrective" options, such as assignment to necessary but unattractive jobs, inside and outside the settlement. Prevention and early detection of unhealthy behavior will be paramount.

Without continued proactive remedial attention, the frontier will tend to be stress-heavy. The challenge is to to make it stress relieving instead: a happy, healthy place to live, work, raise families, grow old, and die fulfilled. **‹ PK ›**

Whistling Straits, site of the 2004 PGA, & Dashed Dreams of 2 Wisconsin NSS Chapters

A "Local Color" Story with Some Lessons

by Peter Kokh ‹ kokhmmm@aol.com ›

In the Spring of 1995. George French, President of the Wisconsin Space Business Roundtable (which the Lunar Reclamation Society, had helped launch two years earlier) learned that the Florida Spaceport Authority had a spare meteorological suborbital sounding rocket, a 12.5 ft. Super Loki, that it was looking to donate to a suitable organization. A call to the governor's office, and Tommy Thompson quickly dispatched French and a Wisconsin Air National Guard c rew down to Florida to pick it up before anyone else had time to get interested.

Meanwhile, WSBR and LRS began brainstorming, quickly agreeing upon a plan. We would look for a suitable launch site, then organize a weekend long event, hopefully in the Spring of '96, involving some 40 students from each of the state's 9 congressional districts, in an obvious move to garner total support from our Congressional delegation.

After putting together a "short list" of promising launch sites, we unanimously pounced on a site some 6 miles upshore from Sheboygan and 60 miles north of Milwaukee. The site, dubbed "**Haven**," had been an artillery and ordinance test side during WW II, and, happily, the associated "no fly zone" off shore in western Lake Michigan, was still on the charts, having never been decommissioned -- a safe and secure down range area of sufficient size.

The former military base now belonged to Wisconsin Electric Power Company who was willing to discuss a 99 year lease! The dream of "Spaceport Wisconsin" was born. Two bunkers on the site would be moonbase for Space Camp type summer Kids programs. The WEPC sold the site out from under us to a golf course operator for big bucks. We found another launch site, alas without bunkers.

Space Camps for Kids -- on the ₵heap

by Peter Kokh ‹ kokhmmm@aol.com ›

Let's continue our train of thought from the story just above and see where it might take us. Several NSS chapters and other small-budget organizations *have* set up "space camp" and "Moon/Mars base" simulations for youth. In the late 1980's, Oregon L5 gained access to a pair of lavatubes outside Bend, Oregon, and erected an outpost structure within out of a tarp covered PVC tube frame. The setting and its isolation did the trick, not the structure.

Make-do Outpost Locations

Few chapters will have access to such ideal mood-setting locations. While desert and mountainous areas with sparse vegetation seem ideal, localized "green-free" areas can be found in many states in the form of limestone caves, quarries, and old strip mines. Even a large unused parking lot could be pressed into service. Of course, getting permission to use such sites is trick number one.

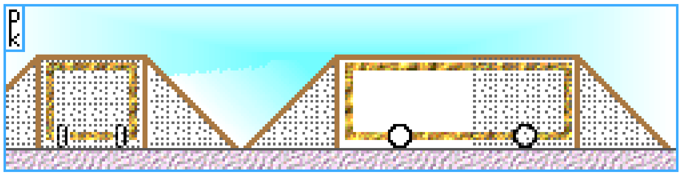
Mockup "Outpost Structures"

If you find such a location logistically handy for your group's use, and can negotiate usage rights, here are some ideas for a structure There may be a construction or operations shack already on site that can be adapted or expanded, using common carpentry skills. No such luck? Options for inexpensive ready-made shelter include an old mobile home, an old school bus, or an old trailer from an 18-wheeler semi, modified for access and ventilation..

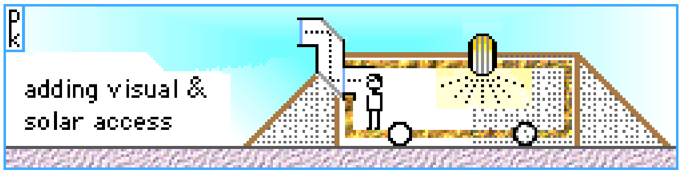
Once your adopted shelter is driven or towed to the location, the real fun begins. You will want to brainstorm how you are going to use it, paying attention to its usable volume and layout constraints, then outfit the interior accordingly, remembering that simple suggestiveness is ample enough as a springboard for young imaginations. A dashboard becomes the mission control center. A vestibule add-on structure outside the door makes an air-lock. If the interior needs to be paneled, choose "glassboard" bathroom panels to simulate glass composites, or Masonite sprayed with Rustoleum Hammerite Silver to simulate metal.

Simulating shielding

Nothing will set the scene better than covering your outpost structure with faux lunar or Martian rego-lith (rock powder blanket) shielding. No need to truck in many cubic yards of sand or gravel or dig up the surroundings for free dirt! Just make a frame of 2"x2"s, staple on chicken wire for support, then staple on canvas or other weather-resisant fabric, spray painted to simulate regolith shielding. Use a gray primer for the Moon and a rust primer for Mars. Blotch overpaint with Kraylon's "Make it Stone" multi-color fleck paints in the appropriate shades. Be sure to leave access to the interior for entry, light, and ventilation. Scatter available rocks or boulders around the perimiter, and Voilà. *Step into another world!*



Above: "Shielding" a Reassigned Vehicle or Structure

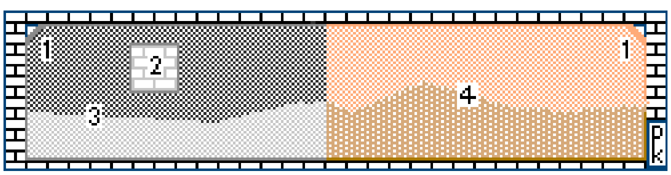


Above: easy upgrades with mirrors

The Urban Warehouse Space Scene Makeover

For even greater simulation, and without the need to look for "life-barren" locations, all we need to do is *move indoors to a large undivided windowless space.* Such an environment allows total lighting control -- *thus* simulation of the two week long lunar dayspans and nightspans or of the 24 hr. 39 minute Martian day, or of any other pattern. Therein we can study human, and plant, reactions and adaptations to non-terrestrial day/night rhythms.

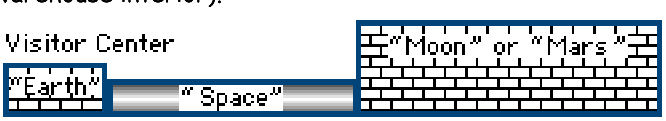
For this purpose a large empty urban warehouse, an unused gym, or an abandoned factory will do - structures which can be found in most urban and even rural settings. Cover and black out all the windows, Use spotlighting to simulate the Sun. For a moonbase, paint the upper walls and ceiling black and the floors gray. For a Mars outpost, paint the upper walls and ceiling the salmon colors of the Martian sky and arrange hidden uplighting to illuminate that setting.



KEY: (1) cove, blending wall into ceiling. (2) block up any windows and painting them out. (3) upper walls and ceiling painted black and lower walls in graytones for the Moon base simulation. (4) upper walls and ceiling salmon color and lower walls in Mars tones for Mars base simulation.

Lightweight frames of wood and chicken wire can support tarps painted to look like the lunar surface shaped like craters and ridges. This will be suitable for areas not "explored on foot." Foot paths will need firmer foundations.

Outside the warehouse there could be a long, black, pitch dark hall connecting to the visitor center. At the center (gift shop, library, exhibits, conference room/ theater, State Space Hall of Fame), kids would enter a golf cart type vehicle redone as a spaceship, for travel through space (the black tunnel) to the "Moon" or "Mars" (the warehouse interior).



First Steps

Now you have a plan for creating a Moon or Mars base outpost that can be used as a Space Camp for kids, a versitile and adaptable design that should put realization within reach of an ambitious chapter or other small-budget organization. You can get started by forming a non-profit foundation, eventually to operate it, but more immediately to receive gifts from sponsors to include the warehouse itself (or other suitible structure) and its use, making the necessary interior makeover along with any needed utility runs; and supplies: wood, wire, tarps, and paint; and other educational resources.

Operations

Missions suitable for young people will be mostly educational. But there is no reason why adults could not have their time in the facility to simulate real operations for the purpose of experimenting with procedure options, equipment options, and testing tolerances, limits, and other aspects, much as would be done in a serious outpost analog station such as the M.A.R.S. or M.D.R.S.

It would, in fact, be natural for both the new facility and its usage to evolve over time. The mighty oak begins with a little acorn. Futures presuppose starts.

The Point

The point is that there are a lot of inexpensive options *once you realize that children do not require the same degree of realism as adults.* Their eager imaginations readily supply the rest. Once operational, improvements can always be made. We have the chance to teach and get across real lessons about space, the possibilities of not only exploring other worlds, but making ourselves at home there, will be driven home. We will be nurturing space supporters, explorers, entrepreneurs, and pioneers of the future.

It is easy to make an endless list of plausible "buts," reasons why this approach is simplistic, reasons not to take even the first step. Yet nothing is to be lost by looking into such a bold plan in the community in which you live. You may indeed uncover a "showstopper." The obstacle may prove temporary. "Nothing ventured, nothing gained."

Recruiting help

But what if none of your chaptermates thinks this is within reach? If no one wants to pursue this idea with you? If no one even wants to humor you? Do as much homework on all aspects of the plan as you can, on your own and then present the idea again, footwork done.

If you get the same reaction, it may be time to recruit fresh support. Start by making your outpost plan the main feature of your public outreach display. A crude model will draw the eye and attract the curious, giving you a chance to hook them on your dream.

Give talks about the "project". People with talents and energies you need may join your chapter just to be a part of your exciting project, to help make it real. **‹ PK ›**

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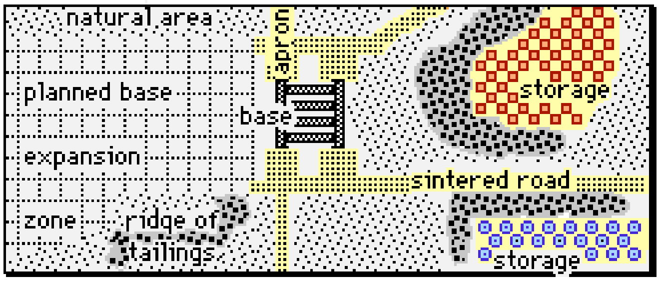


Frontier Storage Chaos Solutions

In MMM # 90, November 1985, two articles, one on "Site Management," the other on "Warehousing" took a first stab at the problem In this issue, we take up the topic afresh in "Storage, Storage, Storage, below. Tackling the storage problem will help lift up frontier settlements "by their bootstraps," improving their viability and survivability.

The Lunar & Martian Frontiers will have Much in Common

by Peter Kokh, President of the Moon Society, and Mars Society Member, Wisconsin Chapter

We are in this together

While the Mars Society and the Moon Society are each properly focused on a different future human frontier, there are many areas in which their interests coincide, overlap, or come together. It is in the interests of both Societies to work together in these areas.

The basic reasoning is this. As different as the Moon and Mars are from one another, *in comparison to our homeworld,* Earth, they are in several ways quite alike:

Neither world has a breathable atmosphere - we must establish self-contained mini-biospheres on both to house and support our outposts and settlements. We need a modular approach, one that provides primary waste treatment at the point of source, to allow our biosphere encradled settlements to grow without trouble. There is no one-size fits all biosphere approach. Modular biospherics is the most promising approach.

Neither world is well protected from "the cosmic elements" - cosmic rays, solar flares, solar ultra-violet, etc. While Mars is not subject to the incessant micro-meteorite rain than the Moon, it is much more exposed than Earth, with its much thicker atmosphere. As a result, outdoor surface activities such as construction will be hazardous duty. Construction and assembly methods which minimize man-hours spent on the surface will be at a premium.

Both worlds experience very cold temperatures. Lubricants and fuels and materials which hold up under those conditions are needed on both worlds. Of course, the Moon has extreme heating to deal with as well, but to a much lesser degree, so do Phobos and Deimos, also without atmospheric heat sinks.

Both worlds have dust management problems. Whether the fine dust on Mars is as intrusive and abrasive as that on the Moon is not sure. But dust control measures are needed on both frontiers.

Safe and reliable modular nuclear power units, add-a-unit-as-needed, will be a big benefit on both frontier, though both worlds have solar power access, the Moon much more so than Mars. And Mars. with good luck and little reason for optimism, may have some geothermal hot spots that can be tapped.

