

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

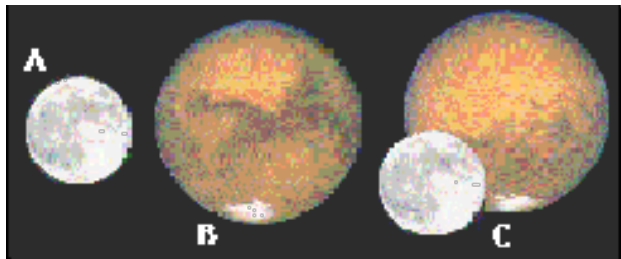
# Mars Moon Miners' Manifesto



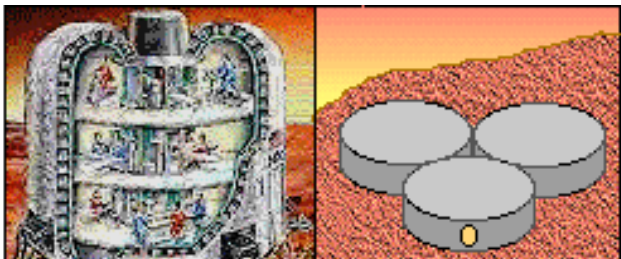
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MMM Classic Themes **MARS**

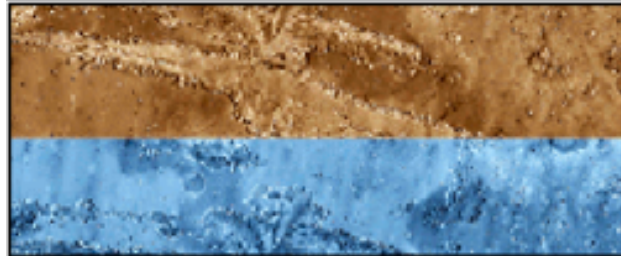
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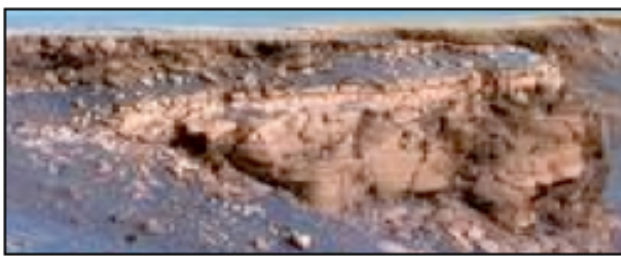
Let's make the right choice - Mars and the Moon!



Advantages of a low profile for shielding



Mars looks like Arizona but feels like Antarctica



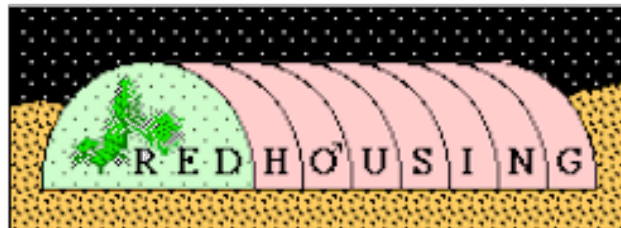
Rover Opportunity at edge of Endeavor Crater



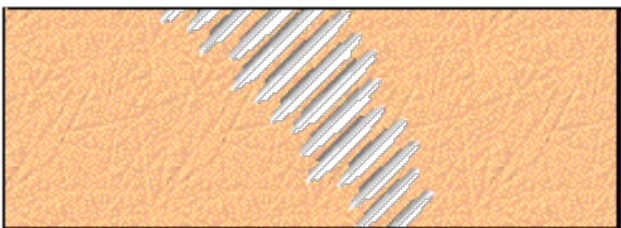
Designing railroads and trains for Mars



Designing planes that can fly in Mars' thin air



Breeding plants to be "Mars-hardy"



Outposts between dunes, pulling sand over them

These are just a few of the Mars-related topics covered in the past 25+ years. Read on for much more! **Why Mars?** The lunar and Martian frontiers will thrive much better as trading

partners than either could on its own. Mars has little to trade to Earth, but a lot it can trade with the Moon. Both can/will thrive together!

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**MMM #6 – JUNE 1987**

ESSAYS IN "M"

By Peter Kokh [kokhmmm@aol.com](mailto:kokhmmm@aol.com)

#### **M IS FOR MISSING VOLATILES:**

The Moon, as compared to our bountiful Earth, is very poor in elements with low boiling points, especially hydrogen (and thus water), nitrogen, and carbon (which is volatile in its usual form as carbon monoxide and/or carbon dioxide.) Other relatively volatile elements, like

sodium and phosphorus, for examples, while present in usable and probably sufficient quantities, are less abundant than on Earth. This volatile depletion is one of the tests to which any theory of the Moon's origin must be put.

More important, this depletion sets constraints on what is economically possible on the Moon. Any Lunar civilization must import the bulk of the hydrogen (barring polar permashade ice fields\*), carbon, and nitrogen it needs for biomass and life-support. Such a civilization must seek to find inorganic substitutes for non-life related uses to which these elements are put on Earth: wood, paper, plastics, coatings, adhesives, oil, and grease, etc.

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

#### **M IS FOR METHANE & 'MMONIA: (poetic license)**

The easiest way to ship the missing volatiles is to combine them as methane (CH<sub>4</sub>) and ammonia (NH<sub>3</sub>) which are easier to liquefy and handle than liquid hydrogen, especially. But any excess needed hydrogen\* would have to be imported in the pure form. (Some hydrochloric acid and hydrofluoric acid might be shipped to co-import any needed chlorine – to combine with Lunar sodium to make salt – and fluorine. Both may be needed to endow recycling ore extraction processes.)

To increase import efficiency to 100%, containers can be used which are made exclusively of elements the Moon needs to import. Such usable "tare" could be of metal, like copper, or of easily reduced solid hydro-carbons like polypropylene, (-CH(CH<sub>3</sub>)CH<sub>2</sub>-)<sup>n</sup>.

\* [Actually, of H, C, and N, Nitrogen will probably be in shortest supply in comparison to the amounts we will need, solely as a buffer gas used with oxygen for breathable "air". Nitrogen can be conserved by reducing the interior air pressure to half sea-level normal, but with the same amount or partial pressure of oxygen, reduced nitrogen accounting for all of the reduced air pressure. If indeed this shortage does turn out to be critical, it will be a strong incentive to keep ceilings low,

Thus reducing the cubic volume of air needed per square foot of inhabited space. Goodbye visions of high-domed megastructures for the time being! – Editor.]

#### **M IS FOR MINIMIZATION OF THE COST OF IMPORTING METHANE, AMMONIA, HYDROGEN, etc.**

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

#### **M IS FOR MANNED MISSIONS TO MARS AND ITS MOONS FROM THE MOON:**

If you want a mission which is not going to be an Apollo-type dead end, or so weight-restricted as to be a token effort you can do two things:

(1) Source as much of your throw weight as possible from the Moon. The spacecraft can be made largely from Lunar materials with their bootstrapping 20:1 advantage.

(2) Depart, fuel tanks topped off (at least Liquid Oxygen), from high on the shoulder of Earth's gravity well, for example from the L1 Lagrangian point about 40,000 Miles in from the Moon towards Earth.

While this would restrict departure to the period of the full moon to head you in the right direction with maximum velocity, the advantage will be so great that you could launch from L1 at several successive full moons on either side of the every-780-days window for the same energy cost as departure from LEO -- low Earth orbit -- at the the heart of the "window."

Looking down the road, manufacturing the building, construction, and mining equipment for use on Mars, Phobos, and Deimos will be a growth industry for the young Lunar settlements. Earth could not compete!

[The likelihood that, in many respects, mining and processing "regolith" on Phobos and Deimos will be very similar to operations on the Moon, makes such synergy all the more sensible.]

**MMMM**

## MARS **PHOBOS** DEIMOS

By Peter Kokh [kokhmmm@aol.com](mailto:kokhmmm@aol.com)

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

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

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

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

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



not to say that unique one-shot opportunities shouldn't be seized. But for regular trade in volatiles, Phobos and Deimos have it all sewed up.

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

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

## MARS!? – AS I SEE IT

By Peter Kokh [kokhmmm@aol.com](mailto:kokhmmm@aol.com)

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

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

Meanwhile the pictures steadily flowing in from the Viking orbiters revealed not so much a Moon-like surface, as one as hauntingly beautiful and awe filling as our own southern Utah and northern Arizona. For millions raised on celluloid sequences of cowboys chasing and being chased up and down Monument Valley, Mars began to look like an unbelievably beautiful -- if barren -- setting in which to imagine all sorts of futures.

In our racial loneliness, most of us hoped that life would be found on Mars after all, in however humble a form. I remember well my own high excitement at the first teasing results of the pyrolytic release experiment. But when these suggestive indications were not borne out by other subsequent tests, I was filled with a crushing and abysmal disappointment that lasted all of 20 seconds before giving way to a new euphoria: IF there is no native life on Mars, THEN Mars is "ours!" by default -- ready and waiting for our own life. Mars took on for me the raiment of a virgin world with mankind serving as the male reproductive agency of Earth by which Gaian Earth-life would fertilize Mars and bring the long-waiting sterile world to the glory of planetary motherhood to which it could never aspire on its own -- no matter how long we left it alone.

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

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

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

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

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


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

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

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

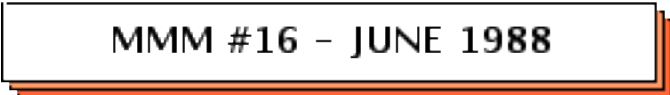
Do we pout and sit on our hands? Do we play the role of good loser and pitch in? Or is there a third, much better option?

We must "second the motion" for Mars, aggressively pointing out that if the Mars Program funds (or co-funds?) a liquid oxygen processing facility on the Moon first, the Mars fleet will be able to fuel up more cheaply in LEO and then top off the tanks at L1 and thus be able to carry much more cargo to Mars. And the groundwork would be laid for follow-up missions.

[Here we clearly pre-stated the mission philosophy soon to be developed by Robert Zubrin, calling for in situ production of fuel for the return to Earth portion of any We also aggressively help by pushing the Mars Program to fund an advance party to Phobos (the prior launch window 780 days earlier) to set up a facility to process fuel for the return\* and do continued remote/robotic research. Our prize? We get our foot in the door for free on both the Moon and Phobos and we benefit from free (to us) R&D for life-support systems and transportation hardware that we'll also need. Not compromise but the co-promising cross-fertilization of our dreams! 

In retrospect we might title this article:





## Frontiers Have Rough Edges

Commentary by Peter Kokh

[This was written with the Moon in mind, but applies to the Mars frontier as well]

A major theme running through many of the articles in the MANIFESTO has been this dual one:

- Settlers can become largely self-sufficient on a volatile-poor world like the Moon and in free-space oases initially dependent on Moon-sourced goods and raw materials
- This effort will involve widespread substitutions (and doing without, when substitutions can't be found) that will take some getting used to, as the pioneers wean themselves from an Earth-learned addiction to sophisticated organic materials so easily produced on the home world only to be casually used, often just once, sometimes not at all, and then just as casually thrown away. The transplantation of human society from Planet 3A to Planet 3B will involve definite sacrifices for the early trailblazers.

There may be many who, misguided by ill-thought-out science-fiction scenarios, look forward to life on the space frontier expecting that there, they will find the latest, the most advanced, the most sophisticated possible technological culture. They would best be jolted out of such illusions and advised to stay home. For to tell the truth, for some decades after the opening of out-settlement, it will be on Earth that the highest, the most advanced, the most sophisticated material civilization will exist, at least in the more fortunate areas. In contrast, space frontier homestead scenes will seem insultingly drab, tedious, and harsh.