If a treaty banning shipment of nuclear fuels through Earth's atmosphere should ever be enacted, fuel for nuclear power plant modules, and for nuclear space ships, can tap substantial Thorium deposits on the Moon, using fast breeder technology to process this into fissionable U-233. Such an industry on the Moon would be a big boon to both frontiers.

Both worlds are without road networks - infrastructure is expensive and labor intensive - on both we will need pressurized ATVs, all terrain vehicles, that can travel fairly fast of boulder strewn stretches.

Lavatubes for ready made shelter are expected to abound on both worlds. They could be used for settlements, warehousing, industrial parks, etc. Construction inside them offers the advantage of substantial regolith shielding already in place. Workers can use lighter-weight, lighter duty, unhardened space suits, and will not have to worry about "outdoor radiation exposure times."

Areas of subsurface ice, or frozen soil, are expected to exist on both worlds

Both worlds are more economically challenged by themselves than if they trade goods and services and work together to develop other in space markets to further the rise of an interplanetary economy that could withstand interruption of support from Earth. Mars, Phobos & Deimos will be cheaper sources than Earth for things the lunar frontier cannot provide for itself, while the development of markets on Earth for these same items is unlikely. And the Moon can probably supply the Martian frontier with some items at a lower expense than they can be shipped from Earth. In short, the Economic Case for Mars, presently mostly wishful thinking, gains a boost from the Moon being a customer. The reverse is also true.

The hardships and challenges of life on the Lunar and Martian frontiers will bear many similarities, along with some obvious differences.

The pioneers will have left behind much, forsaking Earth for a fresh start on a brand new world.

- The ability to go outdoors without a spacesuit and enjoy the sunshine under an open blue sky.

- □ Many outdoor forms of recreation that attempting to do in a spacesuit would have comic results.
- □ An endless, ever increasing variety of consumer goods
- □ Many "favorite" food and beverage specialties
- □ Many hobbies, even indoor ones, that cannot be supported on the frontier, at least not yet.
- □ Many tourist destinations when it is time to "get away"
- □ A still very diversified biosphere rich with special niches for plants and animals
- □ A much wider and more varied list of occupational options and opportunities

They will be chasing similar dreams

- □ a chance to pioneer a virgin, unspoiled, pristine world
- □ a chance to get in on the beginnings , on the ground floor
- □ a chance to try new ways of living
- □ a chance to start over, fresh
- □ a better chance to rise to the top rather than be lost in an enormous pile
- □ a chance to find oneself
- □ a chance to appreciate more deeply what life is all about.
- □ the chance to pioneer new ways to be human, *"to be all that one can be"*
- □ the chance to take a barren world and make it fertile, something it could never be (again or at all) on its own
- □ the chance to learn to be "at home" in a setting where no man could ever have felt "at home" before
- □ the chance to take a step in spreading human and terrestrial life to the stars
- □ the list goes on, and for both the Moon and Mars

They will face similar challenges to their resource-fulness, ingenuity, and adaptability

- □ Making do with a different set of resources and tools
- □ Making substitutions when the material of choice on Earth is not available
- □ Making do without when substitutions are not feasible
- □ Learning to respect the alien, mindless dangers to life
- □ Learning to express one's artistic creativity in new ways
- □ Fewer distinctively different changes of scenery
- □ Raising children where they have never been raised before, and without access to all the variety and glitter of Old Earth they will inevitably learn too mush about.
- □ Developing new sports that play to the new gravity level
- □ Learning new ways to dance in the lower gravityl

They will need to be made of the same "right stuff"

- □ Resourcefulness, ingenuity, creativity, and adaptability
- □ Willingness to make sacrifices
- □ Willingness to try new ways to do old things
- □ Acceptance, down deep, of the frontier as "home"

The Moon's sky may be black while Mars is bright.
Different color pallets, different gravities, special land-scapes, and different suites of commonly available elements.

Underneath, the Moon and Mars, and the people who will pioneer them, will have much in common. **‹ MMM ›**

Passing from Outpost to Settlement

The Tell-tale Signals of Passage

by Peter Kokh

We all realize that a tentative, toe-in-the-water (or regolith!) base/outpost/beachead must come first before real settlement can begin. Some believe that there will be a public policy decision to go for "the next stage." But the transition could come by itself, in many seemingly minor changes of procedure and policy. The baby does not become an adult overnight, after all. Here are some of the things that will give us a clue that the process is underway.

- Operations transition from "mission-driven construction & exploration" to outpost growth and development
- Rigorous sterilization and quarantine procedures are abandoned as unnecessary ritual
- Operations slowly transition from "by the book" to experimental pragmatism -- individual initiative is allowed, then encouraged, in experimentation with processing, manufacturing, even with arts and crafts using local materials to give the outpost a "down home" facelift.
- Crew members are given permission to go outside alone
- Deaths occur from natural causes, and burial (of the body or cremains) is permitted
- Crew members are permitted to "re-up" indefinitely, giving them "vested rights" so to speak
- Relationships between crew members are tacitly accepted, even if official policy is unchanged.
- Permission for pregnancy is given *after the fact* and the pregnant crew member is allowed to carry the fetus to term without having to return to Earth.
- Someone "retires" from official duties, but is allowed to remain on location and tinker to his/her heart's delight.

We welcome your suggestions to other "subtle" clues that the transition is underway. Such a shift in gears may not be planned. It will happen on its own, in due course.

Anecdotal Signs

- The first MacDonalds, Starbucks, Walmart, etc.
- The first Lunar Olympic Events
- The first Lunar Soap Opera broadcast to Earth

It is fun to list things that will broadcast that the outpost beachead "has arrived." These things will come in time. But we are looking for the subtle first signs.

Critical Mass - The indications that the outpost-in-transi-tion has become a settlement with "critical mass" to support "ignition" such as population size, diversity of factories, tools, vehicles, talent pool, reserves, etc. and the amount of vital needs and supplies in storage is another question. Here we are just looking for those first easy to miss clues that a historic phase shift has begun. **‹ MMM ›**

sToRaGe StOrAgE sToRaGe

The art and science of putting everything where it can be found and retrieved in good condition, suitable for use, reuse, or put to a new application.

by Peter Kokh

To many "full steam ahead" fans of progress and development, *Green Peace* is a dirty word. This counter-productive attitude arises from inborn human impatience. We want to get things done. We are impatient with "colla-teral casualties." Over the long haul, that impatience can only bite us in the but, to put it colloquially. *Green Peace* is the activist environmental organization that is known the world over for its efforts to save the whales, disrupt French nuclear bomb tests in the Pacific, and much more. The organization has also concerned itself with changing public policies and business practices that have led to marked degradation of water quality in the Great Lakes.

But how many know of its work in Antarctica. In a fact-finding (busybody, some would say) mission to the main U.S. outpost at McMurdo Sound, *Green Peace* found a real mess. As our Antarctic operations expanded at this location over the years, the area became an unsightly sprawl of outbuildings, storage areas, and dumps - all with little or no preplanning. While our operations on the ice-bound conti-nent had expanded markedly, the visual effect was one of a "trashed environment." While the impact on local living systems may have been negligible, the impact on operational efficiency was major. We didn't know where everything was: there was no rhyme nor reason to where things were stored. The negative impact on our operations was clear. Our lack of well-thought out storage policies (or philosophy) led to things not being stored in a way that they could be easily found and retrieved in good condition, suitable for use, reuse, or put to a new application. We had not thought ahead to develop a sound storage management plan. The "trashing" that *Green Peace* found was but the tell-tale "symptom." To the government's credit (and *Green Peace!*) this situation was corrected. We are all happy campers now.

Lessons for future Outpost frontiers on Moon and Mars

This is not off-topic. Without careful, thoughtful pre-development of a sound storage philsophy and manage-ment systems, we could end up with trashy surroundings. Much worse than the embarrassing publicity sure to be generated, we would be self-saddled with outpost opera-tions that cannot function, much less expand, efficiently and in a timely way. Many of us are all too familiar with disorgan-ization syndrome on a domestic level. We had tackled this general topic in two articles in MMM # 90 November 1995, "Site Management" and "Warehousing on Luna':

www.asi.org/adb/06/09/03/02/090/site-management.html
www.asi.org/adb/06/09/03/02/090/warehouse.html

Things we need to store

Our first step is to develop an open-ended list of the things we may need to store outside our outpost proper. These things will fall into the following general categories:

Incoming from Earth

- Consumables from Earth: fuels and other chemicals; food reserves and rations; initial and backup water reserves
- Replacement parts for structures, systems, and equipment
- Manufacturing supplies
- Modules to be installed, vehicles on standby
- Other items not needed yet

Accumulated on Location

- Samples (for mineralogical analysis and other scientific study) and for use in processing experiments
- Sorted samples by class: highland material, mare material; mantle material, KREEP soil (potassium, rare earth elements, phosphorous); asteroid fragments
- Tailings from processing operations
- Other manufacturing or processing byproducts
- Assorted trash and detritus of operations including discarded and broken items & things no longer needed
- Human wastes and gray water
- Standby storage for items needed intermittently

In transit from/to Earth or in space usage areas

- locally produced fuels (liquid oxygen, silane, etc.)
- manufactured products & sales inventories
- Artifacts created by local artists and craftsmen
- Incomplete assemblies (waiting for parts, etc.)

"Cross-classification" by storage requirements:

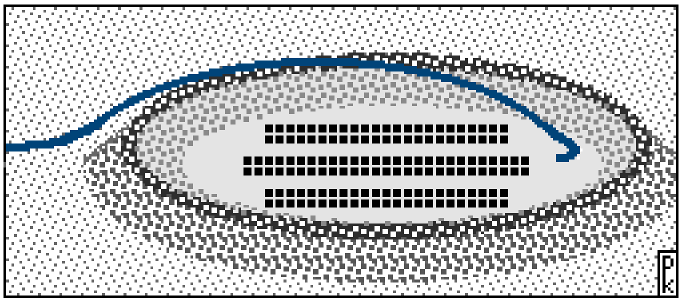
- Items that can be placed on the surface, out in the open, exposed to vacuum.
- Items best placed under a ramada or canopy to protect from solar UV, micrometeorites, or constant cycling between dayspan heat and nightspan cold.
- Items already carefully sorted that should be placed in bins or containers to avoid cross-contamination
- Items that should be stored in pressurized conditions
- Items requiring temperature controlled environments

"A place to put everything and everything put in its place"

It should be clear from the brief analysis above -- we make no claim that it is exhaustive -- will convince anyone that we cannot make do with just "a" storage location, and "additional overflow locations" as needed. While proper double bar-coding procedures can find anything no matter how disorganized the storage areas, witness the eventual remedy for Mir's storage nightmare, efficiency in retrieval will obviously increase if things are physically stored in segregated locations, each with substantial room to grow. Site Management will identify areas, out of sight of regularly used trafficways, where things can be properly stored. Then double bar-coding, of the item to be stored, and of the storage location or bin, will make everyone smile.

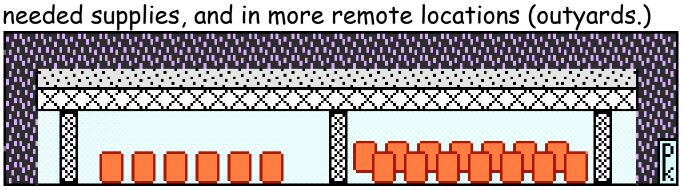
Unique locations for storage

Some natural surface features offer scenic segregation (though not from overflying craft) such as craters and the shadows of East-West running escarpments. Polar "permashade" areas offer permanent "out-of-sight conditions as well as stable very low temperature storage, ideal for items subject to decay at higher temperatures. Lava tubes offer all this and one thing more, an environment protected from the cosmic elements of cosmic rays, thermal extremes, ultraviolet, solar flares, and meteorites.



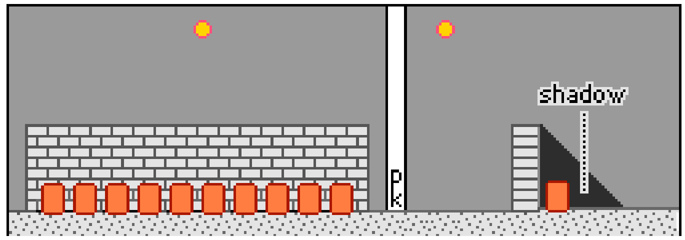
A graded road climbs up the shoulder of a stadium-size crater, across the rim and slowly ramps down the inner wall to the relatively smooth crater floor. Crater storage is attractive to hide stored items from view and also for storage or radioactive wastes. With no atmosphere to worry about, only line-of-sight radiation would pose a problem, and the crater walls would block that.