Even so, 17th and 18th Century Europeans who wanted the material best and most genteel that life had to offer remained in Europe.

Even so, 19th Century East Coast Americans who wanted as comfortable and materially gratifying a life as possible remained in Boston, Philadelphia, Baltimore, and Charleston. The frontier is for those for whom other things are far more important than creature comforts and

sophistication. It was so on the American and Australian frontiers, and will be on the frontiers of the future. Hardship is the stuff frontiers are made of!

Life in the new "outer Siberias" will be simpler, yes, simpler, even if forever dependent on high technology. But it will also be a more authentic and honest life with more attention given to things that count. There will be religiously rigorous recycling and careful accounting for everything.

The premium on art, craft, creativity, and ingenuity will be high and the opportunity to indulge in consumer itch-scratching shopping binges all but nonexistent. There will be glory for both teamwork and individual contribution, but precious little room for unproductive self-involvement.

Despite the dependence on high technology, there will be a new partnership with nature in ark-sized biospheres, a heightened sensitivity to our symbiosis with plant and animal life; a realization that man and living nature thrive together or perish together.

Such prospects appeal to many environment- and ecology-sensitive persons in the Mother Earth movement, types that many of us space advocates customarily dismiss as not worth courting because these crusaders often seem to yearn for throwing out the technology-baby with its bath water. But this is constituency that can enrich us and provide a strength in alliance that we will never realize if we disdainfully go it alone.

If we love our cause, we'll set our egos aside and patiently woo these concerned and energetic individuals. Let's go together, those of us with the right stuff! The rough edges of this frontier are a rasp for personal and cultural baggage best left behind. -- Peter Kokh 5/88

## MMM #18 - SEPTEMBER 1988

### M.U.S.-c.l.e." a 2-part Acronym

You will have noticed the unusual way we spelled "muscle." For our strategy calls for the: M.U.S. (Massive, Unitary, Simple) parts to be made by the settlement and the C.L.E. (Complex, Lightweight, Electronic) components to be made on Earth to support up the gravity well and be mated with the "MUS" subassembly on the Moon (or early space colony).

Here then is the logical formula for giving industrial muscle to the early settlement still too small to diversify into a maze of subcontracting establishments. It is a path that has been trod before. It plays on the strengths of the lunar situation and relies on the early basic industries: lunacrete, iron-steel, ceramic, and glass-glass composites (glax).

And not surprisingly, it is the path of lunar development that will produce the most in exports to LEO, GEO, L5 (?), and even Mars.

### Importance of the M.U.S.-c.l.e. Plan for the Opening of Mars

Yes, Mars. That strangely romantic, sirenic world that so many are so impatient to get to just once even at the cost of perhaps never being able to return. It is possible to go direct to Mars from an LEO depot around Earth. The plan would send humans and cargo not needed till later separately. But if it is worth going to at all, it is worth having every advantage in our favor,

including the capacity -- for the same total fuel cost -- of sending enough equipment to make a prolonged, even permanent stay possible as well as making follow-up trips economical enough to when they find out just how hostile a place withstand the inevitable public loss of interest Mars really is: that Mars isn't Barsoom, after all!

### **Using Made-on-Luna "M.U.S." Components to lower the cost of Missions to Mars**

Back to our Mars expedition: think of the weight savings if only the basic core crew cabin (let the crew put up with the sardine-packing of "steerage" for the short trip out to the Moon on the shoulder of Earth's gravity well) and "C.L.E." cargo had to be boosted up from LEO. More spacious quarters in shell form (M.U.S.) and even the hulls of the Mars landers themselves could be added on at the lunar staging port (probably at the L1 Lagrangian point some 36,000 miles Earthward from the Moon). The crew would be highly motivated by the need for more space and could complete the assembly during the months-long journey out to the Red Planet. Give 'em something to do. The fuel savings would translate into more total cargo and, consequently, a much-enhanced chance of success on Mars.

### **After the Mars Frontier is "Opened"**

If Mars were truly opened up for settlement, and it is in the Moon's interest that it should be developed as an alternative trading partner to Earth, then until Martian industry developed its own "muscle", there will be a strong market on Mars for made-on-Luna vehicle bodies and hulls, ready-made and portable shelters, and other items. It will be far less expensive for the new Martians to import items co-manufactured on Luna as opposed to those wholly made on Earth. Without this advantage, the Martian settlement effort will last only slightly longer than a snowball on Venus.

### **Further Contributions a Phobos-Deimos M.U.S.-c.l.e. Plan Could Make to Mars**

Here we think of those items not needed by a Mars expedition until arrival in Mars orbit: aerobrake shields, parachutes, and landing skids / skis. This is in addition to fuel needed for descent and final braking. Ph.D. (Phobos/Deimos) could also make solar panels for Mars-orbiting communications satellites brought from Earth, etc.

Leveraging each new foothold in space on the one before, we can go far! -- Peter Kokh  
August 1988

# **PAVONIS MONS**

## **Possibly the Most Strategic Mountain in the Solar System**

By Peter Kokh

Now that's some billing! We think of the great mountains in Earth's history. Mt. Olympus and Mt. Meru, homes for whole pantheons of gods; Hundreds, if not thousands, of mountains sacred to some tribal god; The great mountains of Judaism, Christianity, Islam, and Buddhism. In our day, the scattered mountaintops that have become the sacred preserve of great complexes of astronomical observatories: Kitt Peak, Cerro Tololo, and Mauna Kea above all. Then there are the holy mountains consecrated to paranoia: Cheyenne Mountain, for one.

When it comes to angry volcanic mountains, a whole string of names comes to the tongue as well: Vesuvius, Pele, St. Helens, Stromboli, and on and on. Earth has some pretty famous mountains.

Venus has mighty Maxwell Montes in Ishtar Terra, the northern continental highland. And Mars' own Olympus Mons in sheer massiveness, 350 miles across the base, surely tops the list.

Pavonis Mons, "mountain of the peacock" (why it is so named, I have no clue), is the central peak of the three great shield volcanoes (Mauna Kea / Loa is a shield volcano, Earth's

largest) of the Tharsis Ridge, flanked by Ascraeus Mons to the northeast and Arsia Mons to the southwest, with Olympus itself not too far away to the northwest. My map, from National Geographic, shows all four peaks topping out at an impressive 27 km! But that would be too much of a coincidence. Our knowledge of Martian altitudes is in dire need of refinement from future missions. But the exact figure is not going to change the picture.

What does matter is that Pavonis Mons pokes its head high above the densest portion of the thin Martian atmosphere (ours is 140 times more dense) smack on the equator. This suggests two possibilities.

### **1. THE site for a Launch Track**

The more modest is that this mountain is the ideal textbook-perfect launch track site for payloads to Mars orbit, up the gently sloping west flank. At its estimated 87,000 feet above the average reference 'sea-level' altitude of Mars, all comparison to terrestrial equatorial mountains that might be considered for such duty (another article, we promise) simply ruptures. Long extinct (a billion years?) in all probability seismically serene, glacier and avalanche-free, not subject to the typical torrential west slope rains of Earth's equatorial peaks: if launch tracks are your bag, then this is your mountain.

#### **Other Location-Grounded Assets**

It has other assets. Its equatorial position makes its caldera rim the best site on all Mars for an astronomical observatory complex accessing most of both north and south celestial hemispheres. While the seeing will not be as perfect as that offered anywhere on the Moon, it will certainly be far superior to the best available on Earth.

#### **Advantages of being a Shield Volcano**

Further, the flanks of Pavonis Mons offer two distinct advantages in common with the three other great Martian volcanoes as a site for major settlement.

- First, a basaltic composition with predictable composition. In contrast with the case for other areas of Mars, we know what we can build from onsite materials here, and here more than elsewhere, our Lunar experience will be most helpful.
- Second, if Mauna Loa / Mauna Kea are any indication, these giant Martian shield volcanoes should be laced with lavatubes of a size intermediate between terrestrial (a few meters wide, a few kilometers long) and lunar examples (hundreds of meters wide and as much as a hundred kilometers long): large enough to be useful for warehousing, industrial park sites, and initial as well as emergency shelter. This is an asset hard to overlook.

#### **Other Neighborhood Assets**

Just to the west of the escarpment which marks the base of Pavonis Mons is the large crater Ulysses. A settlement on the lower west flank of Pavonis Mons serving as the head for the launch track might then aptly and suggestively be christened Ulysses Junction.

It is hard to think of a name more pregnant with associations of cosmic wanderlust. Barring discovery of more suitable sites by the planned Mars Observer mission scheduled for a 1992 launch date (but threatened with postponement), Ulysses Junction would be this writer's choice for the principal Martian settlement. That it is not smack in the middle of the most interesting geological terrain is not to the point. Sorry, Carl, but we didn't build Los Angeles on the rim of the Grand Canyon, much less in its bosom!

### **2. Anchor for a Space Elevator**

The second possibility, a far out dream for Earth but at last a practical possibility on Mars, is a cableway elevator from the surface to synchronous orbit. Pavonis Mons would be the planet-side anchor. A Martian celestial elevator need only reach upward 10,500 miles to synchronous orbit (23,000 miles above Earth's surface) and fight a gravity only 38% as strong as Earth's. As a result, the requirements for mass and tensile strength ought to be an order of magnitude lower at least (but ask a mathematician or physicist). I personally doubt such a device will ever be built on / at Earth but confidently predict its realization for Mars. It may not be the first: toy-scale elevators may see service first on Ceres, Pallas, or Vesta. At any rate, such a development will only secure the role of Ulysses Junction as the Martian metropolis.

### **Deimos: The Elevator's other anchor**

An elevator to where? Why to Deimos, of course! Conveniently, Deimos is the smaller of the two Martian moonlets, only 10x12x16 kilometers in size. Conveniently too, it currently orbits Mars only a little farther out (1900 miles) than synchronous orbit, making a circuit in 30 hours 21 minutes compared to Mars' 24 hours 37 minutes.

### **Implications for PhD Industrialization**

This suggests that Deimos rather than Phobos be the main mining source of volatiles bound for Luna and that shipments be launched by mass-driver perpendicular (vertical) to Deimos' surface and in the direction of its orbit about Mars. In time, this steady action-reaction will bring Deimos manageable mass (relatively speaking to most other hypothetical subjects of planetary engineering) slowly spiraling down to synchronous orbit where it could then be parked permanently directly above Pavonis Mons to become the gateway to and from Mars itself. Martians of the future will have a much easier (and cheaper) way to junket about the Solar System than Terrestrials. Let's put this in the 22nd century. (Such predictions are dangerous, but I won't be around to take the abuse from being wrong.)

### **Phobos: Fly in the Ointment?**

Whoa! Haven't we forgotten Phobos? It orbits between Deimos and Mars and would in short order intercept the cableway elevator and that would be that! Ho hum, details! There are a couple of approaches to this. The more ambitious and elegant would be to nudge Phobos outward a bit so that its orbital period would increase from the present 7 hours 39 minutes to 8 hours 12 minutes -- exactly one-third the period of Mars and anything in synchronous orbit. This would involve moving it out from Mars only another 271 miles. But bear in mind that Phobos probably weighs about six or seven times as much as Deimos. Now if Phobos' orbital inclination with respect to Deimos was increased a teeny-weeny bit with the nodes carefully placed, it seems Phobos would always pass the elevator safely to one side, unless we've overlooked something, not that unlikely.

A less elegant and less ambitious approach would be to have some slack in the elevator so that it would have a slight bow in it that could be safely moved to the side when Phobos passed. At any rate, it may be a sought-after thrill to be on the elevator at just the right height when Phobos whizzed by at a relative 3260 miles per hour! But we'll leave all these problems in the capable hands of 22nd century Martians.

So, go find yourself a good map of Mars (we have a good one from the Planetary Society incorporated into our space displays) and look up Pavonis Mons. Next get out the Yellow Pages and look for a real estate broker. This turf is going to be hot! -- Peter Kokh  
September 1988

**MMM #19 - OCTOBER 1988**

## **Seizing the Reins of the MARS BANDWAGON**

Commentary by Peter Kokh

To succeed at anything is to create something that others can build upon. There can be no other criterion of achievement that is not self-delusory.

By deliberately choosing being first in a race as the measure of success, and spurning the Von Braun blueprint (a LEO space station for the assembly of reusable Lunar ferries) in favor of a Lunar-orbit-and rendezvous mission profile, the Apollo strategists explicitly chose to fail by the only standard that would eventually matter.

They were politically conditioned to prefer ephemeral gratification of winning a 'race' and having momentary center stage. The opportunity to construct a transportation infrastructure that could serve continued and sustained Lunar exploration and base maintenance was expediently shelved.

Many Mars enthusiasts would have us repeat this mistake. And on the other had, there are those in our Society who would have us concentrate on infrastructure alone, shutting their eyes to the absolute certainty, that without a declared goal, this infrastructure [NASA's Space Station Freedom (freedom from purpose?)] will be miss-designed and miss-built, and be inappropriate as a stepping stone to anywhere.

It is common to portray our Society as the Moon party, the Planetary Society as the Mars party. We accept and encourage such a distinction at our peril. People on both sides of the Moon-Mars "debate" do the future of humankind in space a serious disservice by escalating this impatient, misbegotten polarization. What we sorely need is a Moon-Mars consensus.

Those who believe that we can build an autonomous spacefaring civilization based on volatile-poor Lunar resources alone are surely living in the land of Oz. Those who think that this Lunar resource shortfall can be made up by Earth-approaching asteroids (which owing to infrequent windows can hardly be more than sporadic targets of opportunity in the near term) ignore the laws of orbital mechanics. Without the additional regularly accessible resources of Mars' companions, Phobos and Deimos, and Earth-Moon economy will be doomed to inevitable collapse, however valiant and brilliant an effort is made to make a go of it -- a futile exercise.

Imagine an alternative solar system in which neither "Earth" nor "Mars" have natural satellites (even as Mercury and Venus do not) and in which there are no asteroids. Then try to construct a scenario by which a solar system ranging civilization might arise despite such handicaps. Hard, isn't it? Yes, we are blessed -- by chance or by design is not to the point. But to blueprint a spacefaring society while petulantly (yes! that is the right word!) ignoring those assets handed us on silver platter is patently stupid.

The Moon needs "Mars PhD" Mars needs Phobos, Deimos -- and the Moon. This inter-world trade economy will be the keystone of our future in space. Without this axis, we cannot economically fill Cislunar space with space colonies and solar power satellites. Without this backbone, we cannot realistically develop asteroidal and cometary resources. Without this anchoring, we cannot access the wealth of the Outer Solar System.

Those of us who want to postpone a "choice" between the Moon and Mars PhD are just as off track as those of us who want to rush such a "choice." The truth is that in the end, we will either have both or we will have neither.

The one pragmatic strategy which alone promises us this Moon-Mars synergism is to court the considerable ranks of Mars advocates and convince them that what they really want is not just a quickie release of pent-up curiosity in a one-shot exploratory picnic à la Apollo, but a sustained opening to Mars leading to permanent human presence there, to development and self-continuing settlement. Instead of pooh-poohing the chances for such a realization, we ought to be at the forefront - brainstorming the options.

Once Mars hopefuls are converted to the goal of making Mars a second home world for humanity, Lunar settlement and economic development will be assured, since it is the only way such an opening to Mars can be sustained in the face of certain and inevitable political and media disenchantment.

A Mars program worth pursuing includes the Moon and the Moon's needs. It enlists government financing of the infra-structure and technologies needed to open the Moon: deep space vehicles, closed loop life support systems, pocket-sized hospitals, etc. And then it leaves the way open to private enterprise and multinational consortia to take it from there.

On the other hand, if the government is not occupied with Mars, i.e. if it is not benignly neglectful of the Moon, then no doubt the Moon will see activity, but as a closed frontier of a handful of government run Antarctic-style science stations. Unfortunately, there are many of us with sights so lowered that we would be content with so token a presence.

The Moon is the first, and most important (in terms of potential trade tonnage), part of the formula for an open space frontier. But it does not supply the whole underpinning. It is best that the attention of our government(s) be focused on the most all-encompassing, all-inclusive space vision, and that is the opening of a human frontier on Mars, and not mere limited



manned exploration as the criterion of “success.” Then we’ll have it all: an open frontier that will eventually include the whole Solar System as the rightful range of our species.

It is time for our Society leadership and for our grass roots activists alike to awaken to these facts and seize the reins of the Mars Bandwagon, leading it where the Planetary Society has not the vision to venture. The challenge is great, and it is upon us now. If we avoid it, we fail. -- PK 9/88

[And drop the ball we did, making necessary the eventual formation of the independent Mars Society, whose founding we actively supported, giving Bob Zubrin a plenary session slot at ISDC 1998 to announce formation of the new Society.]

## Settler Mars Quiz

### QUESTIONS

1. On what planets (assuming a surface and a clear atmosphere) might you see a moon rise in the west and set in the east? (Hint. such moons must orbit faster than their planets rotate.)
2. “Hohmannliners” would be ships that plied between the planets on slow, minimum energy trajectories called Hohmann transfer orbits. What is the risk in high energy “super Hohmann” spaceflights that could reach a planet faster?
3. Mars orbits the Sun just inside the Main Asteroid Belt. Why, especially when time is more important than price, will the Moon, not Mars nor Phobos/Deimos be the logical supply and resupply base for future “Belters?”
4. Where is the greatest known expanse of sand dunes in the Solar System?
5. In comparison with Earth, the Moon’s mineral wealth is fairly homogeneously distributed. Will Mars be like the Moon in this respect, or will it have enriched deposits as does Earth?
6. What other geographic/geological features of economic import will attract Martian settlers?
7. Standing on one rim of the 150 mile wide Valles Marineris, the vast canyon complex on Mars, could one see the opposite rim?

### ANSWERS

1. Mars [Phobos] and Jupiter (Metis and Adastrea)
2. If the speeding spaceship failed to decelerate on time, it would coast deeper into the outer Solar System, perhaps not to return to the inner system until after consumables had long been exhausted. But, just as assuredly, this risk will be accepted, once we have the propulsive power to attempt it..
3. First, Mars will have little need of asteroidal resources, whereas the Moon’s need will be one of “do or die.” Second, one commonly overlooked consequence of orbital mechanics is that the closer any two orbits lie in their periods, the less frequent are the Hohmann trajectory launch windows between them. To illustrate, windows open between Mars and Vesta every 47 months, between the Moon and Vesta, every 16.5 months; similarly there are opportunities every 38 months between Mars and Ceres, but suppliers need wait only 15.3 months for Moon–Ceres openings. The Lunar advantage is considerable, when fuel costs are secondary to timeliness. Yet science fiction writers and others commonly assume that Mars will be “Asteroid Belt Central.”
4. Surrounding the north polar cap of Mars, in the great circumpolar lowland basin known as Vastitas Borealis, the Northern Wastes, possibly the bed of an ancient ocean. Many features detected by Viking Orbiter cameras suggest this possibility, but only “ground–truth’ sampling probes can confirm or disprove it.
5. The great unevenness with which Earth’s mineral resources are distributed is the result of billions of years of plate tectonics involving continental plate drift, well–lubricated by an ample hydrosphere, the ocean. This process never occurred on the Moon, but may have operated sputteringly on Mars for a comparably brief period. It is an outside chance that

there are some enriched ore veins deposited by superheated water on a much smaller scale than on Earth. Searching for such veins may keep the hardest prospectors busy, given the economic advantage that they would confer. The chaotic canyonlands at the western head of Valles Marineris, the Mariner Valleys, named Noctis Labyrinthus, the Labyrinth of Night, might be one place to start looking.

6. Whichever way proves to be the easiest, simplest, and cheapest way to get water will determine a lot. We suspect extensive permafrost, ice-saturated ground, but do not know its extent, its nearness to the surface, its concentration (percentage of ice to soil), or its saline and metal content. These will vary widely with the topography, and any permafrost will surely be easier to tap in some places than in others. If the main known water reservoir, the North Polar Cap, proves to be the most practical source, detailed altimetry mapping of the lay of the land will determine the easiest routes between the cap and the equatorial regions for ice-hauling trucks, and someday, for covered and heated canals or aquifers, hopefully with Lowellian names.
7. Yes, surprisingly, considering the tighter curvature and closer horizons of Mars compared to Earth. From one 5 mile high rim, you might see out as far as 145 miles along the valley floor, with the opposite rim standing two degrees above the horizon. But this incomparable may be totally "pinked out" by dust in the atmosphere, probably the usual situation.

## **MARS: OPTION TO STAY**

By Peter Kokh

Perhaps most of our readers have read one or more speculative accounts of how Earth's first expedition to Mars will unfold -- the ships, the crew, the Mars shuttles and aerobrakes, the habitat and lab modules, the cross terrain vehicles, and the surface activities of scientific exploration. A half dozen books aimed at filling you in are already in the book stores. Since the Case For Mars Conferences began in 1981 in Boulder, Colorado, serious planning has become more and more elaborate and detailed. New options are being developed, less satisfactory ones discarded. Make no mistake. A whole lot of homework has already gone into Mars planning and much more is underway.

All the scenarios currently being floated aim at a one-time scientific orgasm of activity -- and then we come home, probably never to return, once the public thrill with early results begins to wear thin. It goes without saying that all these people doing the careful planning will want to return to set up a permanent base. But once it finally sinks into the mass consciousness that even Antarctica is a friendlier place, political support will vanish and funding will vanish, unless ...

Unless we plan the very first Mars expedition with a built-in

### **OPTION TO STAY.**

#### **SCENARIO 1: Timeline 2020?**

##### **✓ A Complete Phobos Base:**

A united (NSS, TPS, SSI, WSF, USSF, etc.) Mars front sells the government(s) on a beefed-up Mars Mission, successfully making the point that one deluxe mission will be cheaper than two economy expeditions and less dangerous. The government(s) have been convinced that a forward base on Phobos is necessary for success of the effort. This base will produce and stockpile fuels for the actual Mars landing and for the return trip to Earth and do the final preparatory Mars tele-science from its forward position.

Phobos (and/or Deimos) Base will teleoperate rovers on the Martian surface to do ground truth-checks to compare with data gathered by an armada of orbiting instruments monitoring the weather (monitoring developing dust storms and dust devils), do landsat geochemical resource mapping (to help make wiser final site selections for a more productive mission), survey for permafrost and possible thermal hot spots and areas with abnormal radioactivity levels, do detailed high resolution altimetry and radar mapping (to get an idea of

potential drainage patterns and routing choices), monitor a network of seismic penetrator stations listening for marsquakes, and sniff the atmosphere for recent and ongoing volcanic gas emissions. Surface rovers will also collect many samples for relatively cheap return to a Phobos lab only 3700 miles above rather than the long, time-consuming, and expensive return to the Earth-LEO labs many millions of miles away -- thus boosting the amount of soil samples that can be checked by many, many times. Phobos / Deimos could also teleoperate drone photo reconnaissance airplanes and dirigibles in the thin atmosphere below.

Meanwhile, Phobos Base will earn its keep by also processing volatiles (carbon, hydrogen, and nitrogen) in the form of methane (CH<sub>4</sub>) and ammonia (NH<sub>3</sub>) for back-shipment to thirsty Luna. There may well be a steady stream of "tackliner" cargo freighters -- container pods hauled to and fro most efficiently by great solar sails, accelerating slowly but persistently to give some measure of freedom from launch windows and building up caches of supplies from Mars orbit to be on hand when the sprinting human crews arrive.