A similar "lee" or "soft" vacuum environment can be created by building ramada canopies or hangers for storage where lightweight, unhardened space suits can be worn, and glare-free, bright sky conditions maintained. "Underyard duty," if one can call it that, will be much more pleasant and less stressful than similar duties out on the exposed surface. Ramadas can be built immediately adjacent to the outpost complex (inyards) ideal for storage of routinely needed supplies, and in more remote locations (outyards.)

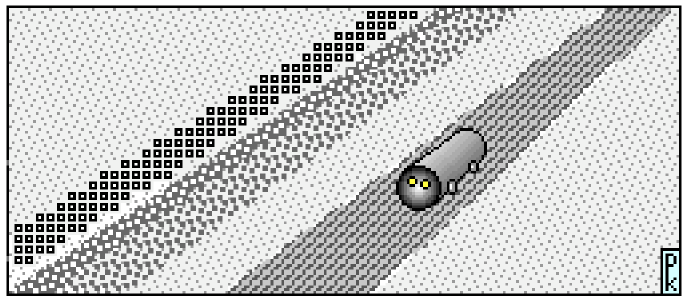


Here a space frame canopy covered with a meter or two of regolith provides protection from the cosmic elements of lunar "weather" including cosmic rays, solar flares, ultra-violet light and the incessant micrometeorite rain as well as providing thermal equilibrium -- protection from the monthly cycling of high dayspan heat and low nightspan cold -- all the while leaving the space underneath this "ramada" open to the vacuum. Ramada storage facilities will be ideal for items needing such protection, too sensitive or valuable to be left fully exposed. Ramadas extend that same protection to any storage management workers involved.

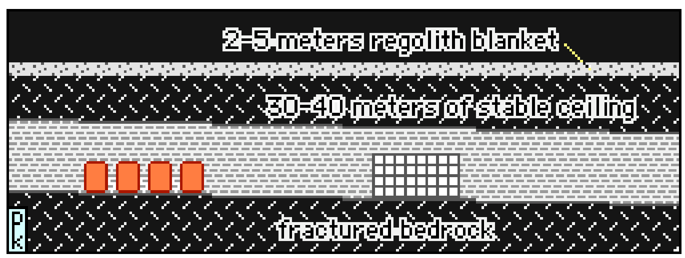
In addition to ramadas, well away from the equator, block walls can provide dayspan long protyective shade.



In this illustration, drums containing liquid and sludge wastes remain frozen and inert behind an east-west shade wall. This idea will work in the Moon's "temperate" zones, north or south of the equator, where the sun is never overhead (the Moon's axial tilt is negligible, 1.5°, the seasonal variation of the shadow angle is very low.)



A berm along a highway provides both out-of-sight storage and the convenience of highway access.



Storage in a stable lavatube with its gently sloping profile is the ultimate in lunar and Martian storage options. Enough protected and stable storage volume for all of the storage and warehousing needs for frontier civilization for generations, perhaps millennia to come. Even enough room to completely archive all of human history and civilization in a setting that should remain stable for billions of years to come. Freight elevator shaft access from the surface would do the trick. Lava-tube storage is also the ultimate solution for radioactive materials, toxic chemical wastes, and virulent biological pathogen collections. The Moon's lavatubes are an asset rivaling anything else the Moon has to offer, including farside radio silence and helium-3. Lavatubes are a naturally occuring feature in lava sheet flows such as the Moon's maria or seas, and in shield volcanoes.

On Mars, storage immediately behind walls built perpendicular to the prevailing winds, will provide some harbor. Properly designed, they will reduce the accumulation of fine dust and sand.

Preventative measures

On the Moon, with resupply windows virtually open around the calendar, the need to maintain a large inventory for replacement parts, equipment, and commodities will be much less severe than on Mars, where windows open up every 25-26 months. On the Moon, a "just-in-time" inventory system should be doable. Not so on Mars.

When it comes to inventories of reusable materials embodied in discarded items, "having it in storage' is not the same as "having it ready to fetch and use." Whether it is a discarded appliance or vehicle or anything else manufactured of multiple, individually reusable parts, it makes sense to maintain a "just-in-time" inventory of dissassembled items, properly sorted by material ready to reuse. Whether it be a routine chore of youngsters after school or on the local equivalent of Saturday morning, or of universal service work corps, the pioneers would do well to be handling the proper disassembly of discarded products *as it comes in.*

On the frontier, a lot of things will be in short supply, and losing track of things, or having things misplaced, or mixed and unsorted only exacerbates the problems and greatly handicaps the "resourcefulness" that is the pioneers' main trump card, the "ace up the sleeve." Honing their resourceful abilities be a frontier preoccupation.

Storage Management starts with a philosophy, capsulated in a vision statement, and a comprehensive organization and logistics strategy, summed up in a vision statement, with periodic reviews and adjustments,

- *common sense* - its where you put it when you need it - organization & logistics & efficiency & resourcefulness
- *respect for the environment*, lifeless perhaps, but with a beauty not to be marred senselessly, but with art & plan.
- *a plan for what should be stored, and stored separately* so that it is a resource, not a waste nor a loss

On the frontier, the necessity of making the most of everything will be the mother of invention in storage, tracking, and fetching systems. One can even foresee a Byproduct Trade Exchange, all computerized and bar-coded, integrated with fetching & shipping systems, and automated order/import just-in-time software & distribution systems.

Incentives to help maintain discipline

The most brilliantly crafted system is only as good as the discipline with which it is followed and respected. Tax and fine incentives are a time-honored way to increase the percentage of compliant "good behavior." While on the Moon, where nothing can be taken for granted, citizen awareness of the need to exercise individual responsibility for keeping things working will be high. Yet the temptations of laziness, combined with probably all too frequent inconvenience of making the needed effort are sure to also guarantee that compliance will slack off with time. Help from the tax and fine codes might not be bad insurance.

For individuals and companies alike, one good idea might be a tax on undisassembled discarded items, no tax on things properly separated and sorted. For companies with a need to remove byproducts and processing and manufacturing wastes off the premises, there could be a prohibitively steep fee for illegal "dumping," a medium fee for taking to an approved storage location for unsorted materials, and no fee at all for storing items and materials properly sorted. To work, the fees would have to be higher than the costs of employing people or equipment to do the proper sorting and/or disassembly. Mechanization, containerization, and computer software will ease the burden and minimize both full- and low-exposure man hours. .

Promoting reuse and use of sorted materials
And the GST "Gross Settlement Throughput" Index

If there were a tax or price paid by manufacturers and processors on all use of virgin regolith, but no or a significantly lower fee or price for using tailings and other stored byproducts and any beneficiated materials or wastes, the total "throughput" or gross natural material consumption index of the settlement would be lower.

> The lower the ratio of virgin raw materials used to new products produced, the more efficient a civilization is in minimizing its impact on its host world.

Our impact on the lunar or Martian environments, while certain to grow, would grow more slowly in comparison to population growth. Again, prices have to be set at a level to encourage the desired corporate and individual activities, and should be adjusted regularly to fit changing conditions.

Making sure

Government policies do not work unless they affect indivi-dual behavior. It is the net change in total individual actions that makes a difference one way or another. Incentives are helpful, but not enough. "Correct" action has to be made easy, easier in fact than lapsing into the behavior we are trying to remedy or eradicate. Nature, human nature too, tends to follow the past of least resistance. Individual economic decisions rule. Here is where most well-intentioned official policy legislation falls down and becomes ineffective.

Thus a properly designed storage management system and coordinated recycling program must avail itself of helpful tricks. Color, pattern, and texture coding of the various receptacles will make choice of the right one easier. A computerized "Yard Guard" that recognizes a correct placement and notes that on the record of the person making the drop, rewards effort to "do it right." Docking pay, or hours, for wrong choices will help too. "Anything worth doing, is worth doing right."

Implications for early frontier industry
The "Storage Industries"

To begin this program at the outset of operations of the first outpost, all that will be needed is a vehicle that can pick up items to be stored, take them to an initial storage area that has been identified, and set them on the ground in an orderly fashion, separating them by type, and using a bar coder to tag both item and exact storage location. Such barcoding had been in use for at least a decade on Mir, with great success.

Then as each new industry comes up to speed, iron, steel, aluminum, cast basalt, glass, ceramics, glass-glass composites, and concrete it can use slack time from producing products for domestic consumption and export by making drums, bins, boxes, and stalls to hold items, especially regolith samples, and sorted discarded items, in a way that helps prevent cross-contamination.

Tailings from materials processing can be put to work in storage by piling them up as berms to visually fence off storage areas as they expand. Regolith that needs to be moved out of the way can be tamped into molds and sintered into construction blocks to make shade walls.

Eventually, as we are able to make spars for space frames, probably from glass composites, we can start making hangers or ramadas covered with shielding for storing things that could be damaged by prolonged exposure to the cosmic elements, but do not need pressurization. In short no "new" industry is needed to get this program going.

University Involvement

Long before the first outpost-becoming-a-settlement sprouts an infant university, a University of Luna - Earthside will have become involved in brainstorming the industrial and commercial expansion and diversification of the settlement, endeavoring to keep several steps ahead of reality, least growth be haphazard. The University, first from Earth, then on location, will take the lead in Storage Management Science, recycling systems, shepherding new storage related enterprises, aggressively developing new products that can recycle the many types of discarded items and materials, and working on marketing strategies. Marketing the storage management systems, know-how, and software that the University has developed and licensing of the manufacturing of field-tested storage related equipment and systems to other settlements, *and to to municipalities on Earth as well,* help provide the University with some research and development income.

Employment

On any frontier, "there are always more jobs needing to be done than people to do them. The Moon and Mars will be no exception. When it comes down to priorities the nod must go to jobs that produce saleable exports to earn credits to buy what cannot yet be produced locally, and for production of domestic goods, so that such items no longer need to be imported. That means, that as important as our storage endeavor is, we will need to rely as much as possible on mechanical and robotic systems for placement and retrieval of storage items, the cost of that equipment being far less than the real cost of diverting manpower to these task. People that must be involved will use automated and teleoperated equipment.

However, some tasks involved will be automation-resistant, such as disassembly of items so that individual components can be properly sorted and stored according to material composition. Some of these menial chores can be assigned to the settlement youngsters as after school or "Saturday morning" type chores. We're all in this together.

California Closets Goes to the Moon?

Think of a disorganized storage area on the Moon as one big outdoor closet, jam-packed with assorted stuff in helter-skelter fashion, with no real way to find anything inside. The all-too-common domestic version of this chaos is what gave birth to the *California Closets Company,* the brainchild of a seventeen year old California youth who was soon employing both his parents. The company's many novel solutions have all had their budget imitators, of course, many of them designed for the do-it-yourselfer. But this kind of left-to-itsef disorganization is precisely the market on the Moon, Mars and other space frontiers for well-thought out and practical storage management systems.

The Holy Grail

The Holy Grail of Storage Management *and Reuse Systems* is "to landfill nothing." But once we adopt the principle and experiences some real time benefits, pioneers will be encouraged to reach new heights. Items that remain on the discard pile represent a loss of the energy invested in their original production. Replacing them means using ever more fresh regolith, when that may not be necessary. Of course such a goal will never be reached. But "we must aim high to hit the mark.

Meanwhile, what would have been landfill becomes organized invested storage. Properly done, little energy will be required to maintain this stored potential wealth indefinitely. Nor will the cost of land be a problem for some time.

We'll plan ahead for our storage islands, our "storage parks" integrating them into the planned frontier urban landscape, just as we do industrial parks. Properly screened with pleasant berms and other devices, storage parks will be good neighbors.

The Upshot

Useless Diversion or an "investment in resource availability for the future? Nothing less than the settlement's viability and survivability are at stake. Storing things so that they can be efficiently put back into use is but a concrete application of our pioneers "lifting themselves up by their bootstraps." Not with the plan? Stay home!