Finally, Phobos Base could oversee the carefully plotted siting of parachute-landed robotic production plants on the Martian surface to stockpile nitrogen, oxygen, argon, carbon monoxide, water, methane, and ammonia -- all processed from the atmosphere -- to be ready for the base-to-be and handy for refueling the various planned cross-terrain expeditions. It might be possible, too, to drop automated facilities that would produce and store some fallback food staples such as algae cakes. [written prior to Mars Direct]

The Phobos Base would then have a joint mutually reinforcing mission: to vastly enhance the chances of success for a crewed Mars surface mission and to assist the economic bootstrapping of the early Moon Settlement so that it could manufacture and ship some items ["M.U.S.-c.l.e." in MMM #18] at considerably less expense than they could be sourced from Earth.

#### ✓ **Mission Flight Profile:**

A flexible flight profile is chosen which allows either a short stay (30 – 50 dates) and a longer interval before a 2nd base occupancy at the next opportunity (25 months between windows) or a longer stay (100 – 300 dates) with a shorter period of abandonment or, alternately, a shorter wait for anyone choosing to stay behind before reinforcements might (?) arrive on a follow-up mission.

#### ✓ **A Full and Footloose Crew:**

Only personnel without legal and moral obligations on Earth would be eligible, so that they could in fact exercise a free option to stay over as part of a base caretaker crew. The crew should come with talents beyond those strictly needed for the scientific success of the expedition. There should be a musical/performing talent, a journalist to produce a weekly base paper (The Martian Chronicle, of course), some with artistic and crafting talent, and so on.

#### ✓ **Extra Marsbase Facilities:**

1) A Feasibility Lab: the ivory tower pedantry of geophysics, geochemistry, and geology notwithstanding, we will not truly know Mars until we know how to provide for ourselves on that world from the resources it offers us. On-base air and fuel processing from the atmosphere is a step in the right direction. But we must also provide the base with a materials processing lab to develop easy-to-produce-and-use building and craft materials from the Martian soil. And such a facility must be staffed with appropriately talented and experienced individuals, and outfitted with the tools and equipment needed.

2) An Experimental Farm: Besides any agricultural unit (hydroponics or other) to help provide the crew with fresh food, we must have an experimental agricultural facility that works with the local soil and unaltered compressed Mars atmosphere (CO<sub>2</sub>) to begin acculturating terrestrial plant species to a prospective new home. [We find the disconcertingly common belief that native Martian organisms could have survived three billion years of extremely hostile conditions incredulous! We also firmly believe that early Mars was not benign long enough to have allowed life to evolve in the first place!] Meanwhile, the food producing unit or farm should be generous enough and well-enough designed to provide a park-like retreat, no matter how small, for the crew. However hearty they may be, they will need the comforting reassurance that

only being nestled by living nature can provide -- especially so for those considering staying behind.

3) High Capacity Computer Facility: The base should have first class computing power, not sized just to operate the base and handle incoming science data from the field teams, but ample enough to assist the Feasibility Lab and Experimental Farm, and with capacity to spare.

✓ **Incentives to Exercise the Option to Stay:**

1) Homework galore for a sense of being needed here. There should be a backup and supplemental agenda of field exploration for any Mars Science people staying on, with tasks sized for smaller crews, even individuals, closer to base, filling in the holes in the data from nearby targets of opportunity. Ongoing work tending both the regular and experimental farms, stockpiling a harvest of Mars-grown food for the next (hopefully) team from Earth -- would keep several people quite busy. An especially ambitious project would be locally grown cotton for the first made-on-Mars occasional wear, a sure morale booster worth the work and needed equipment.

2) Ongoing building and craft materials development with possible stockpiling of early production items for bootstrap base expansion when and if more people-power arrives. For respite, any personnel so involved could build up a cache of "Touch of Mars" craft items to make the place more homey, less sterile, less totally alien-derived. Such items might include ceramic or glass vases, flower pots, dishes and serving platters and mugs, jewelry, decorative tiles, and other furnishings accents to add a home-sweet-home ambiance to greet new arrivals.

3) Regular Phobos down-shipments of surprise package goodies made there or on the Moon. A continuous communications hookup for reassuring conversation with another nearby pocket of humanity without the isolation-reinforcing time delay (6-40 minutes from Earth / Moon) would be part of the "frosting" of a Phobos base (which, once begun, a Lunar outpost would attempt to maintain for its own needs even if Earth gave up on Mars). Regular newscasts on a "Marstime" schedule via relay satellite when necessary would give subtle security ("coming to you from radio XPHD in beautiful downtown Port Stickney. Here is today's Mars and Inner Belt news ...")

4) Other easy-to-provide low weight Seductively Martian Amenities: watches that tell Martian time and calendars that mark Martian dates [see next article] with Earth-dates in very fine print. A pre-prepared Martian sing-along book of well chosen folk song selections, perhaps even a specially composed Martian anthem: "Going Martian". An extra generous audiovisual library should be provided along with gaming and gym facilities.

5) A modest Retreat in the form of a detached cottage/station ("suburb") over the horizon where personnel could take turns getting away from the rest (downtown) whether for romantic privacy or just for a break, either relaxing, working on a hobby, or doing optional work. And for those who go home, the great experience of their Martian sojourn will be the untranscendable high point of their lives, with everything to come being anticlimactic.

Those who stay will face unpredictable hardships (even the loneliest of deaths) and endless challenges (a brave new world that's never been touched) but also the possibility of even more rewarding experiences with yet higher highs. They may be the first ancestors of a new human world. Those choosing to stay on might mark the occasion by renaming the base (it will probably have been named so-and-so memorial station) something like Nos Martiani (nohss mahr-SHAH-nee,) Latin for "We Martians" for their choice will have made them the first.

## **SCENARIO II**

In this scenario, the Moon joins the Earth's Mars effort in an enhancing function, providing facilities we (Luna) see as necessary for the Option To Stay but which the Earth government(s) do(es) not want to fund. This will include a module to house Lunar personnel to assemble and maintain the extra facilities in question. All this would be sent separately, at no freight penalty to the Terrestrials. It would include life support extras needed to allow a caretaker stayover, more built-in amenities, a building products feasibility lab, etc.

Such a Lunan effort might well be supported by Earth nations not invited to participate in the original mission. This might include China, India, Australia, Brazil, Korea, and other emerging giants. Such nations might provide equipment for the Moon-led mission enhancement effort that could not be provided by the Lunar settlement itself. Lunan personnel would be ready and able to take over the base on a tentative caretaker basis if no members of the principal expedition elect to stay. How many personnel would be needed for scenarios I or II? Perhaps 40–50 with a quarter of them on Phobos/Deimos.

### SCENARIO III

The Earth nation(s) that mount(s) the Mars expedition spurn(s) the "upstart" participation of the fledgling human community on the Moon. What can the early Lunar settlement do to promote its goals all the same? If the Lunans are advanced enough to set up their own Mars camp (the longer the first Mars landing is delayed, the less unlikely this will be), they could have best effect by doing so on the basaltic (Lunar maria-like) slopes of the vast Tharsis bulge which includes the great Martian shield volcanoes [cf. MMM#18 "Pavonis Mons"]. An outpost at "Ulysses Junction" [ibid.] would concentrate not on Mars Science 101 (the geophysics, geology, geochemistry, and meteorology of Mars) but on Mars Science 102: learning to make building materials and furnishings for bootstrap base expansion Lunan style and from the familiar soils of this region. From here they might attempt to establish a visiting/trading relationship with the Earth-power(s) base which most likely will be sited off the Tharsis bulge but still in the same general area of Mars, so generously endowed with scenic wonders and geologically tempting targets.

If, on the other hand, Lunans are not prepared to participate uninvited on the planet's surface, but are involved in the staffing of the Phobos base, they might still be able to give logistical and moral (communications, see above) support. Hopefully, as Lunan relief crews arrive, the retiring Phobos staff would have the capacity to shuttle Mars-side staff to serve as a caretaker (or takeover) crew for the Mars Base when it is abandoned, perhaps permanently, by the nation(s) that erected it. Thus, even if men from Earth never returned, a Mars base, once built, might serve as the core of a growing community of transplanted Lunans, thanks to the Moon's need to maintain the Phobos Base, perhaps also built -- and abandoned -- by Earth.



By Peter Kokh

### The Week and its Days

On Mars, it's always Tuesday (Tiw or Tiu was the Teutonic god of war identified with Mars of the Romans hence Tuesday is Mardi (French), Martes (Spanish), Martedì (Italian), Marti (Romanian) and Ares for the Greeks. For the Martian sol and day-night cycle is some 37 minutes 23 seconds longer than the day provided by Earth's rotation. Accordingly, if you inaugurated a Martian calendar with day one lined up -- day of the week for day of the week -- with Earth's calendar, by the middle of the 38th day, you'd be one full weekday behind Earth. And after some nine months, you'd be a full week behind. Fridays, Saturdays, and Sundays (to mention the more sacrosanct cows of sundry fundamentalisms) are not cosmic time markers, but arbitrary conventions that mean nothing, except by choice, even on Earth, much less beyond. A Martian calendar need pay no attention to what day of the week it is on Earth. To avoid confusion, future Martians should choose a different set of day names altogether.

"Seven" presents no problem -- it's arbitrary but extremely entrenched in human custom; Roman, French Revolutionary, and Russian Bolshevik attempts to institute eight, ten, and five days weeks respectively met with with most stubborn resistance. There are plenty of seven-sets besides ours which names the only seven solar system bodies (other than Earth) known from prehistoric times through 1780.

There are seven major moons: Luna/the Moon (Earth), Io, Europa, Ganymede, Callisto (Jupiter), Titan (Saturn), Triton (Neptune). There are seven Greek vowels and seven musical

notes in the diatonic scale (do, re, mi, fa, sol, la, ti). Colors can come in seven if the rainbow's five of red, orange, yellow, green, and blue are joined alternatively by violet and indigo, white and black, or purple and white (personal preference). Or perhaps a more Mars-like palette of red, ocher, rust, orange, pink, and salmon! Then there are seven spatial situations: one "here" and six "there"s -- fore, aft, right, left, up, and down (or alternately north, south, east, west, zenith, nadir). But why not go with seven different versions of Tuesday? All we need are seven totally different names for Mars from the Earth's many languages.

For month-like (circamestral) spans, local Martian sky rhythms do not give much guidance. It is eight hours from full Phobos to full Phobos and eleven hours from Phobosrise to Phobosrise; thirty-some hours from full Deimos to full Deimos and five days and an inconvenient fraction from Deimosrise to Deimosrise; meanwhile Phobos catches up with Deimos every ten and a fraction hours. So let's start with a clean slate.

### **Months**

By our 24-hour reckoning, Mars takes 686.98 days to circuit the Sun. But a Mars calendar with its 2.6% longer days would only have a 668.6 dates. Conveniently, this is only 3.4 dates shy of 24 months of 28 dates (4 weeks exactly). A scheme with 23 months of 29 dates each would be a closer match (1.6 days too few) but would be awkward for dividing into the handy halves and quarters beloved of bookkeepers and tax collectors.

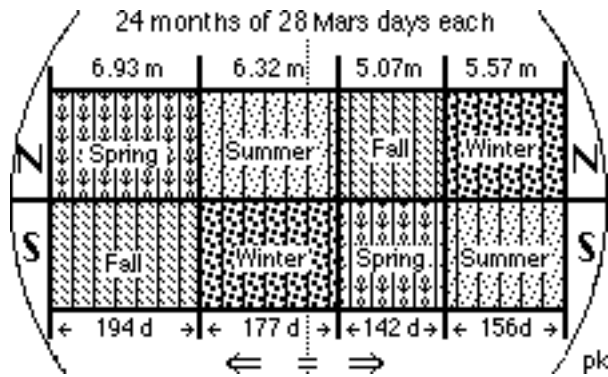
On the other hand, a month with four weeks exactly gives an enviably rational calendar in which every month begins on the same day of the week. As to the three or four dates that must be dropped every 24 months, I doubt that many would object to a "lost Monday" or its Martian equivalent here and there. As to the length, 28 Mars-dates would approximate 28.75 Earth days, close to a leap February.

And names for the 24 months, one could, of course, propose twelve longer 56 date months, but I have chosen a rhythm more in keeping with tradition). Finding 24 names is not a problem either. Basing the names on the 24 letters of the Greek alphabet would be one solution. Another is taking the 12 constellations of the ecliptic (the Sun's apparent path through the celestial background) and either doubling them (Sagittarius I, Sagittarius II, Capricorn I, Capricorn II, etc.) or adding twelve other constellations from Mars celestial equator (different from ours, since Mars' poles -- similar tilt notwithstanding -- point in altogether different directions ).

### **The "Half-Year" Plan**

But again invoking custom and experience, I have a seemingly radical suggestion: divide the 686.6 date period of Mars' revolution about the Sun into two periods. One would count the 334.3 dates from perihelion (Mars closest to the Sun - paralleling the situation of our own January 1st) to aphelion (Mars furthest from the Sun.) The second would tally the dates from aphelion back to perihelion along Mars' comparatively eccentric path. Such alternating outbound and inbound periods, 343.5 Earth days long, would better embody our ingrained sense of "year" and serves as the marker for anniversaries, feasts and festivals, holidays and Holy Days.

In other words, whereas for Earthlings "year" and period of revolution about the Sun are taken to mean one and the same, I propose that elsewhere in the Solar System, we make a distinction in using these terms. "Year" would become a purely calendrical term, and "revolution" (or how about "Zodiac" or "Zode," for once around the Zodiac) an astronomical one. In the case of Mars, they would be related two to one.



For Martians of the future, all odd/ outbound years would have similar patterns (roughly northern spring/summer, southern autumn/winter) and all even/inbound years would have similar patterns (northern autumn/winter, southern spring/summer.) Such a system of dual calendar years roughly commensurate with our cultural experience might be more palatable to those entrusted with leading their faithful in observance of a religious cadence of celebration, penance, and renewal.

To make such a system work, however, it would be better to have only one set of twelve month-names, perhaps with one suffix denoting odd outbound years, another even inbound years. That way, one would never mix up anniversaries and seasons. For a set of twelve month names to be repeated twice per orbit, constellation or zodiac names would not do at all. Pairs of Greek letters might work. But again why not have twelve more different language versions of "Mars?" (That would make it always Tuesday, and always March, just in twelve different languages!)

### Centuries

Spanning Earth's 100 year century would be 106.33 of these 6% shorter Martian years (Martenniums?). To avoid confusion, 100 Martian short-years could be called a Seculum [Latin for "age."].

### The Epoch

Regardless of when we get to Mars, it would be convenient if the two epochs, Terrestrial and Martian, had a convenient point of convergence. I suggest that October 12, 2001, when Mars is at its first perihelion in Earth's brand new millennium, be day one, year one on Mars. (If you prefer a Christocentric calibration of the epoch, that would make it the first day of Martian year 2127, again following the split-year schema.

For some businessmen active on the interplanetary market and for that dwindling minority of Tory-minded Martian settlers who foster a fetish of having to know what time and day it is "really," a specialty calendar that noted the Earth date alongside the Mars date would be easy enough to provide. (It would have to tell the ever-advancing hour/minute time each Marsdate when the Earthdate began, Universal Time, Mars day being some 37+ minutes longer than ours) There are similar such calendars for those living on the inter-face of the Jewish and Western or Islamic and Western worlds.

### Telling the Time of Day

Of course some Martian settlers may want to break all cultural bonds to Earth and manufacture analog clocks that use non-standard seconds, minutes, and hours – each 1.0275 times as long as on Earth. The penalty would be the need for wholesale translation of all scientific and technical works – a very stiff penalty for the sake of provincialism. Now if Mars were settled in only one time zone (15 degrees of longitude wide,) a digital watch could reset to 0:00:01 after each 8 hour we minute and 27 second "work shift." But scattered settlements and outposts in different areas, a system of time zones would be necessary and for the sake of synchronizing hours (think broadcasting schedules,) the hour would have to advance uniformly after every 61 minutes 33.5 seconds. Standard 60 minute hours could be used for all elapsed

time determinations, and for scientific calculations. The 24 hour day is relatively unimportant in science. At any rate, time will fly on Tuesday's world also!

### **Telling Time on Phobos and Deimos**

But what about those poor wretches working the mines on Deimos, or manning the Port of Mars Authority installations on Phobos? These two moonlets have their own day-night cycles. Fate, or something like it, is on the side of convenience here. Phobos first. Its day-night routine is just 20.6 minutes shy of an Earth-style 8 hour shift. Put three of these to a Phobos date (100 seconds shy of 23 hours) and thirty of these would be just 17 minutes shy of a standard 28 date Martian month. So while Phobos work details might use local time, at least they could synchronize their "months" with those of the rusty dusties down below. To avoid confusion, Phobos dates could be lettered or counted down, or rely on some other telltale indicator.

On Deimos, however, the day-night cycle or sol is inconveniently long at 30 hours and 21 minutes, a difficult, but not impossible adjustment for the human system. Yet obligingly, 3/4 of this period would give us Phobos-like dates 22.77 hours long (4 dates per 3 periods.) The lighting patterns would repeat every 4th, 8th, 12th etc. dates (an 8 day week would work well for pattern repeat purposes.) And again, 30 such shorter dates would mesh well with the Martian 28-date month pace. In both cases, thanks to digital timekeeping, preserving a solar system wide standard second and minute, and even the hour, would be no problem at all. A digital watch can reset to zero at any odd preprogrammed sum of hours, minutes, and seconds. Such a watch could be devised to show the time alternately on Mars (specify time zone, please,) Phobos and Deimos. PK

**NOTE:** The Author has since reworked these ideas to maturity. (1999}

Read all about "The MarsPulse Calendar" online at:

[http://www.moonsociety.org/publications/mmm\\_papers/marspulse\\_cal.html](http://www.moonsociety.org/publications/mmm_papers/marspulse_cal.html)

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## **Nuclear rocket using Indigenous Martian Fuel**

**An Enabling Technology for Manned Mars Missions with Global Access in a Single Launch**

**Robert M. Zubrin**

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**ABSTRACT:** This paper presents a preliminary examination of a novel concept for a Mars descent, ascent, and exploratory vehicle. Propulsion is provided by utilizing a nuclear thermal reactor to heat a propellant gas indigenous to Mars to form a high thrust rocket exhaust. Candidate propellants whose performance, materials, compatibility, and ease of acquisition are examined include carbon dioxide, water, methane, nitrogen, carbon monoxide, and argon. Ballistic and winged supersonic vehicle configurations are discussed. The use of this method of propulsion potentially offers high payoff to a manned Mars mission both by sharply reducing the initial mission mass required in low Earth orbit, and by providing Mars explorers with greatly enhanced mobility in traveling about the planet through the use of a vehicle that can refuel itself each time it lands. Utilizing the nuclear landing craft in combination with a hydrogen fueled nuclear thermal interplanetary vehicle and a heavy lift booster, it is possible to achieve a manned Mars mission in one launch.



**INTRODUCTION:** Interplanetary travel and colonization can be greatly facilitated if indigenous propellants can be used in place of those transported from Earth. Nuclear thermal rockets, which use a solid core fission reactor to heat a gaseous propellant, and which were successfully developed during the 1960s under the ROVER/NERVA programs as hydrogen fueled interplanetary transfer vehicles, offer significant promise in this regard, since, in principle, any gas at all can be made to perform to some extent. Here we present a preliminary examination of the potential implementation of such a concept in the context of manned Mars missions. This vehicle we term a NIMF: Nuclear rocket using Indigenous Martian Fuel.

[Body of Paper Condensed by MMM Editor]

**Candidate Martian Propellants:** The atmosphere of Mars consists of 95.0% carbon dioxide [CO<sub>2</sub>]

2.7% nitrogen [N] 1.6% argon [A]

all candidate fuels for NIMF. Water could also be used after harvesting ice or permafrost. Carbon monoxide [CO] and methane [CH<sub>4</sub>] can be produced from the above atmospheric gases by processing.

**Table 1:** Ideal Specific Impulse of Martian Propellants

Temp °K	CO <sub>2</sub>	H <sub>2</sub> O	CH <sub>4</sub>	CO/N <sub>2</sub>	A
** 2800	283	370	606	253	165
	3000	310	393	625	264
* 3200	337	418	644	274	178
	3500	381	458	671	187

NB.\*\* 2800 °K = safe operating temperature per extensive NERVA testing

\* 3200 °K may eventually be attainable

**Carbon Dioxide** – composing 95% of the Martian atmosphere, can be obtained by pumping the air into a tank. At an ambient temperature of -40 °C, CO<sub>2</sub> liquifies at 10 ATM for an energy cost of just 84 kW hrs per metric ton. A NIMF engine produces over 1000 MW (thermal). If an electrical capacity of 1 MWe is built in as well, then the 2800 K, 40 metric ton, NIMF could fuel itself for a flight into high orbit in less than 14 hours! Liquid CO<sub>2</sub> has a density 1.16 times water and is eminently storable under Martian conditions.

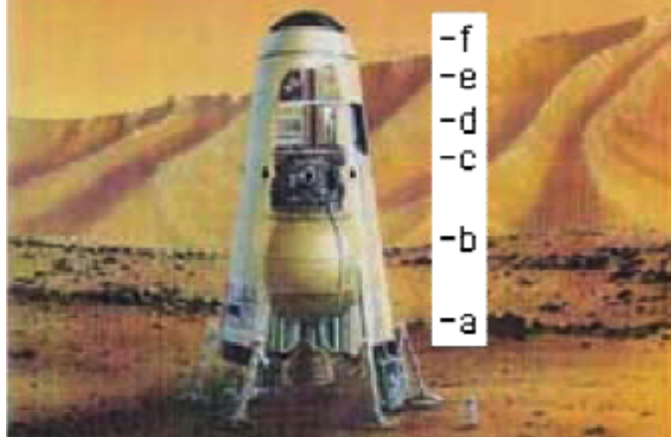
As CO<sub>2</sub> is so readily acquired, it is a convenient fuel for multiple suborbital hops, allowing a Mars mission to visit many sites (as a ballistic hopper or a supersonic winged aircraft. Figures 1 & 2 below.

One drawback is that CO<sub>2</sub> (and water) would oxidize carbide elements at the high temperatures involved. Instead high temperature oxide elements, possibly coated uranium-thorium oxide, must be used, and such elements would probably be incompatible with the high Isp hydrogen fuel ideal for interplanetary usage.

**Water:** In the form of permafrost ice, water is commonly expected to be abundant, but it will require an operation of some complexity to harvest it. Once a Martian base is established, locally mined water could function as a near ideal fuel for both Earth return, near Mars, and beyond Mars operations. If a base on Phobos is used for a point of departure, a 3000 °K water propelled NIMF could fly to Earth, aerobrake into a loosely bound orbit, and return to Mars without refueling!

**Methane:** Per the table above, methane would be an excellent high Isp [specific impulse] fuel. It could be produced and stored under refrigeration at advanced surface stations (not suitable for early use or needs). Moreover, it is compatible with conventional NERVA carbide elements. An unresolved problem is that methane would dissociate at the high temperatures involved with free carbons causing coking problems. Experimentation is needed.