Storage is not just about efficient housekeeping. It has environmental and economic significance. Establishing and maintaining the viability of settlements will be a constant uphill battle. The settlement that has its storage act together, will stand a better chance of still being around generations and centuries to come. **‹ MMM ›**

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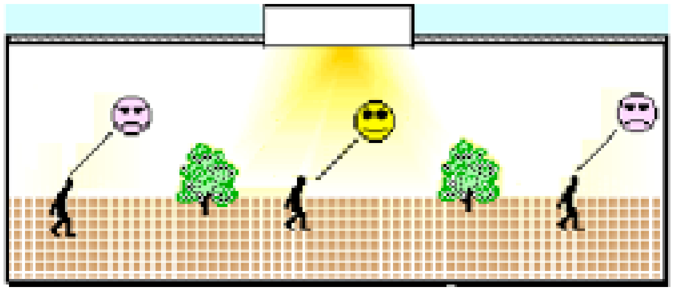


Skylight Highs for Future Lunans?

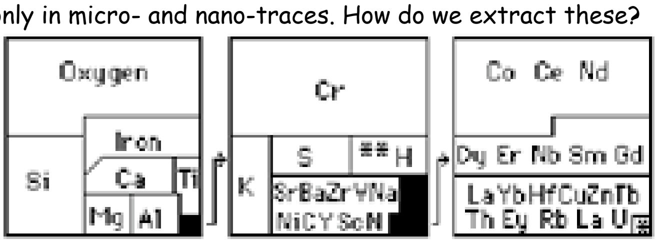
Perhaps long-time residents of "sunbelt" areas will not have experienced it, but for those of us in the "cloud belt," sunny days are especially relished. Even indoors in a shopping mall equipped, as many are, with skylights to increase ambient lighting levels, a patch of bright sunlit sky infuses those passing below with a fleeting rush of euphoria. Are lunar pioneers just out of luck? See below.

[Laying the Foundations for Lunar Industry]
Extracting Valuable Trace Elements With the Help of Micro-organisms
Bioleaching: a Proven Tool for Moon Mining

by Dave Dietzler <Dietz37@msn.com>

Editor's Forward:

Seven elements make up the bulk of the 2-10 meter thick impact-pulverized blanket of dust and rock fragments that we call the regolith: oxygen, silicon, aluminum, calcium, iron, magnesium, and titanium. Chromium, potassium and sulfur are abundant in parts per ten thousand. But many of the elements vital to modern industry were found by the six Apollo and two Luna sample return missions to be present only in micro- and nano-traces. How do we extract these?



2nd Box: ** The moondust regolith contains significant gas reserves from the Solar Wind: H, C, N and He4, Ne, Ar, Kr, Ze, He3. Note that solar wind Hydrogen is the 11th most abundant element, more common than all the elements listed below it in the 2nd and 3rd Boxes above.
3rd Box: *(ppb): Ir Re Au Sb Ge Se Te Ag In Cd Bi Tl Br

Basics of Lunar Geology

It is believed that the Moon was once covered by a magma ocean several hundred kilometers deep. Heavier minerals like pyroxenes, olivine and chromite sank while lighter anorthositic (aluminosilicate suite) material floated to form the upper crust. Volcanism and massive asteroid impacts shattered the crust and molten lava flowed to the surface to fill in the mare basins.

Meanwhile iron sank to the core, chalcophile (copper-loving) elements like copper and PGEs (Platinum Group Elements) sank to the mantle (below the crust and above the core). Central crater peaks and masscons (mass concentrations where surface gravity is above normal) may represent denser mantle or deep crustal up-thrusts or rebounds from these impacts. [Ed.: We have no sample returns from these areas, and a robotic mission to a promising crater central peak should be a high priority.]

G. J. Taylor and Linda Martel believe that chromium, platinum group metals, nickel and titanium may be found in central peaks and crater rims[1]. They also think that silver, Platinum-group, zinc, mercury, lead and copper could be found in pyroclastic (volcanic origin) deposits near volcanic vents in the maria. It is fairly certain that orange and green glass micro spheres discovered by Apollo missions were spewed out from volcanic vents, now long extinct, so deep lavas from the lower crust and upper mantle, bearing valuable metals, may have reached the surface or subsurface beneath the homogenized regolith. Even so, "ores" of silver, platinum and copper are likely to be very low grade, and novel extraction methods will be needed to recover these metals, often called LDEs or lunar deficient elements.

Bioleaching

Bioleaching involves the use of micro-organisms to extract metals from low grade ores and has been performed successfully on Earth to obtain gold, copper and uranium[2]. About 20% of the world's copper is produced by bioleaching. This type of process has been used to extract uranium from the Elliott Lake district in northern Ontario, Canada[3].

Bioleaching of nickel, zinc and cobalt can be done with thermophyllic bacteria but has not proven economical; however, on the Moon where resources are sparse and imports comparatively expensive, this approach may be worthwhile. Nickel and cobalt are used to alloy steel and zinc is used to alloy magnesium.

Thiobacillus ferrooxidans, Leptospirillum ferrooxidans, Thiobacillus thiooxidans, Sulfolobus species and others have been used for bioleaching. Acidiphilium, Sulfobacillus, Ferroplasma, Sulfolobus, Metallosphaera, and Acidianus have also been used. These bacteria tolerate acids and metabolize sulfur. Weak solutions of acids are dripped through the ore and a bacterial liquor forms that is then electrolytically or chemically processed [4].

Sometimes this requires water and an organic substrate like potato peels as well as solvents to extract the metals from the bacterial mass. Chaff from crops may be used for bioleaching rather than livestock feed. Precious water will be recycled. If bioleaching becomes a major industrial activity on the Moon we will be pressed to conserve our vital water and hydrogen resources for this instead of wasting them in the form of rocket fuel.

As the bacteria feed on sulfur, only ores containing sulfur can be bioleached. Bioleaching does not require lots of energy but it is slow. High temperature roasting and smelting is not needed -- decided benefits in addition to the fact that bioleaching can get metals from low grade ores.

References:
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2) Mining and Mineral Fact Sheets
http://www.fact-index.com/b/bi/bioleaching.html
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www.bioteach.ubc.ca/Bioengineering/microbialmining/

More Information:
www.imm.org.uk/gilbertsonpaper.htm
www.nrcan-rncan.gc.ca/biotechnology/english/m_bioleach.html
http://en.wikipedia.org/wiki/Bioleaching **<DD>**

In Search of the Moon's Missing Resources

by Peter Kokh with Dave Dietzler

While the moondust samples returned by the six Apollo Moon-landing missions and the two unmanned Soviet sample return missions did differ from location to location, it was largely a difference of percentages. The highland areas such as the Descartes region visited by Apollo 16 (the Orion) are richer in aluminum, calcium, and magnesium, and the mare areas visited by other missions, are richer in iron and titanium. But the impact-pulverized surface of the Moon has matured to a point where in any given location, half of the material found has been ejected there from somewhere else. The Moon is somewhat "homogenized."

It is of concern that no place sampled has what we would consider to be an economically mine able concentra tion of some elements that are critical to modern industry: copper, zinc, silver, gold, to name a few. Nor will we find ore veins of these elements. Ores are deposited through eons of geological processing in the presence of water. No water to speak of, not now, not in the past.

Dave and I have been brainstorming back and forth the possibility of finding a Sudbury-type astrobleme (relic crater) on the Moon. In the vicinity of Sudbury, north of Lake Huron in Ontario, Canada, lies half the world's supply of nickel, and much of its copper - a gift from an especially rich asteroid. Common myth has it that ore-rich asteroids are commonplace. But the lie in that is clear from the impact evidence on Earth. Now the more massive Earth attracts eight times the number of impactors as does the Moon. But three quarters of those land in the ocean. So the odds for ore-rich impacts on Earth's land surface would seem to be only twice that on the Moon. If we knew how to look, we might just get lucky. And that would significantly improve the odds for a positive lunar settlement trade balance.

Lunar Prospector's gamma ray spectrometer was not fine-tuned for copper or nickel. Even if it had been, its poor 100-mile resolution might not have picked up o deposit even as large as that at Sudbury. But apparently the Sudbury ores all involve Sulfur as well. Could we build a gamma ray spectrometer with vastly higher resolution and fine-tuned to pick up unusual concentrations of sulfur?

We do not have all the answers, or even some of them to our satisfaction. A query has been sent to the Canadian Journal of Remote Sensing to determine whether or not the special character of the Sudbury impact area shows up in any existing remote sensing surveys. That it is a crater is obvious. That is not the point. Has any instrument detected its copper and nickel rich character? We need to know. In September 2003, I passed through Sudbury, not free to stop. A revisit, stopping at its new Earth sciences museum may be in order. Ultimately, a workshop to design a Sudbury-capable Lunar Prospector II?

We'll keep you informed. **<MMM@work>**

Trash >> Treasure = Trashure
Waste >> Resource = Wasource

Trashure Creativity & Wasourcefulnes: Two Critical Talents on the Space Frontier

by Peter Kokh

A shining example

There are many people who make their living, and many more who supplement what they can buy from day job wages or salaries by rescuing things others have thrown out as trash. They/we (for I am surely one of the later) reuse some things as they are, refinish other things, and find wholly new uses or adaptations for still other items. The practice of turning Trash into Treasure ("One man's **trash** is another man's treas**ure**" has so long been a part of our culture that the hybrid word "**trashure**" is now well estab-lished as a search engine exercise will demonstrate.

Yet it is certainly the case that most people are not up to speed on this -- perhaps they lack the spirit of creative adventure involved in "dumpster diving" and the thrill of acquiring, for little effort or money, something to treasure in their homes, or perhaps they can't be bothered to make the effort, or perhaps they disdain anything with a "history" or perhaps they have the cash to buy "new" (read unsullied.) Yet trashure is well-enough established to have become a respectable, even admired hobby.

On the Lunar and Martian frontiers, as on Earth, pioneer artists and craftsmen will find used materials and items their least expensive and most readily available option. It will pay for settlement citizens, individual and corporate, to presort discarded items and send them to a Stuffs or Trashure Market where, hopefully, a good and growing percentage of it will be adopted for reuse, rehabilitation, or transformation into new utilitarian and/or decorative items. "Dumpster Diving," "alley scrounging," and "moving day curbside scavenging" will come out of the closet.

Creative and enterprising volunteers will turn this windfall into unique furniture and furnishings items, works of art (sculptures, for example), musical instruments, toys, and even personal adornment jewelry items -- for personal use and for sale. The trashure industry will grow as the amount and variety of discard items increases, becoming a significant complimentary sector in the overall economy.

Everyone will benefit, as this activity will significantly expand the variety of locally produced items. Visiting trashstuff markets, flea markets, arts & crafts fairs, and specialty shops filled with born-again items on consignment will add weekend pleasures to spare time menu options.

Front End Trash Reduction Measures

Not all pioneers will have the creative talent and urge to make use of the flow of trash. If the volume of discarded items and materials is not to swamp them, up front measures will be needed to reduce the sheer amount of stuff finding its way to the general pile. Here are some simple measures that will help (that some of our spoiled manufacturers may be temporarily inconvenienced by having to switch philosophies and gears should not dissuade settlement fathers from insisting on these protocols.)

- Using KD (easy "knockdown" or disassembly-friendly) methods of assembly, especially when dissimilar materials best recycled separately are involved. We are used to dissimilar items being permanently "bonded" by adhesives, and thus mutually contaminating one another as far as economical recycling options are concerned.
- Tax breaks on items so manufactured, calculated by special rates for kind of material and strategic value.
- Turn-in credit rewards for consumers and manufacturers (who may discard unworkable seconds) discarding items in a properly sorted and disassembled state
- University involvement through a department of Industrial Engineering, in searching for designs that make secondary adaptive reuse relatively simple. Containers that can be reused as canisters, as stackable dresser drawers, as planters, etc.: [The "world bottle" was an inconclusive project in the 1970s to design a beverage bottle that could be used as a building brick.] If there are sufficient incentives, manufacturers will be motivated by profit to create items, normally for one-time use, that can become "pop" stuffs for all sorts of uses. We'll revisit this idea in a future article.

The same strictures should apply to the construction industry. Methods that make separation of materials that need to be recycled separately (i.e. metals and organics) all but impossible such as adhesives (yes, Liquid Nails) and staples, should be taxed sufficiently to provide the money (and labor) necessary to undo these difficult bonds, especially when organic or synthetic materials that embody elements scarce on the Moon (hydrogen, carbon, nitrogen, but also some metals such as copper, brass, zinc, lead, gold, silver, platinum.) **KD! KD! KD!** The tax should be sufficiently onerous to make KD assembly methods more attractive. Think of those who follow, if what you build or put together is not meant to work or perform forever!