**Nitrogen, carbon monoxide, and argon** [see the table above] are inferior to the much more readily available carbon dioxide. Further, they require about a hundred times as much energy to produce. However, they have the advantage of not reacting chemically with fuel or cladding materials compatible with hydrogen. Thus the same reactor which uses carbon monoxide for ascent to orbit could also use hydrogen with 950 Isp for interplanetary transfers.

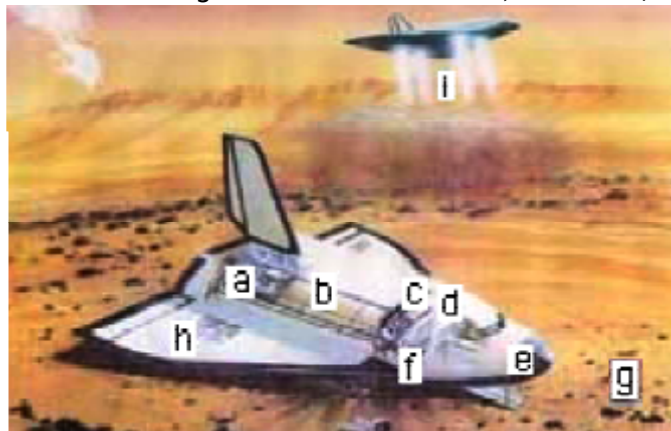


**Figure 1: A NIMF ballistic vehicle on Mars** (by Martin Marietta artist Robert Murray]

solid

- a. Nuclear engine surrounded by a coaxial fuel tank (when full, augments the lithium/tungsten shadow shield with liquid CO<sub>2</sub>)
- b. main spherical fuel tank
- c. Machine deck with CO<sub>2</sub> intake pumps.
- d. Habitation deck. e. Command deck.
- f. Parachute (several) compartment.

Nb. The NIMF's fuselage acts as an aerobrake, with a lift/drag approaching unity.



**Figure 2: Winged NIMF rocketplane on Mars.** (courtesy free lance artist Jeff Danelek)

- a. Nuclear engine surrounded by coaxial four-pi liquid shield
- b. The main tank forward of the reactor.
- c. Machine compartment
- d. Habitation compartment
- e. Control deck.
- f. Forward storage area with ramp
- g. Electric rover charged by NIMF reactor
- h. Delta shuttle-like wings for supersonic flight with lift/drag of 4 at Mach 4
- i. 4 VTOL underslung rockets for Harrier-like landings/ascents from/to Mach 1

#### **A NANNED NARS MISSION IN A SINGLE LAUNCH**

Since the days of the Apollo program, NASA's thinking about manned planetary landings has been dominated by approaches based on an orbiting mother ship containing long term living quarters and a small landing craft, a fraction of which manages to ascend to orbit after a stay on the surface. With the advent of NIMF, such an approach is no longer necessary. In fact,

since any mass landed upon Mars can be lifted back to orbit using readily available indigenous propellant, it becomes advantageous to abandon the concept of the orbiting mother ship altogether, and instead land the entire spacecraft living quarters on the planet's surface. That is, NIMF and interplanetary vessel are one.

Three alternative mission scenarios were examined. In each case, a 40 metric ton NIMF with a 3 person crew departs from a 300 km LEO orbit on a minimum energy trajectory to Mars, lands on Mars, hops around visiting various sites, ultimately returns to Earth via Hohmann transfer orbit.

**Scenario 1** uses an orbital transfer vehicle (OTV) to propel NIMF out of LEO, and which is then expended. This is the cheapest option in terms of total fuel use. In the other two scenarios, the OTV accompanies NIMF to Mars and is stored in Mars orbit for the joint return. In **Scenario 2** both aerobrake at Mars, saving fuel while in **Scenario 3** the NERVA-OTV brakes via a retrofire to keep it out of the Martian atmosphere. In either variation, artificial gravity could be provided for the long interplanetary trips out and back by spinning the pair at opposite ends of a tether.

### NIMF MANNED MARS MISSIONS: 3 SCENARIOS

(metric tons)	Scen.1	Scen.2	Scen.3
Mission Mass	73	100	145
Expended Mass	33	53	100

There are numerous mission architectures where an initial manned Mars Mission can be accomplished with a single launch of the STS-Z (125 MT to LEO) or ALS (100 MT to LEO) or even by a single Shuttle-C (80 MT to LEO). Furthermore, repeat missions (craft already in space, needing only refueling and reprovisioning) can be supported by a single shuttle, Titan IV upgrade, or STS-C launch. This contrasts with current NASA plans which would require from 700-1000 metric tons of propellant per mission, 6 or more STS-Z launches! Yet despite their enormous cost and complexity, such mission plans leave the explorers relatively impotent to accomplish much in the way of either exploration or development, as their cryogenic landing vehicle will necessarily restrict their visits to one site, and they lack a substantial source of electric or thermal power i.e. little potential for human exploration of the Red Planet and none at all for sustaining a human presence there. NIMF will allow ready, repeated, and inexpensive access to Mars, opening up a new world to humans.

### MERITS OF NIMF VS CHEMICAL (CO+O2) HOPPERS

In some respects, these two candidates for getting around Mars (Global Access) are equal. Both obtain a specific impulse in the 280-290 range. While neither engine is a developed technology today, the principles underlying both are well understood, and either could be developed given the appropriate development funds.

However, that's where the equivalence with the chemical option ends. The energy cost for producing CO and O2 from the atmosphere is more than one hundred times that for simply liquefying the given CO2. Worse yet for the chemical hopper, we not only have to pay an exorbitant premium for the fuel, but we have to pay for a ground-based nuclear reactor and a significant chemical engineering plant. That's a lot of infrastructure that NIMF doesn't need. The corresponding features are built into NIMF. If we go with the chemical option, global access will be delayed possibly for years, until the needed development is in place. With NIMF, such global access is an immediate capability.

Since NIMF can refuel itself for return trips, it can go as far one way as its fuel will allow, landing empty. In contrast, the chemical hopper must carry fuel for the return and extra first leg fuel to bring the return fuel along. By the same token, can afford to build NIMF heavier, with a stronger frame that can carry more instruments and supplies, capable of extended forays.

The chemical hopper must be on target on its return trips, pay attention to boiloff, outgassing, and other potentially explosive and toxic leakage of its cryogenic fuels. Immune to all this, NIMF can recharge the fuel cells on land rovers it carries, not so the chemical hopper.

Highly versatile non-ballistic supersonic winged aircraft configurations are possible for NIMF which is less weight restricted. Because the NIMF propellant is the atmosphere itself, in-flight propellant acquisition systems are possible – not so for the chemical vehicle.

What about safety? NIMF carries a nuclear reactor (however 5 orders of magnitude less radioactive than a power reactor, and not capable of meltdown). This small radioactive inventory represents a small hazard compared to that presented by the chemical alternative to NIMF, which will be virtually a flying bomb, a lightly built structure filled to the gills with toxic gas and chemical high explosives.

#### **OTHER EXOTIC MISSIONS FOR NIMF ALONE**

- A winged automated NIMF condensing its CO<sub>2</sub> from the air, could carry out a **Venus surface sample return**, collecting ground samples and low level aerial reconnaissance from every part of the planet before returning to orbit.
- A methane propelled NIMF could use **Titan as a base for repeat sallies to Saturn's moons**, returning to Earth with ground samples and low level observations from each one.
- A water fueled NIMF could **explore the Jovian system** from Callisto, Ganymede, and Europa.
- Water fueled NIMFs refueling on Ceres, the Trojans, even comets, could explore the Asteroid Belt, and the entire system including Pluto as well as comet sample returns. – [RZ/pk]

# WANTED

By Peter Kokh

**WANTED: Split personality types for Mars Expedition.** Besides being willing and able to leave Earth, family, and friends behind for three years or more, must for the trip out and back, have a high tolerance for sensory deprivation and thrive on boring routine tasks; and, at the same time, for the period spent on the surface, must be thrill- and challenge positive, keenly attuned to external situations with all their unpredictability. If you are such a Jekyll-Hyde combination, please send your resume to:

- Mars Expedition Personnel Office, Mars Training Camp, Spitsbergen Island, Svalbard

For as long as the era of chemical rockets lasts, interplanetary journeys to Mars or the asteroids, will be long tedious affairs that will be very trying for the kind of people ideally suited for the kind of life that awaits them at their destinations. This presents us with a choice. We can either look for persons with such chimeric personality combinations as suggested above who will perform reasonably well under such diametrically opposite circumstances, or we can start now to plan ways to structure the times of transit to better fit the personality traits of those best cut out for the exploratory and/or rugged pioneer life on the untamed worlds of their destination.

The path of least effort, and a temptation to mission planners, is the former. Transit times will be filled with makework: solar-wind measurements and other astronomical chores that could either be done just as well from LEO, or if not, by robot probes. To this will be added routine periods of exercise and other monastic treats. Meanwhile, people better suited for the planetary surface stay itself, will be bypassed if they evidence any signs of being less content than pigs in a mud hole by such a diet of time-whittling.

We need to take a creative look at alternatives. First, we must recognize that the trip out and the trip home are radically different in the deep psychological challenges they present. Outbound, the crew will be filled with anticipation. Homebound, they may experience both anticlimactic letdown and an impatience to get back home.

The opportunities for damping these feelings with engrossing and meaningful activities are also diverse. In the article "M.U.S./c.l.e." [<http://www.moonsociety.org/publications/>

[mmm\\_papers/](#)) we suggested that equipment manufactured on Earth for use on the Martian surface be disassembled (all parts tested and checked individual and in test assembly) to be put together in a Big Dumb Volume hold manufactured for the expedition in Lunar Outposts. The crew would be highly motivated to put everything together right. This opportunity will predictably be seen as risky business by some who may favor keeping Mars-bound crews busy performing safer make-work.

Surface expedition concluded, the crew would be similarly motivated to do preliminary chemical and physical analysis of samples being returned to Earth, along with some building materials processing experiments. NASA, however, may forbid them to touch the samples, not trusting them to handle the precious cargo and possibly invalidate intended research by more expert investigators in better equipped Earthside labs.

In both cases, there is probably a point of compromise between NASA's natural paternalistic prudence and the not unimportant needs of the explorers-en-route. For example, ultra-critical equipment can be shipped preassembled, with less sensitive equipment and backup equipment shipped "KD" (knocked-down) for assembly en route.

For the Earth-return, a similar division could be made. Surface samples could be separated into two quota portions, those held safe and untouched for labs on Earth/LEO, and those on which preliminary analysis and experimentation can proceed en route; trained geologists, chemists, and other scientists will be essential to the crew. To deny them "first rights" can only sow and nourish a festering resentment. Such avoidable psychological compost heaps should not be discounted as threats to the overall success of the mission.

In the overall spirit and atmosphere aboard the return crew vessel is positive, there will be other time-filling things to do. Debriefings and reports while experiences are fresh can be followed by round table discussions of how the success of a follow-up mission could be enhanced (new equipment, tools, lap facilities, housing etc.; better training; additional talents represented in the crew mix, etc.) Sensory and other impressions can be set to canvas or disk by those on board of artistic, poetic, or philosophical bent.

So much for generalities. Undetermined at this time, but absolutely relevant to the matter we are considering, is whether the voyagers will enjoy the amenities or artificial gravity for the long coast out and back. One gets the feeling that provision of at least fractional weight poses engineering challenges that neither Intercosmos nor NASA are eager to tackle. So what if the astronauts or cosmonauts can survive such long periods of zero-G without irreparable harm! The unchallengeable reality that the crew of a zero-G ship will arrive at Mars in a physical shape unequal to the demanding tasks at hand in the very limited time frame provided, should be more than enough to convince mission planners to err on the side of patience. One wonders whom they are kidding!