Extending the paradigm: packaging waste

In MMM #4, April 1987, "Paper Chase II" (online at www.asi.org/adb/06/09/03/02/004/paperchase2.html), we speculated about ways settlers could do without paper. Paper as an agricultural byproduct should be reserved for quick-turnaround uses: art du jour or temporary children's art, for example, where it can easily and routinely be recycled back into the biosphere-biomass cycle. On Mars, where the stuffs of organic compounds (hydrogen, carbon, and nitrogen) are comparatively abundant, such stringent restrictions may not be necessary (but still wise!)

Paper and cardboard and other packaging materials constitute one third of the total volume of trash and rubbish in modern America. On the Moon, packaging will preferably be made of inorganic materials (e.g. wire mesh bags and baskets, foil, "tin" containers, etc.) or will be formulated and/or designed for easy craft reuse, especially as media for developing artistic talents in children.

There are many other suggestions in the article mentioned. The packaging nightmare has been greatly exacerbated in recent times by having to resort to shrink-wrap cardboard packaging for small items previously held in open bins, as a shoplifting counter-measure. Hopefully, the settlers will come up with other means of discouraging shoplifting in order to do away with this wasteful use of paper and plastic based materials -- but something short of the medieval custom of chopping off the hand of a thief!

Plastics

Most of our plastics are coal- or petroleum-derived. But there has been considerable effort in the past few decades since the first Oil Crisis, to derive suitable organic feedstocks from 'oliferous' plants. Those who would pioneer the Martian Frontier are looking for even more direct routes, synthesizing basic plastics feedstocks like ethylene and propylene directly from the carbon, oxygen, nitrogen, and hydrogen in the Martian atmosphere. Their success will be of use to Lunan pioneers as well, though without such an atmospheric reservoir of needed key elements.

Import shipment "dunnage," the "co-imported" shipping container stuffs such as barrels, crates, skids, separators, dividers, and cushioning materials, will be a primary source of simpler plastics such as polyethylene and polypropylene that can be reformed and reused over and over again, if separately recycled. Current plastics recycling is mostly limited to those containers marked 1 or 2 (inside the recycling triangle symbol). Other containers may be marked properly, but the market for their reuse is not strong enough to support active recycling. On the frontier, it will be the best strategy to allow in (by import) only those plastics the settlement is prepared to recycle. Subvarieties, color-coded both for proper sortation and for use in creating KD children's toys, could help expand options.

We have written previously about Plastics in MMM #26 June 1989, "Toy Chest" and "Thermoplastics" pp 5-6. These articles will be republished in MMM Classics 3, as a free access pdf file, in January, 2005. Also relevant is the article "Stowaway Imports" in MMM #65, May 1993.

Mining Wastes & Byproducts

Mining wastes include tailings, piles of gravel and other solids leftover after the extraction of the sought for element or ore out of the host soil or rock material. Also a problem is unrecycled reagents or acidic leachings dumped into ground water or drainage basins. On Earth, we can try to handle such problems by fines, but a far more effective way is to promote the identification, with University assistance, of profitable products that can be made of such unwanted materials and wastes, and/or profitable markets for sale of such byproducts as is. It can be more profitable to sell byproducts than to discard them. But product and market development must be aggressively pursued.

This kind of thinking and these kinds of processes need to be incorporated in the drawing board stage of development of lunar industries and their diversification. New products from what would otherwise be wasted will mean a more diversified supply of products for domestic use on the Moon, but also a more diversified portfolio of products for export to other in-space markets. Making use of tailings, used reagents and leachings is best seen as a great opportunity for Lunar enterprise, rather than a burden that erodes their profit margins. Those without the right attitude should be discouraged from getting involved.

Tailings will be the host regolith minus the extracted element or suite of extracted elements. The flip side of the coin is that tailings are now "enriched" in all the elements not extracted! That makes tailings a potential feedstock for other materials.

Tailings that are of no further economic use, can perhaps be reused as aggregate for lunar concrete, paving material for lunar roads, and sintered into building materials for unpressurized vacuum exposed structures such as shade walls and radiation-shielding canopies or ramadas for storage purposes.

The tightest possible recovery and recycling of organic reagents and acid and heavy metal leachings will be a cornerstone of lunar industrialization. Given the tight supply of hydrogen, carbon, and nitrogen, and the need to reserve as much of that as possible to support the maintenance and browth of lunar settlement biospheres, no other policy makes sense, either environmentally or economically.

Manufacturing Wastes & Byproducts

Manufacturers will operate under the same environmental and economic sommon sense constraints. Material left over from exuding, casting, or machining parts will have to be recycled back into the source bin. Material contaminated by machine oils can be cleaned in house or shipped out to a service provider. Shipping containers that cannot be reused, will either be turned into sideline products or sold on a web-based byproducts and waste materials market. Most of these materials will be reused domestically on the Moon. But some may find viable export markets, further improving the Moon's import-export equation and overall economic viability.

Consultants will suggest new uses for manufacturing byproducts and waste materials will become a key player in making the lunar industrial system work well. Some of them may even take over a customer-approved plan as prime contractors. Bigger manufacturers may have in-house research departments doing this, spinning off subsidiary enterprises in the process. Waste reduction and recycling will be good business.

Agricultural "Wastes"

Once I was told by an expert in space agriculture that cotton was not a candidate plant for lunar agriculture. Despite the fact that no other fabric is as versatile, comfortable and recyclable, there is too much waste biomass involved. Fully 86% of the plant by weight is of no use. The statement, expert source or not, is absurd. One has only to look at the example of the African-American agricultural pioneer, George Washington Carver, with well over a hundred patents to his name on products that could be produced from the peanut plant. What Carver did in Tuskegee, Alabama should be a challenge to would be lunar farmers and farm product processors. That example could inspire a considerable diversification of lunar agriculture-based industries and enterprises. But even should future Lunan processors have less luck with cotton, it remains true that biodigesters have been demonstrated that can take any and all waste biomass and reduce it to an edible tofu like product, with only 2% stubborn waste.

Liquid and Liquefied Wastes: A Plumber's point of view

As a jack of all home-improvement trades, plumbing among them, I believe a lot of problems and challenges can be minimized by proper plumbing. In MMM #40 NOV '90, "Cloacal vs. Tritreme Plumbing" I described our present municipal plumbing systems, descended without substantial improvement from that of the ancient Indus Valley town of Mohenjo-Daro c. 2,500 B.C., as "cloacal." A cloaca is the discharge system used by monotremes (one hole), primitive mammals such as the duck billed platypus, in which the anus doubles as ureter. "One hole serves all." "One drain serves all." Nowadays some cities are belatedly trying to separate storm sewers from sanitary sewers. Too little, too late.

On the Moon, where we have a unique opportunity to design our infrastructure from scratch on a clean drawing board, we can institute polytreme, multi-hole multi-drain systems to minimize the treatment and recycling challenge. Agricultural runnoff, shower and sink runnoff, toiled wastes, manufacturing waste water - these can all be plumbed separately, minimizing the problem instead of compounding it. If we start off on the right foot right away, this way of doing "business" will not be seen as a burden, but as the only civilized way of doing things, implying derision of primitive terrestrials for the four and a half thousand year old system they insist on proliferating.

Primary Point-Source Treatment

Rigorously separated polytreme drain and sewer plumbing systems will make the job of finding market-worthy products derived from properly separated wastes that much easier. And even this challenge will be minimized by primary Point-Source Treatment.

Biological gray water treatment of human wastes, on the model of the 25 year field-tested Wolverton Graywater System (www.wolvertonenvironmental.com/ww.htm) which provides the home, office, restaurant or other toilethosting modules or structures with fresh sweet air (regenerating oxygen from carbon dioxide), abundant greenery, and sunlight is an option. Such systems will enable synchronized modular growth of settlement biospheres because every new toilet-equipped unit, resi-dence, office, commercial, industrial, or other, will be equipped to execute a 95% pretreatment of human wastes before the gray water enters the settlement municipal sanitary drain system. The central burden for both water and air recycling will be enormously minimized. Waste waters from other sources can also receive primary treat-ment at the point source, again enabling the modular growth of the biosphere, with farming and industrial areas each contributing their share.

Where does this put us?

Trash and rubbish are one thing. liquid wastes and sludges are something else, carrying the connotation of unclean and unsanitary, of polluted or even toxic. My point? If on Earth we can afford not to extend the same rehabilitation effort to liquified waste as we do, with growing frequency, to trash, that will not be the case on the Moon. On Mars, the pioneers could probably get away with indulging the same bad habits we have on Earth. The difference can be summed up in one word: volatiles. Most wastes, especially liquid ones (with or without solids) are composed of organics; volatile elements abundant on Earth, and accessible on Mars. On the Moon, these elements must be scavenged from solar wind gases trapped in the upper regolith layer or refined from comet-derived polar perma-shade ice depositsl. What on Earth is useless and without value will be priceless on the Moon.

Toilet systems that use human wastes to feed plants are now demonstrated. Entrepreneurs have learned to use drained motor oil as fuel for heating. But most organic wastes are just "wasted." The Lunan pioneers will need a whole new attitude towards all kinds of organic wastes from human wastes, to food production and prepara-tion wastes to chemical plant wastes. They will need to do *the mental flip flop that equates waste with potential resource.* Waste not, want not! It's not just for the dinner table anymore.

This kind of frugality is an investment in the future To promote the idea, first among potential Lunan pioneers, then among our terrestrial brothers and sisters, we offer the trashure-parallel coinage: **wa**ste + re**source** = **wasource** pronounced "WAYsource".

Wasources must be integrated into the Lunar Resources pantry. Wasourcefulness must become part of their frontier culture, an aspect of settler resourcefulness. The frontier government can offer incentives to entrepreneurs and established companies alike to develop nontrivial uses for various types of waste. An Internet-based waste metainventory database and exchange program could be inaugurated. A frontier university should be very much involved both in maintaining the system, in expanding the categories as needed, in research and development of new processes and product lines, and in waysource-based enterprise creation and assistance.

Wasources represent invested hydrocarbons and other organic and synthetic enabling elements. Chemical feedstocks for plastics, lubricants, even pharmaceuticals are among the rewards. The volatiles involved will either have been brought from Earth as food stuffs, agricultural nutrients and fertilizers, medications, chemical reagents. Some will come from routine gas scavenging of the solar wind gases in the regolith. Much of this will find their way through the human digestive track. Some of it will be waste byproduct of various food and regolith processing and manufacturing orations. The salient point is that any volatiles embodied in wastes (of whatever kind) should be treated as an investment, an endowment that should continue to produce income - not be flushed into some never-never land out-of-sight-out-of mind from which retrieval may be difficult and unprofitable.

Storing Wasources

In designing a complete and efficiently organized storage system, thought must be given to storing waste liquid and sludges, carefully segregated according to source and gross chemical makeup. At least that should be a goal for priority implementation.

Before we get too far along in developing our initial beachhead outpost into an infant settlement, we will either be already recycling human wastes, hopefully near their individual point sources as in the Wolverton toilet=plant bed system, or we will have chosen by default for the settlement to fail. But early on, before such systems are in place, we will want to store these wastes in durable containers from which they can be retrieved when we are ready for them. To do that, all we need is to put them in permanently shaded areas (under a shed will do) where their chemical wealth can stay frozen and inert. To do otherwise would be seen in retrospect as an act of treason against the future human frontier, much as the currently accepted practice of scuttling the shuttle external tank just short of orbit may be so judged, if only for its seven tons of copper, each, of almost astronomical value on the copper deficient Moon.