Marsweight, 38% Earth-normal, can be provided by a simple tether arrangement with crew pods at one end and equipment not needed before arrival at the other. Artificial gravity can also be provided more elaborately by a fixed structure, for example by a conjoining for the Marsbound craft as in the Case for Mars I studies.

Experiments with tether-provided artificial gravity could begin soon using the Shuttle and an External Tank brought to orbit with it. We have yet to do an EVA in an artificial gravity environment! An astronaut would have to remain tethered and would share the angular momentum that obtained at the exit lock. It would be tricky stuff at first, fraught with perils that could nonetheless become routine, even as driving in heavy traffic or flying in formation. Appropriate maneuvers and cautious could become second nature. There will be mis-moves but careful provision could minimize serious accidents.

The point to be made here is that, to NASA's abject horror, no doubt, there is a very real opportunity for totally new tethered-EVA sports outside rotating structures. By shortening a tether to the hub, one would advance on the structure; by paying it out one would fall behind - simple conservation of angular momentum. Using such maneuvers in tag matches might be risky, but rally-type events tin which one faced the clock, one at a time, to land first on a

forward perch or tag ring, then on one to the rear, before returning 'home', all by manipulating the effective length of the tether, could provide healthy, adrenalin-racing sport. This could be welcome stuff to a crew chosen to be optimally tuned to the pace of activity of the Mars surface part of the expedition. When such sport is embraced, either on the sly or with reluctant official consent, we'll have come a long way towards making the spacelanes home. [PK]



## FI\$CAL POSTSCRIPT

[To "Mars Calendar" MMM #19 October 1988, above]

By Peter Kokh

In the previous article, we suggested that the 668.6 Martian date (24 hr 37 min 23 sec) long orbital period of Mars was an inconveniently long peg on which to hang anniversaries and the rotation of holidays, holy days, and other recurring observances. Halving this period would provide more comfortable 334.3 Mars date ceremonial cycles 343.4 Earth days long. All that would be required would be the introduction of a distinction of terms. The "demi" period described above could be called a "Marscal" or an "Ennium"; the full orbital period, a "Zodian" i.e. once around the Zodiac, or something to that effect.

Reaction to these suggestions was generally positive. But we also heard from Tories (i.e. those unable to leave the mother culture behind) who insisted that for practical business reasons, the standard 24 hour Earth day and 365/6 day year would prevail throughout the Solar System, that when the Sun rises or sets on Mars is irrelevant. (We had suggested that Martian Law protect such people, allowing them to hide "Earth-style" calendars under their pillows without fear of search & seizure.)

To fairly address the interests of business in this matter, let's take another look, this time from the vantage point of the business cycle: the Fiscal Year. On Earth, a "fiscal year" is any twelve month period, not necessarily coincident with the calendar year that provides a convenient accounting cycle for a particular business. By common practice, any business subject to regular busy and slow seasons, closes the books, completing the accounting cycle, at the end of its most active season. Businesses catering primarily to summer tourists might close their fiscal year on September 30th, beginning the next on October 1st. Ski resorts might pick March 31st as the end of their cycle; Department stores January 31st, etc. At any rate, it is the seasons or consumer buying cycles or inventory cycles – the length of the fiscal year on Earth remaining the same – the 365/6 days of the civil calendar.

On Mars, those businesses involving transactions principally among the settler population and whose ups and downs are significantly affected by the passage of the long Martian seasons, will only be able to introduce real accounting regularity (fiscal comparability of one business cycle to the next) by adopting the full 668/9 date length of the Martian "year" or "zodian," with cycle opening and closing dates appropriate to business type.

It is reasonable to expect at least some businesses to fall in this category. But we might also expect services and manufacturing businesses whose ups and downs will be pegged rather to the civil "demi-calendar" of 334/5 Mars dates.

But then what about the Export-Import Houses trading with Earth and the Moon? And what about manufacturers on Mars who depend heavily on Earth/Moon-sourced shipments of parts? Won't they want to use Earth-standard fiscal years?

The answer to that is clearly NO! Until new methods of interplanetary propulsion antiquate the term "launch window", the one overwhelming Fact of Earth/Moon – Mars trade will be their mutual orbital synodic period which determines the frequency of launch windows. This period coincides with neither terrestrial nor Martian years, but averages 780 standard days or 760 Mars dates, some 25.6 months.

In short, business considerations may well lead some Martian enterprises to adopt fiscal cycles other than the 334/5 date civil Calendar we proposed for Mars. But even if Earth UT Time & Date provides a common shipboard reference time throughout the System, on Mars, businesses and settlers alike will live, work, and dance to more locally appropriate drums.  
<MMMM>

Are there

## METEOR SHOWERS

On Mars?

By Harald Schenk, Sheboygan Space Society

As the Sun sets behind a rock-strewn horizon, a spacecraft named Viking prepares for yet another lonely night.

Quickly, the heavens transform into deep blue velvet, revealing a splendor unequalled on Earth. It is nighttime on Mars. One of the many since Viking settled upon the alien surface, yet this one will prove to be quite different.

Suddenly, a flash of light illuminates the landscape. Within minutes, this flash is followed by several others. Is Viking under attack by Martian forces? Are the imaginary inhabitants of H. G Wells approaching with their "heat rays" to finally rid the planet of this strange intruder?

While Viking is only a robot, human observers would soon recognize the truth. It is a phenomenon common even on Earth. These flashes of light are nothing more than the individual members of a meteor shower.

Does this really occur? Does Mars indeed have meteor showers, and if so, how might they differ from those seen on Earth? The answer depends on several factors such as atmosphere and distance from the Sun.

Many years have passed since meteor showers were first associated with the orbit of comets. Composed of dust and ice, a comet will lose part of its mass with each passage around the Sun. Although this material has separated from the parent body, it may continue following the same orbital path for some time to come.

In this manner, comet debris can pollute the entire orbit, and continue producing meteor showers long after the comet has ceased to exist. If a planet enters any portion of this orbital path, it sweeps up some of the particles, and they in turn produce the celestial display we call a "meteor shower."

There are actually two types of shower. The one described above is called an annual shower, because debris seems to fill most of the orbit. There are some comets that do not seem to contain much dust. Meteor showers from such comets are difficult to predict, because particles seem to cluster in groups rather than disperse along the entire orbit. This is known as a periodic shower.

There are a number of comets whose orbits intersect that of the planet Mars. Two of these are Comet Temple-Swift, and Comet Arend-Rigaux. To speculate as to what the showers from these comets might look like, we have to look at some orbital comparisons.

On Earth, these flashes of light are due to the high temperatures produced when the particles enter our atmosphere. The temperature, in turn, depends on the velocity with which each dust bit strikes.

There is a range of maximum and minimum velocity with which we might expect meteors to pass through an atmosphere. Minimum depends on the velocity required to orbit a particular planet. For Earth, this minimum velocity is 48 miles (77.2 km) per second. On Mars, the minimum is only 2.2 miles (3.5 km) per second. [Any infalling material must accelerate in the gravity well to at least these velocities.]

The maximum possible velocity would be obtained by an object entering the Solar System from interstellar space, and moving in a retrograde orbit (opposite to that of the planets). This can be calculated by adding rotational and orbital velocities, plus the escape velocity from the Sun at the point of impact.

For Earth, this turns out to be a maximum velocity of 45.0 miles (72.4 km) per second. On Mars, the maximum is only 36.4 miles (55.7 km) per second.

These maximum values are not reached because meteoroids (as scientists call meteors before they enter the atmosphere) travel in closed orbits, and therefore have much smaller velocities.

The average meteor shower is caused by particles the size of a grain of sand. Due to the high impact velocity, these tiny specks are vaporized at altitudes 70 to 50 miles (113 to 80 km) above Earth's surface.

On Mars, with a much thinner atmosphere, vaporization would not begin until the particles had reached much closer to the surface. This would have the effect of stretching the radiant (direction out of which the particles appear to come) over a much larger portion of the sky. The smaller velocities would also increase chances that some of the particles might reach the surface.

Does Mars have meteor showers? The answer may have to await the arrival of men from Earth. Viking's eyes have been turned off for some time, and were not suited for recording such brief flashes of light.

[Note: This piece was written in 1989. Since then, Pathfinder and the two Mars Exploration Rovers, Spirit and Opportunity, have been on Mars, but the same remarks about these rovers visual abilities also applies.]

**MMM #41 DECEMBER 1990**

## **IMAGINEERING MARS ROVERS**

By Peter Kokh

When you consider the immensity of the challenge (Mars' surface area is equal to all Earth's continental land masses combined) present architectural strategies for constructing Mars Rovers, automated or not, NASA or industry, seem patently inadequate.

To spend some exorbitant amount of money creating a vehicle that can range only a few score miles from the landing site seems to imply pre-acceptance of an Apollo-like "science-picnic" scenario we go, look around, and come back home, never to return. For, if we are serious about opening up Mars for eventual human settlement, we ought also to be serious about designing globe-ranging vehicles from the outset.

What does that imply? Until we have graded highways cleared of boulders, wheeled vehicles are quite inappropriate. Most of the Martian surface, so far as we have explored it from our Viking Orbiters and Landers, is a continuous "strewn-field" - a 'Maginot' obstacle to wheels and tracked vehicles. While walkers would seem to be indicated, the ideas so far being put forth to make them self-navigating are absurd. Again, to spend millions developing anything whose usefulness will not extend beyond the limited scope of a first landing expedition - a radius of a few miles - is a waste of time. Self-navigation software that allows a vehicle to either wheel or walk at only a couple of hundred feet an hour is not what we ought to be spending our time on. What we need is a Broken-Field Runner!

JPL is testing a system using stereo cameras to provide 3D maps of the terrain ahead which the rover's computer will analyze to decide on the safest course forward, repeating the process every 15-25 ft! Can you imagine Olympic Games races on such a basis! WE NEED a



heuristic software program that will allow the Rover to learn from experience, gaining confidence and speed. No human runner, negotiating an obstacle course, ever preceeded on the basis JPL proposes.

A good software program would allow a Rover, walking or wheeled, to recognize generically familiar patterns, attention focused only, and time-savings, on the SIGNIFICANT differences AS they pop up. This, certainly, is how we do it – often even below the threshold of consciousness. Now a proper program designed in such a manner may make for slow learning at first. But there is no reason why a heuristic Mars rover can't do most of its learning right here on Earth in 'Marssimilar' terrain! Once on Mars, it would have to go slow for the first few moments while it adjusted its reaction patterns to the different gravity level. If all this is beyond our current level of expertise in Artificial Intelligence expertise, then perhaps we ought to set this project aside – until we are ready to do it justice. Why spend millions only to create some quaint anachronism, which is more likely to grace some dusty museum hall than the dusty plains of Mars?

If suitability for Global Mars Access is to be our faithful guide, surface contact rovers, whether wheeled or legged, should not be the only option we explore. Even though Mars' air is rather thin, we should be able to engineer ground-effects skimmers – especially if they are equipped with hydrogen-filled buoyancy bags to neutralize most of the weight. (Hydrogen cannot burn in the carbon dioxide atmosphere of Mars.) "Skimmers" would provide a swift means of personnel and cargo transportation by route of choice over a large percentage of the Martian landscape. Personally, I cannot see the sense of sending an expedition to Mars not so equipped. Skimmers could range in type from 'jeeps', to buses, pick up trucks, even analogs of our "18-wheelers."

Skimmers would free the opening of Mars from the Roman precedent of prior construction of a network of trunk roads. Bottled Methane and Oxygen, processed from the air, could run their engines, rereleasing Martian air as exhaust, and perhaps saving the steam.

Space enthusiasts should continue to be very suspicious of unnecessarily self-limiting schemes for Mars exploration. As the old saying goes, anything worth doing, is worth doing right.