Pioneering the Moon will take a whole new set of attitudes, if we are going to make it work to enhance the viability of human outposts on a hostile world.. Wasourcefulness is one of them. Fortunately, there is a subculture paradigm for inspiration: that of "trashure." **‹ MMM ›**

The Black Sky "Blues"

Part III: Faux Skylights & Clerestories

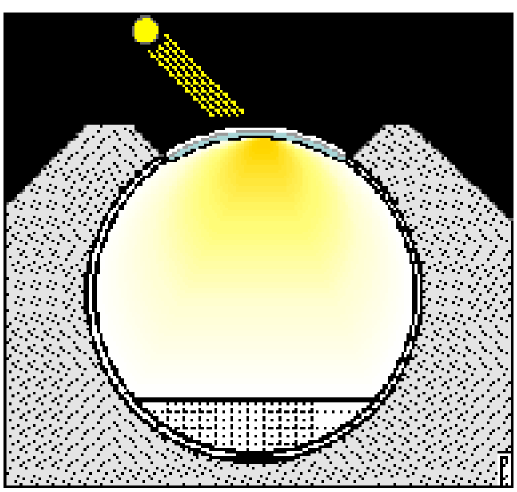
by Peter Kokh

MMM #138 SEP 2000, p 4. The Black Sky "Blues"
MMM #176 JUN 2004, p 7. "Black Sky Blues" Revisited

The skies of Luna will always be black and the uncomfortable glaring contrast with the overly bright sunlit surface will always be harsh. On Earth, water vapor in the atmosphere scatters the suns rays so that light seems to come uniformly from all directions. Our atmosphere is a natural "diffuser" with a bluish cast. In the first article cited above, I floated this suggestion:

"For those windows meant to bring in light but not necessarily the views, could we produce some sort of frosted and translucent, but not transparent, glass pane that will not only let in sunlight but appear itself to be bright, giving the illusion of a bright sky beyond? Again we but throw out the challenge. One might experiment by holding up various kinds of existing glass and diffusers to a streetlight against the dark nighttime sky."

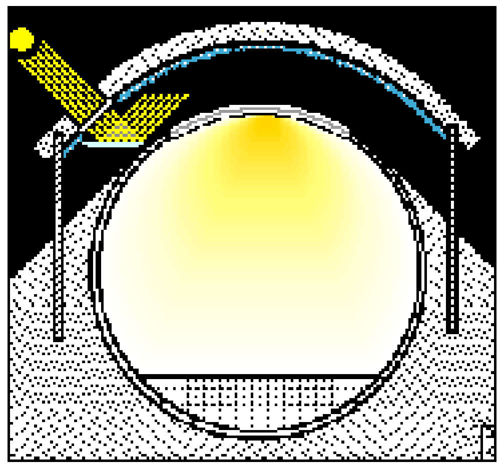
The simple set of experiments is still worth making.



It might require dual panes set some distance apart. But even if this worked, it would introduce the problem of breaching the shielding blanket.

This breach creates an intolerable situation. This type of skylight could be permitted only in locations rarely visited, such as honeymoon hotel suites. Proper shielding should be preserved in all regularly occupied structures.

But there are other ways to fool the eye with the desired uplifting effect. A shielded vault section could be suspended over a transparent glass skylight, its underside painted a bright matte blue. Sunlight would be funneled by mirrors to reflect on the underside of this outer 'sky vault' creating the illusion of a bright blue sky within the habitat. These are admittedly very crude illustrations (in the absence of the services of a good illustrator, services MMM has lacked from the outset.) The engineering would differ from location to location depending on the latitude above or below the equator and the path of the sun across the sky.



In this illustration, a vault i covers & shields all vision angles throughthe skylight. Mirrors are shaped to scatter sunlight as evenly ault via a fresnel lens.

The skylight, as shown, follows the cylindrical or spherical shape of the module it is in. But in practice, the curvature should be inward, towards the pressurized interior as glass is much stronger under compression than under tension. During nightspan, an exterior sulfur lamp could take the place of the absent sun, using the same pathway. The skylight could also be shuttered as desired.

A properly done matte blue finish would seem to put the faux blue sky at an indefinite distance, increasing the illusion. Only reflected sunlight would entire the habitat area through the skylight. It is common practice on Earth to place skylights in north facing roof slopes (in the northern hemisphere) so as to feature the bright sky, not direct sunlight. So this arrangement would follow that practice.

Faux sky vault facing skylights could be installed in high end homesteads over a library, family room, or garden area. They might be more common in lunar settlement hotel atriums, in restaurants, and in corporate office foyers.

Future Lunan Pioneers will not give up access to sunlight and outside views. Neither, do we predict, will they long choose to do without bright blue skies. There is more than one way to skin this cat. **‹MMM›**

How large is the Moon compared to Earth?

Parameter	Earth	Moon
Mean diameter	12,742 km	3,476 km
Volume	1.08321 x 10^{12} km	32.199 x 10^{10} km3
Mass	5.9736 x 10^{24} kg	7.349 x 10^{22} kg
Mean density (H2O=1)	5.515	3.342
Surface gravity	9.78 m/s^2	2.16 m/s^2
Escape velocity	11.2 km/s	2.38 km/s
Visual albedo	0.367	0.12

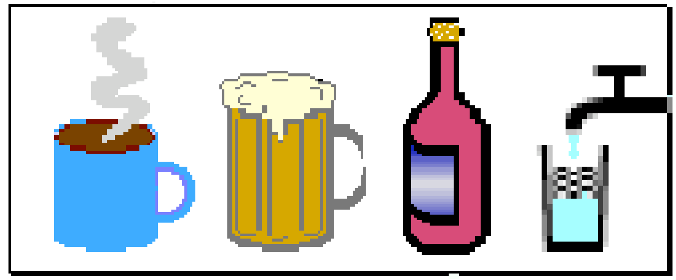
The surface area of the Moon is just 7.44% that of Earth or 14,657,415 sq. mi. vs. Earth's 196,961,284 sq. mi. (The formula is $4\pi r^2$) But if you compare the surface of the Moon *to just the land surface* of Earth (only 57,500,000 sq. mi.), the Moon's surface is fully 26.2% as large as Earth's.

Imagine Canada and the U.S. on the nearside hemisphere China and Brazil on the farside, and you about have it. Or North and South America less Mexico and Central America, or Africa (11,668,000 sq.mi.) *plus Europe* 3,000,000 sq.mi.). Many writers wrongly equate Africa and the Moon in size.

From the Moon, Earth appears 3.67 times as wide, and takes up 13.4 times as much area of sky. Thanks to the polar ice and all the clouds, Earth reflects much more light than the relatively dark Moon, and the full Earth appears 60 times as bright from the Moon as the full Moon we see.

Thanks to its smaller yet significant size and lower density, the Moon enjoys just 1/6th our gravity. Only Ganymede, Titan, Callisto, and Io are larger satellites, and only Io is more dense and has slightly more gravity. **MMM**

MMM #180 - NOV 2004



The Early Frontier – "What's to Drink"

One highly individual thing is our attachment to various beverages. That attachment can be well cultivated and go beyond the generic to specific brands. Or it can be very all-imbibing. Those with more generalized tastes will make for happier pioneers. But the quest for better quality beverages and a growing variety of them will be a major driver for frontier entrepreneurs. *See below.*

Lunar Nuclear Fuel, At Last

by Dave Dietzler < Dietz37@msn.com >

From Seawater to Lunar KREEP

From the excellent book "Megawatts and Megatons" by Richard L. Garwin and Georges Charpak, we find that French and Japanese scientists have successfully experimented with the extraction of uranium from seawater with plastic filters.From one kilogram of plastic filter they obtained 3g uranium, 2g titanium, 6g vanadium and 6g of cobalt. The metals are extracted and the plastic filter is reused many times.

Not only does this mean that we can have a massive supply of uranium for nuclear power on Earth obtained more cleanly than by mining which causes the release of radon gas from mine tailings, it means great news for us Moon miners. You see, KREEP [Potassium (K), Rare Earth Elements (REE), and Phosphorus (P)], although it is richer in uranium and thorium than other forms of moondust, is still a very low grade ore.See the table below (info from Van Nostrand's):

Constituent	Anorthositic Rocks	KREEP
Al2O3	>25%	15-20%
FeO	0-5%	8-10%
MgO	2-8%	7-13%
P2O5	0-0.06%	0.3-2%
K2O	0.01-0.2%	0.2-2%
Uranium	<0.4 ppm	2-6 ppm
Lanthanum	0.1-4.5 ppm	40-80 ppm
Hafnium	<0.01-5 ppm	10-30 ppm

An abundance of 2-6 ppm of uranium does not seem very significant, but seawater only has 3.3 milligrams per cubic meter or ton. That's just 3.3 parts per billion.If we can get that uranium out of seawater we can certainly get it out of KREEP which has a thousand times as much (that's 3.3 ppm/ 3.3 ppb = 1000)! KREEP consists of complex minerals made mostly of silicon, oxygen, aluminum, iron and magnesium with some other good stuff like phosphorus, potassium, uranium and rare earth metals like lanthanum (used to increase the refractive index of glass) and hafnium (used for reactor control rods).

What we must do is break down the crystal matrix like we do with other minerals by melting, quenching and grinding. Then we can carbochlorinate the stuff by mixing it with carbon dust, exposing it to a stream of chlorine gas (both C and Cl will be carefully recycled, and any losses replenished by scavenging solar wind volatiles adsorbed to the fine particles in the surface covering regolith blanket, whenever we are moving lunar soil around) -- see www.asi.org/adb/09/06/02/03/023/gas.html) and heating it with solar reflectors or lenses.This will convert the stuff to chloride salts like that which we find in seawater.

The silicon tetrachloride will boil off at only 56.9 C.It will be decomposed with solar heat to get pure silicon for solar panels and recover chlorine gas.Carbon monoxide will also form and vaporize off to be recycled by reaction with hydrogen for conversion to methane and water which can be pyrolyzed and electrolyzed respectively to recover carbon and hydrogen, and get some oxygen.

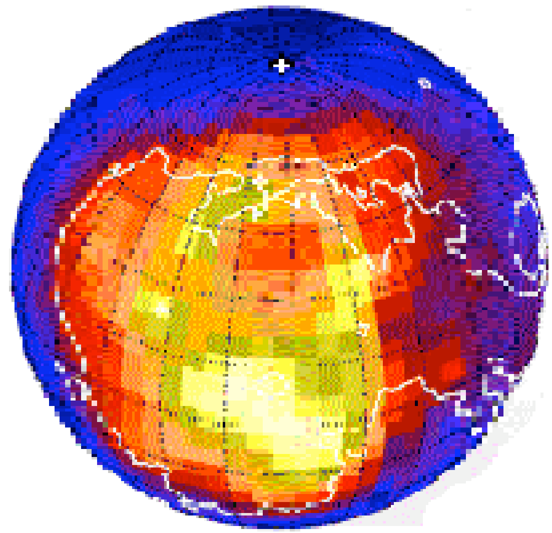
The chloride salts that remain will be dissolved in water and pumped through plastic filters to get the uranium. We can imagine other plastic filters that will absorb phosphorus, potassium, rare earths, thorium and other trace metals perhaps.

Byproducts of Uranium Production from KREEP

After uranium filtration, the salt laden water will be boiled down, condensed, and the metallic chloride salts are decomposed with extreme (mirror-concentrated) solar heat in a ceramic retort to recover chlorine, or they will be subjected to electrolysis. Aluminum chloride can be electrolyzed to get aluminum.The iron salts could be removed with magnets and that would pull out any salts of nickel and cobalt that might be present.These could be broken down with heat and treated with carbon monoxide gas to make liquid carbonyls that can be separated by distillation.

Note that the nuclear scientists also filtered titanium, vanadium and cobalt out of seawater, so we should capture these in the process of filtering out uranium if they are present.Separating those metals from each other could be problematical.Uranium can be fluorinated to make UF_6 which has a low boiling point, so we could just do that to roast it out of the mix of metals we filter out of our salt solution.Uranium hexafluoride can than be run through gas centrifuges which use only 10% as much energy as gaseous diffusion to enrich the uranium for use in nuclear power reactors and nuclear rocket engines.Another barrier to lunar industrialization seems to have fallen by the wayside!

Lunar Prospector – Thorium in Western Nearside Maria



Globe is tilted with North Pole (✙) towards viewer

Area coincides with the splashout reach from the Mare Imbrium impact event.

A Prospector's Visionary Tour of The Inner Solar System

Dave Dietzler < Dietz37@msn.com >

Have Mercury and Venus been Prematurely written off?

Most space travel advocates these days have just about written off Mercury and Venus while focusing on the Moon, Mars and orbital space. The blazing hot Sun on Mercury and the corrosive atmosphere and heat of Venus make these two planets seem like worthless territory.

The Case for Mercury

Actually, they offer much to mankind in the future. First of all, they have unique positions in the solar system. Solar energy is 6.7 times more intense at Mercury than in Earth orbit, therefore a silicon solar panel or foil solar thermal collector can gather almost seven times as much energy from a given area as would a solar panel at Earth's distance from the Sun or on the Moon. About 9000 watts of energy falls on a square meter at Mercury. If the solar panel is 15% efficient it will generate 1350 watts. A 100% efficient solar panel would be needed to do that on the Moon or in Earth orbit. Foil collectors will reflect about 95% of the light falling on them.

On airless Mercury or in solar orbit at that distance robotic factories will be rich in electricity and solar energy for direct application to smelting and melting of metals for casting or alloying. Moreover, Mercury seems to be 60-70% iron and 30% silicates. The planet is a storehouse of heavy metals waiting to be mined and launched into space with electromagnetic mass drivers.

The Case for Venus

Venus is enshrouded by a thick atmosphere of CO_2 that contains far more carbon than is available in Earth's fossil fuels. At Venus, solar energy is twice as intense. Many schemes for terraforming Venus have been devised. We could also build balloon borne robotic factories floating at high altitude where the pressure is only one atmosphere and the temperatures reasonable. Chemical processing equipment could be used to extract carbon and nitrogen from the Venusian atmosphere as well as some hydrogen and sulfur from sulfuric acid in the Venusian mists. Oxygen could also be extracted. A simple 19th century chemical process involving catalysts to spur the reaction of CO_2 with hydrogen to form methane and water which are then easily decomposed to hydrogen which will be recycled, carbon and oxygen is all that's needed.

Rockets using nuclear thermal engines and liquefied CO_2 could orbit those payloads. Carbon dioxide is easily liquefied by expansion and pressurization, thus it is easy to separate from nitrogen which must be much colder to liquefy. It is essentially inert and will not corrode nuclear thermal engines or their cooling jackets since it doesn't decompose to carbon monoxide and oxygen until about 3000 degrees C. The rockets could also have jet-atomic engines. Nobody is going to be harmed by power from uranium, plutonium and thorium on Venus!

Cf. "Rehabilitating Venus as a Human Destination" - a compilation of articles about Venus that have appeared in past issues of MMM --
www.lunar-reclamation.org/papers/venus_rehabpaper.htm

Mercury : Grand Central Station of the Solar System?

Transportation of metals from Mercury and of carbon and nitrogen from Venus to other places in the solar system will not require vast amounts of rocket fuel. Slow "interplanetary barges" using a combination of mag-sails with solar sails affixed to the mag-sail staying lines could use the free and intense solar wind and light of the Sun to ride out to other places in the inner solar system where space colonies were being built, Earth and the Moon, and beyond.

The AI [artificial intelligence] robots that do the work will originally be built of lunar materials and sailed in to Mercury and Venus. Once mining and transportation between Mercury and Venus is established, metals from Mercury could be used to build more replicating robots and rockets for Venus and Veneran carbon, nitrogen and perhaps hydrogen and sulfur can be used by robots on Mercury to make chemicals and synthetic materials like silicones.

Accessing Resources in Mercury's big iron core

Mercury will be more than a big chunk of iron. When combined with carbon we have steel. It gets better than that. The iron core of Mercury (relatively larger than Earth's iron core and much closer to the surface) is bound to be rich in nickel also. Like iron meteorites, it will be rich in siderophile or "iron loving" elements like sodium, zinc, germanium, arsenic, selenium, bromine, silver, cadmium, indium, antimony, tellurium, rhenium, osmium, iridium, gold, thallium, bismuth and tin. The crust will contain more silicates and the mantle magnesium-silicates, but the mantle of Mercury is thin, the core huge, and internal heat not much greater than the Moon's thereby enabling extremely deep mining by the AI robots that work tirelessly. There will certainly be places where core material upwelled in the past. If we must, we can use nuclear explosives to bore deep shafts into Mercury.

What about mining the asteroids?

It may be argued that iron asteroids are easier targets for metal mining, but these don't have the strategic locations that Venus and Mercury have. Even so-called "near Earth asteroids" are not near Earth most of the time. In a cruel cosmic Catch 22, the closer two orbits (Earth and a near-Earth asteroid) are in period, the less frequent the launch windows between them. The advantages of Mercury and Venus's locations are indicated in the tables below.

To and from Mercury

Planet	days between launch windows	days to/from*
Venus	144	75
Earth	116	105
Mars	110	170
Jupiter	90	855
Saturn	89	1965

* via minimum delta V Hohmann transfer orbit

To and from Venus

Planet	days between launch windows	days to/from*
Mercury	144	75
Earth	593	150
Mars	337	217
Jupiter	239	831
Saturn	230	2015

Mars is not the springboard to the Outer Solar System

It takes more energy to travel between Mercury, Venus, Earth and Mars but time of flight is low and launch windows frequent. Launch windows between Earth and Mars are 778 days apart and a Hohmann trajectory flight takes 260 days! And while you might think that Mars is a "springboard" to the outer solar system, launch windows from Mars to the outer planets are 800 to 700 days apart. Mars does not have the intense solar winds and light pressure to drive sails on their way without any fuel.

Resources in the Outer Solar System

What do the outer planets have that would be of interest to inhabitants of the inner solar system? Mostly hydrogen. Ice could be mined on Callisto, safely outside Jupiter's hot radiation belt. Hydrogen extracted and launched in tanks to orbit around the Jovian moon could be loaded on freighters that use nuclear powered electrodynamic tethers to move around amongst the Jovian moons (Jupiter has a powerful magnetic field) and even spiral out to escape velocity. A VASIMR drive using hydrogen could also help the freighter. The "interplanetary barges" loaded with liquid hydrogen would use foil shaded radiators exposed only to the depths of space to reliquefy boil off from the massive LH2 load with out much energy at all. They would not need to drag along retro rocket fuel and the higher initial fuel load that this would require. Upon entry into the inner system the barges would just unfurl their rolled up solar sails and energize their mag-sails and brake for free into orbit around Mercury or Venus or space colonies in solar orbit and unload their hydrogen cargo. Since they would head back out to Jupiter with tanks empty the sails won't have to acquire too much thrust from the Sun's light and charged particle streams to get up to speed. Traveling by capture orbits they won't need retro rockets on return to Jupiter. Once captured into orbit by Jupiter's gravity they'd get around by electrodynamic tethers and rendezvous with space stations for more hydrogen.

"Pipelines" of slow interplanetary barges would emerge between Mercury, Venus and Jupiter's moons. We won't get enough hydrogen to douse Venus with water but we will have enough to supply miners on Mercury and Venus as well as space colonists in giant toruses with thousands of inhabitants orbiting within the orbit of Earth or Mars.

Lunans might also use imported Jovian hydrogen for rocket propulsion, although the Moon can use aluminum-oxygen rockets, mass drivers and perhaps space elevators in the future. With Jovian hydrogen, Venusian carbon and abun-dant lunar silicon and oxygen it may be possible to build huge silicone "eco-spheres" on the Moon shielded with water or transparent silicone oil that isn't effected by the the Moon's temperature extremes

How much would all this cost? I can only believe that these things will be possible in a world that has controlled its population growth rate and planted colonies in space and on other worlds for the excitement of doing so. Artificially intelligent robots would do most of the mining and factory work on Earth and in space. The robots would produce such a vast wealth of material goods that poverty is abolished, freeing us to pursue the arts, sciences, sports.

Many people will have information technology jobs and do the fine handiwork the robots cannot do. If a man builds a robot and the robot goes to work night and day producing metals and finished products, that man will be highly productive. People would still work but the work they do would be far more valuable than planting rows and picking cotton or slaving away on an assembly line. I don't suggest androids that climb ladders and build skyscrapers, but I do suggest robots that can crank out steel beams, building materials and modules so fast that the price of these things becomes negligible and robot assisted human construction workers become more productive than ever.

Imagine human crane operators assembling a prefab modular skyscraper. The cost of high rises would plummet and the supply would be enormous. Anybody who wants an office on the 100th floor or a penthouse could have one. Technology designed for space could be applied Earth. We envision modular habitations on the Moon made of steel and glass-glass fiber composites assembled by robots with humans moving in later. What if we did that on Earth? We could have more mansions than people to fill them!

Population growth will not be limited by housing but by food production which will be increased with GMOs and the freedom to do more than work in a rice paddy and have kids, half who die young. We will go beyond working to support our kids to working to have fun. That's the best reason for colonizing the galaxy! **<DD>**

Sail the Solar System: the Grand Tour

Dave Dietzler < Dietz37@msn.com >

First a bit about Physics terms & notation

- Force = 2(P*A)/c
- P (power) = 1400 watts/sq. meter at 1 A.U., {Earth's distance from the Sun)
  (at Mars' orbit, P= 600 watts/sq. meter)
- A = sail area in sq. meters
- c = lightspeed 300,000,000 m/s
- 0.21976 pounds of thrust per newton

Now for the fun

At Mercury, P = 9000 watts/square meter. A 10,000 tonne (or 10,000,000 kg. or 22,000,000 pound) solar sailing barge with 50 km. by 50 km. sails would reach:

2(9000*2,500,000,000 sq. meters)/300,000,000
= 150,000 newtons or 32,964 pounds of thrust.
32,964/22,000,000 = 0.0015 G
or 0.0147 meters per second per second acceleration

In 90 days we will reach 0.0147*3600*24*90= 114,182 m/s or 114 kps or 410,000 kilometers per hour!!! That's 255,000 mph!

Since we will be moving out away from the source of sunlight our rate of acceleration will continue to diminish, but if you tried to launch from Mars you would disappear into the dim regions of the solar system and lose thrust, especially with light falling off with the inverse square of distance from the Sun

I don't know how fast you could actually go with a solar sail or how much faster you would go in combination with a mag-sail, but I have no doubt that barges could launch to Jupiter, travel between Venus, Mercury and Earth, and brake into the inner solar system when coming in from Jupiter's icy moons.

How do we make the sails? Glass filament reinforced foil? Aluminized plastic? Carbon fibers? Details! We will make them.

According to my computer program, you need 17.43 kps over and above Mercury's orbital speed about the Suget on a Hohmann transfer trajectory to Jupiter. You need to lose 8.193 kps to go from Jupiter to Mercury. Haven't figured out how much to overcome Jove's gravity but we get the idea. I don't know much about the capabilities of electrodynamic tethers, but my intuition tells me they could be used to escape from Jupiter. I did double check my calculations, so this is correct and amazing.

Our Grand Tour Begins

In Arthur C. Clarke's Imperial Earth he describes a fusion powered space liner that leaves Earth, flies by Venus and Mercury, stops at Mars,if I remember right, and then goes out to Titan. Could we actually do that? I don't know about fusion but we could certainly use nuclear electric ion drives and solar sails to leave GEO or L1 (or L2). I would prefer to take a trip to the Moon first (since this is a luxury cruise Grand Tour) then exit from L1 and get some gravity assist from Earth. Swing down to Venus and use sails to brake into orbit there. More courageous passengers could fly down to the AeroCities floating just below the cloud decks and see the Venusian surface. * That really can't be more dangerous than re-entry I guess. It's all a matter of perceived dangers.

Past MMM articles about the possibility of subnubilar (below the cloud deck) floating cities over Venus are republished in the following online paper:

"Rehabilitating Venus as a Human Destination"
www.lunar-reclamation.org/papers/venus_rehabpaper.htm

We could then use the sails to fly down to Mercury and after no more than 144 days at Venus and spend no more than 110 days at Mercury before getting a launch window to Mars. (In both cases, the wait for a launch window could be much shorter.) Then race around the Sun and head out to Mars at high speed. We could brake into orbit around Mars with nuclear thermal rockets stocked up on Venusian CO_2 or hydrogen from the pipeline from Jupiter's icy moons.

Waiting on Mars for a launch window to Jupiter would take up to 814 days. Some can stay on Mars, others go back to Earth on the next cycling station, and others can make the long haul to Jupiter. Or we could fly straight to Jupiter after no more than 90 days on Mercury and do it fast with sail power. Then we can cruise around in the Jove system, visit cities beneath the ice of Europa, go to Callisto, etc. Getting back to Earth will be done by spiraling away from Jupiter with electrodynamic tethers and using nuclear electric engines. We will brake into orbit around Earth with the sails so we will burn up all the fuel we can to get some speed back to Earth instead of lugging retrorocket fuel.

Our Sail-liner would have thick radiation shields and artificial gravity. A ten thousand ton ship constructed of magnesium, aluminum and titanium would be quite large. It might amass more than that. It could even use active magnetic radiation shields instead of massive solid material for shields to reduce mass and give us more tonnage devoted to habitable volume.

Putting the brakes on Imagination

I don't think the women will be wearing Victorian fashions, but to me this is not an overly pessimistic or optimistic vision. It's based on real science and engineering possibilities. We just need the wealth and space infrastructure needed to do such things.

I don't believe in vacuum energy, antigravity, or antimatter. I am pessimistic about low mass fusion drives. Fission using a vapor core reactor like that being researched by Dr. Travis Knight and others at the University of Florida's Innovative Nuclear Space Power Institute is my choice for power. The vapor core reactor can get over one kilowatt per kilogram of system mass and that is an order of magnitude better than other fission systems.

There's enough uranium in seawater to power human civilization for thousands of years. There's four times as much thorium in the Earth's crust than uranium. When we mine Mercury, the Moon, Mars and perhaps some asteroids we will have even more fission fuel for space propulsion. [Lunar Prospector found thorium highly concentrated in and around the nearside western maria.]

Cf. MMM #116, July '98, pp. 7-8 "Uranium and Thorium on the Moon" - More in MMM #123

Human civilization will probably be powered by solar and fission. We can use low mass fission power systems for spaceship propulsion in addition to solar sails and mag-sails (which need a source of electricity). We have plenty of fission fuel -- uranium, plutonium and thorium, to power interplanetary travel for a long time.

If we ever do get low mass fusion reactors or even vacuum energy we will use them, but I am only trying to illustrate the possibilities that exist with foreseeable technology, and those possibilities are tremendous. I didn't even mention beam riders in the Grand Tour sketch above.

With power stations on other planets or even in free space (firing opposing beams to stay in "one place") we could build power plants so massive they could never be useful on a ship, but they could direct microwave or laser beams at the sails of a spaceship and propel it to high speeds. Perhaps this is how we will use fusion-"stationary" fusion power plants to energize the beams. With beaming stations on Deimos, Phobos and the Martian surface we could propel ships from Mars to the outer planets. We could even put beams on minor planets like Ceres and Vesta.

In my humble opinion, matter-antimatter drives, trans-luminal travel, antigravity, inertialess drives and other science fiction staples are going to seem quaint in 100 years or more. The reality will be sails, electrodynamic tethers, ion drives, low mass vapor core fission reactors, propulsion beams and ground based or space based fusion power plants to energize the beams, nuclear thermal rocket engines using whatever reaction mass is available from hydrogen to LOX augmentation to CO2, methane or ammonia, cycling stations and rockets burning metals mixed with LOX.

Now, if some science fiction writers would pick up on those technologies and think about the solar system and thousands of cities flourishing on other worlds and fanta-stic landscapes from Venus to Callisto and even Titan and some neat Space Oases also, they would have a realistic scenario as exciting as the many worlds of Star Trek. No alien monsters to fight every week, but hopefully most of us have outgrown that sort of thing.

We hope you enjoyed your ride and will choose DD Spacelines for your next spaceflight! <DD>

[A movie that got away]

PLYMOUTH – (1991)(ABC–Disney TV)

http://www.imdb.com/title/tt0102681/

Director/Writer: Lee David Zlotoff (McGyver)

Plot Summary:

The inhabitants of the small town of Plymouth have to evacuate their homes. Collectively they move to a moon base. Despite the agreement that no babies should be born there, because of the risks involved, the base's doctor does get pregnant. And then a sun flare hits the moon and everybody has to seek shelter.

Cast:

Dale Midkiff* Gil Eaton
Cindy Pickett Addy Mathewson
Richard Hamilton Mayor Wendell Mackenzies

*Lead (Daren Lambert) TV Series **Time Trax** 1993-94

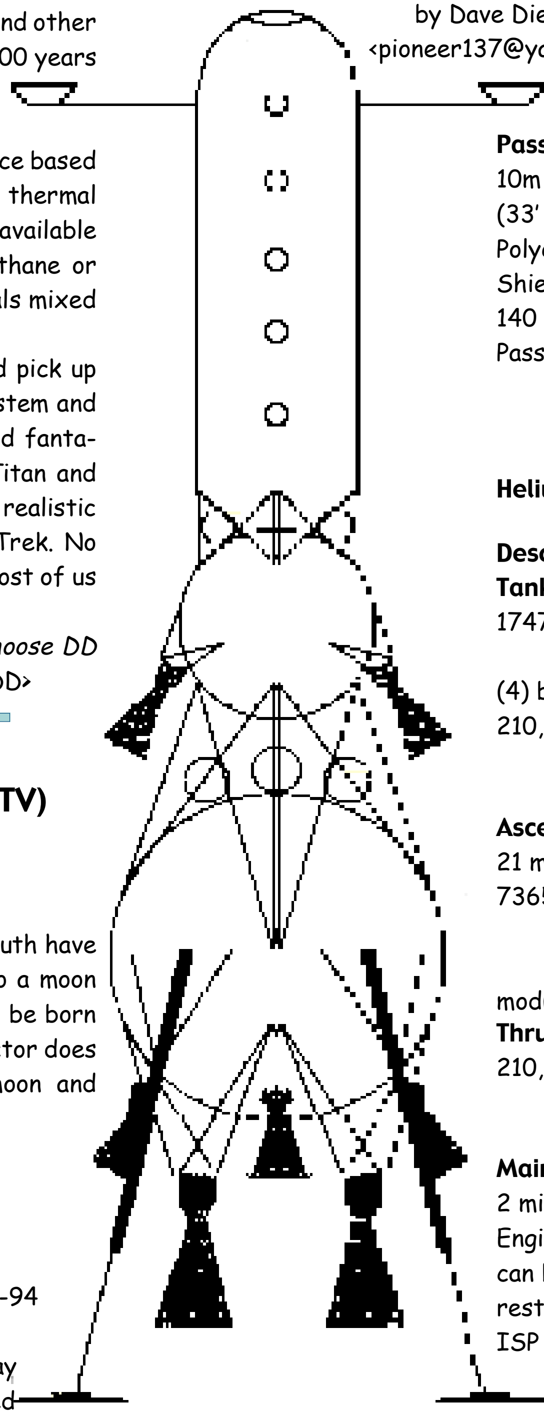
Status:

Shown only twice, Saturday, Memorial Day Weekend in both 1991 and 1992. The ratings, judged by those who watched, were insufficient to motivate ABC to take it to Series, though it was intended as a series pilot. No VHS recording was ever released. The only avail-able copies are those made privately off one of the live airings. Fan-made DVDs made from the Fan-made VHS tapes are also available, though not publicly advertised.

As a film, the only one ever produced to treat the Moon as a place to go for resources that could help solve Earth's (energy) problems, **Plymouth** has real value as an outreach tool for space activists. **<MMM>**

A late 21st Century Moon Rocket for 200 Tourists or Pioneers

by Dave Dietzler
<pioneer137@yahoo.com>



Passenger Section
10m x 32m
(33' w x 10' h)
Polyethylene Radiation Shield
140 tons empty
Passenger Capacity 20 tons

Helium Pressurant Tanks

Descent Monopropellant Tank 13 m (43') wide
1747 tons Si-Al-Mg+LOX

(4) back-up motors
210,000 lbs thrust each

Ascent Tank
21 m (69') wide
7365 tons monopropellant

modulated steering
Thrust Motors (4)
210,000 lbs thrust each

Main Engines
2 million lbs. thrust each
Engines are pressure fed, can be stopped, restarted, and throttled,
ISP 250-285 secs

Gross Lift-off Mass 9,625 tons
Lunar Weight 1503 tons or 3.53 million lbs.
Height 92 m (302')
Dry Mass 510 tons, 85 tons Lunar
Titanium frame and Aluminum-Lithium alloy skin
Tanks coated with polyurethane and aluminum foil

More details and more pictures at
www.moonminer.com/Moon_Shuttle.html

What's to Drink?

Beverages

on the early Lunar and Martian Frontiers

by Peter Kokh

"What's to drink in this place?" is likely to be the number 1 most frequent first question by new visitors to the frontier. After a long (or very long, as the case may be) to the frontier, whether to quench one's thirst, relieve the stresses built up during the trip, to just relax, and/or to celebrate a safe arrival, a drink will be "just what the doctor ordered." What are the choices?

That will depend on how established the frontier is. At first water and beverages reconstituted from freeze dried powder brought along on this or previous trips. Sound "tangy?" The question deserves more than dismissal. Beverages can have a considerable effect on morale, whether it is a cup of coffee, a Coke™, fresh-squeezed orange juice, tea or herbal brew -- or a swig of the good stuff. ISS and Mir crews have had been there, done that.

On the Moon and Mars we will be in a somewhat different situation, where imports from Earth will have to be justified gram by gram -- they will be that expensive. Assuming that water can be produced locally on both frontiers, we would be talking about import of freeze dried, instant, and highly concentrated beverage stuffs.

Some dry beverage starters could be shipped as packaging, a medium in which to pack delicate items. But other, less dense (and overall heavy) materials such as recyclable and reformable plastic foam pellets or peanuts may get the nod. Co-importation as packing may be more common early on before frontier farms are established.

But with local food production, the holy grail will be the derivation of potable brews from agricultural waste biomass products. Don't expect pressure acreage to be set aside for Coffee, Tea, or Cocoa plantations or Orange orchards. In time that may come -- stress on "in time!"

Meanwhile, once we start building homesteads with modules manufactured from locally produced building materials -- and the rush for elbow room becomes a real frontier economic driver -- homestead gardening will emerge and with it many a garden-based cottage industry begun.

See MMM #148 SEPT. 2001, p 3. "EarthPatch": Anchoring Lunar & Martian Homesteads.
The pdf file for this issue is freely accessible at:
http://www.lunar-reclamation.org/mmm_samples/mmm148_Sep2001.pdf

Individual pioneer (families) will begin to market home made beverages ready-to-drink, in concentrate, and in raw ingredients form. Streetside Farmers' Markets will be a place where one can by dried leaves, roots, and other home garden products from which to try one's own hand at beverage making -- or brewing -- whether for one's own consumption or as marketable products.

In the past two decades there has been an enormous expansion of beverage choices for us Earthers. Coffee entrepreneurs have given us expressos, capuchinos, lattés and a seemingly infinite variety of each. Herbal tea makers have been equally inventive, as have producers of ready-to drink Ice Teas, and flavored waters. Let's speak bluntly. If you are addicted to any of these and unwilling to experiment on your own or make do with substitutes, you are definitely not material for the early, stress on early, frontier days of either the Moon or Mars!

But if you have a spirit of adventure and are game enough to try make-do substitutes and be happy with less, you will do just fine. The frontier, any frontier, by its very essence, is a rough and rugged environment where those addicted to the genteel and sophisticated refinements of "cultured civilization" are in for a rude awakening.

So what's to Drink?

Follow the Agricultural Trail! Vegetables and Fruits will be top priority, along with adding a variety of both. Beverages can be squeezed out of most vegetables and fruit and so we will see a lot of that in the early frontier both as pure juices and squeezes, with or without pulp, and as creative blends like V8™ and "flavors Mother Nature never thought of, but should have." And these are all healthy, provided that they are not too laced with salt or sugar, both of which are going to be scarce on the early frontier, replaced with garden grown seasoning stuffs (herbs and peppers, etc.) and fructose from fruits.

Plus Soy Milk ;-(Okay, so the health nuts will be well taken care of. What about us caffeine and cocoa (hot chocolate, not cocaine) addicts? The cheapest thing to do would seem to import pure caffeine and cocoa extract without the other coffee, tea, and cocoa accompanying substances, and add them into frontier herbal brews.

Are you deaf? What's to Drink?

Alcoholic beverages: some never touch the stuff, Some of us habitually overindulge. Some of us enjoy a bit now and then to relax and/or as a socializing lubricant. Here we are in luck. Because almost anything that can be grown can be fermented. Perhaps in no area have humans been so inventive, and enterprising!

We will see both grain-based and fruit-based alcoholic beverages (yes, grapes too!) on the early frontier. But if you have cultivated a refined taste for Skky Vodka or Jack Daniels Whiskey and no other label will do, just keep your sissy butt at home. Butif bar stock is good enough and if your tastes are versatile, you'll do just fine. Over time, the quest for a greater variety of beverages, and of better quality will be a powerful driver for frontier enterprise and agriculture. Over time!

So don't sweat. It'll all be okay. < MMM >

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Email submissions to KokhMMM@aol.com
Preferred method is to copy & paste the text in the message body *without formatting* (we reformat anyway). However we accept MS Word attachments, text file attachments, and pdf file attachments.

We much prefer electronically submitted copy but will look at typed hard copy mailed to:

Moon Miners' Manifesto, c/o Peter Kokh,
1630 N. 32nd Street, Milwaukee WI 53208-2040

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