## **RETHINK MARS SAMPLE RETURN!**

Commentary by Peter Kokh

We definitely do need to know more about the chemical and mineralogical composition of the Martian surface along with the geological heterogeneity with which such potential resources are distributed. And we should have this knowledge in hand BEFORE we launch a crewed expedition! But is the Mars Sample Return Mission the way to gain such knowledge? We think not.

First, unlike the Moon, Mars is much more diverse from place to place. One or even a few sites sampled for return to Earth would give us a very skimpy knowledge at best. Rather we should launch a Mars ORBITAL Retrieved Sample Examination LAB (or MORSEL) to which a whole FLEET of surface samplers could send their troves. Better to sample more areas, examining them in Mars Orbit, than fewer areas, sending the samples all the way back to Earth. A greatly reduced sample bag of tagged soil and rocks defying analysis or yielding enigmatic results could then be sent to Earth after the great bulk of the samples had been satisfactorily characterized aboard this automated orbital pre-examination facility. This would also supply a "ground truth" calibration check.

If we can't yet build such an automated lab, let's start brainstorming now. how to go about doing so. MORSEL would give us a more adequate picture of Mars.

## **LUNAR DEVELOPMENT & MARS**

Commentary by Peter Kokh

If some would ignore the Moon, it is in our deepest self-interest not to return the snub. No one should put all their eggs in the same basket – here we are referring to building the LUNAR ECONOMY on the sole foundation of supplying energy to Earth, through either or all current scenarios: Solar Power Satellites in GEO, Lunar Surface based Solar arrays, or a Helium-3 harvesting operation for future fusion plants.

If one's sole goal is to build space colonies as a byproduct of Solar Power Satellite construction, what ultimately happens to the Lunar Economy may seem unimportant. But we think that reaching a stage of healthy self-sufficiency for the Lunar Economy is probably the best choice of granite out of which to carve the cornerstone for a truly "circumsolar" civilization. If this viewpoint is on the mark, then it becomes rather important to DIVERSIFY the Lunar Economy. Serving the needs of pioneers opening Mars, is surely one such promising avenue for expansion.

Mars itself has nothing to sell the Earth except tourist meccas for the obscenely wealthy. Its moonlets, Phobos and Deimos, most likely are well endowed in the volatiles the Moon lacks. And any developing Lunar Settlement will be steadily acquiring the capacity to self-manufacture the more weighty of its needs to keep its trade balance with Earth as favorable as possible. It will be just such items that the Mars Settlement will need also and which the Lunans can supply at a definite fuel=cost advantage over similar items from the Earth's gravid surface. It is a two-way trade natural.

Until the Martian Settlement develops a diverse enough industrial base to shun trade altogether and turn in on itself – something the Moon happily will never be able to do – the more Mars' economy grows, the more the Moon's economy stands to grow in linkage.

The same is true vis-à-vis the Asteroids. The Moon, with a gravity well shallower than either Earth's or Mars', and with shorter synodic 'windows' to the asteroid belt than Mars, is much better situated than either Earth, LEO, or Mars to serve as the major outfitting and supply base for efforts to exploit the promised wealth of the asteroids, Earth-approaching or Main Belt. The more the rest of the Solar System is opened up, the more the Lunar Economy should grow.

Mars should fascinate would-be Lunans! – PK

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

– A. Gide

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## TEMPTATIONS TO ECO-CARELESSNESS

Commentary by Peter Kokh

Paradoxically, there will be little room for Lunatics and Lunacy on the Moon. Our biospheres on that desolate globe must be fully closed for economic reasons grounded in the need to import three of the four elements most essential to life: hydrogen, carbon, and nitrogen [oxygen being abundant on the Moon]. Not to religiously recycle "exotics" would be prohibitive.

When we get to Mars, the settler pioneers can expect a reprieve of sorts. The thin Martian atmosphere, with just 1/140th of Earth's atmospheric pressure, can yet be "mined" by well-known means to produce water, an Earth-normal air mix for habitat pressurization, and even oxygen/carbon monoxide and oxygen/methane fuel combinations to run vehicles, generators, and other equipment.

This undeniable head start advantage towards self-sufficiency has fooled many. The inventory of indigenous raw materials is not the whole key to economic self-sufficiency. If it were, Japan would be one of the World's poorest countries. The point is that Mars has nothing but tourist spots to market to Earth in exchange for those things its infant industries can't yet

produce for itself; whereas the volatile-impoverished Moon has the far more important triple pluses of "location, location, and location."

Nonetheless, the Rusty Dusties pioneering the mountain slopes, canyonlands and plains of Mars will find themselves tempted to exhaust their pollutants to the outside atmosphere and soil, since fresh replacement atmosphere and water is, in comparison to the harsh lunar experience, so cheap and easy to reprocess from the generous surroundings.

Atmospheric winds will sing a siren song: "We offer an inexhaustible sink for your cares." Dirty water will freeze, not mixing with the pristine permafrost from which fresh water is drawn (one of the water options.) We are so few, our settlement so small, and yet Mars is so big! What can it hurt?`

Even James Lovelock, of Gaia Hypothesis [1] fame, suggested in another book, The Greening of Mars, [2] that we use abandoned military missiles, ganged together to provide the necessary staging and delta-V, to rocket to Mars all of the stockpiled chlorofluorocarbons (CFC's) that we dare not use up on Earth if we don't want to destroy the last vestiges of the Ozone layer. On Mars, where we can't breathe the air anyway, and where there is no ozone to destroy, a CFC greenhouse effect would be most welcome. Fine! - if we are never going to "terraform" Mars! But if we are to leave open such a possibility for later more populous and capable generations of Martians-to-come, had we not best be careful about rushing down some potential cul-de-sac?

Dire prediction: IF Mars is settled directly by Earth folk laden with bad habits, instead of by seasoned Lunans living right, eco-disaster will occur.

#### References:

[1] Gaia: A New Look at Life on Earth by James Lovelock 1979, 1987. [ 2000 edition: Oxford University Press, ISBN: 0192862189

[2] Greening of Mars by Michael Allaby, James Lovelock [1985 Reprint edition Warner Books; ISBN: 0446329673] - PK >>>

"No grimmer fate can be imagined than  
That of humans, possessed of godlike powers,  
Confined to one single fragile world." -- Kraft Ehrlicke

*To Inject a Unique Flavor into Martian Settlement Culture,  
add the Romantic Touch of Old*

**Barsoom**

By Peter Kokh

#### Precedents

When European settlers first arrived in the Americas, they brought many place names with them: (New) York, Boston, Norfolk, Birmingham, Cartagena etc.

They reached into the pages of antiquity for other names: Memphis, Cincinnati, Atlanta, Phoenix.

But often enough, they were quite content to adopt native names for places, or Anglicized versions thereof: Seattle, Tacoma, Chicago, Milwaukee, Chattanooga, Wichita, Quito, Mexico, Bogota etc. Using Indian names not only helped cut ties to the various motherlands, but gave the New World a special flavor.

## What to expect on Mars

When and if settlers come to Mars, they will have an assist from the list of features already named by the International Astronomical Union following their identification on orbiter photographs. In naming settlements, they can refer to such pre-named natural features as a starting point e.g. Marineris Heights, Port Pavonis etc. They can also use baggage-names from Earth: New This and New That. But to supply "Mars the World" with that special colorful indigenous touch?

## The Mars Touch, from Science Fiction, e.g. the novels about ancient "Barsoom"

While native Martian names are not available, strictly speaking, Mars has been previously populated in various romantic Science-Fiction novels and in the pseudoscientific overreachings of Percival Lowell and his many followers. If we build aqueducts to bring melted polar cap ice to the equatorial zone, why not assign them romantic names from Lowell's list of imagined canals?

Perhaps the most elaborate fanciful glimpse of Mars was that of Edgar Rice Burroughs, the creator of Tarzan, who wrote ten or more novels about **Barsoom** over a thirty year period from 1911-41. What harm could there be in immortalizing some of his Barsoomian city names and names of his heroes, heroines, and villains?

In a planet of unrelieved ocher, rust, red, orange, pink, salmon, and coral shadings, a little literary color would be most welcome – a helpful assistance to the pioneers in seeking to establish a new collective identity, a symbolic declaration and reminder that "This is not Earth!"

Here are some of the Barsoomian city names which might be lifted out of fiction and into reality: the most famous, the twin cities of Greater and Lesser Helium (with their mile-high towers, pneumatic tubes, the great Avenue of Ancestors); then the storied seaports of old Aanthor (Avenue of the Quays, mono-liths), Hastor, Lothat, Thark, and Xanator; other cities such as Amhor, Duhor, Exum (on the equator at the Prime Meridian), Ghasta, Gooli, Horz, Illal, Invak, Jahma, Kadabra, Kamtol, Kobol, Korad, Manataj, Manator, Manatos, Morbus, Morgor, Onvak, Pankor, Phundahl, Ptharth, Toonl, Tjanath, Torquas, Zodanga, and Zor.

Awaiting assignment to various real geographic features are the Anatolian Hills, Dor and Otznean aquifer-ocean. Names ready-made for regions or districts are Domnia, Dugar, Gathol, Jahar, Jahma, Kaol, Okar, Marentina, Masena, Panar, Raxar, and Warhoon. A circum-Mars equatorial highway or mag-lev route, could take the 'old Barsoomian name' for equator: Polodona.

For Phobos the name pool includes: Thuria, Ladan, Ombra, and Tarid. For Deimos: Cluros.

Young settler girls could be given, or take, such names as Dejah (the famed Dejah Thoris), Haja, Janai, Lano, O Ala, Olvia, Ozara, Phao, Rojas, Sanoma, Sharu, Sola, Tavia, Thuvia, Ulah, Vaja, Vantija and Vanuma. Young pioneer boys: Carter, Carthoris, Djor, Floran, Gahan, Hovan, Jat Or, Kantos, Kulan, Lum Tar, Notan, Orm-O, Parthak, Ras, Sovan, Talu, Tars, Torith, Turan, Turjun, and Vandor – villains excluded.

If special plants are bio-engineered to thrive in Mars' climate some "local" names out of Barsoom's "past" are gloresta and pimalia flowers, mantalia and umpalla shrubs, sompus and usa fruit trees; and the trees skeel and sorapus.

If for pets, settlers breed novel varieties of cats, they might call them banths, komals, and soraks. New dog breeds could include calots and woolas; a new bird, the malagor. Large designer animals can be named orluk, thoat, and zitadar.

When the Mars Republic issues its own currency, it could be called the tanpi. And ready now to be instilled with life is the much-described Barsoomian chess game, Jetan, played on a board of 10x10 orange and black squares with dwars, padwars, panthans, princesses, thoats, warriors. Less defined is a game of chance called Yano in which small numbered spheres are rolled across a board with numbered holes.

Future Martians will develop their own fresh frontier customs. Taking cues from Burroughs' Barsoom, they might include: special remembrances of their ancestors, the exchange of armlets upon establishing friendship, laying of hand(s) upon another's shoulder(s)

in greeting instead of shaking hands. “Kaor” could replace “hello” and “Good Day”. At parting, goodbyes might be signified by hand(s) above head, palm(s) backward. And at weddings, the spouses-to-be might exchange gold ceremonial collars.

A regional governor might be called a Jed. If there is a chief planetary executive, his/her title might be Jeddak/Jeddara.

We’ll certainly use the thin air of Mars for transportation, but the Martian planes or flyers will look like strange caricatures of those plying Earth’s skies, their design driven by different ambient conditions. A small flyer design can be called a pinaar; a large airliner a vanator.

In seeking to establish a separate identity, the immigrants to Mars can either start from scratch or borrow from the imaginations of past writers. A touch of old Barsoom would help!

[\* For more colorful tidbits, see John Flint Roy’s 1976 **A Guide to Barsoom: The Mars of Edgar Rice Burroughs** – Ballantine, ISBN 0-345-24722-1-175] <MMM>

MMM # 42 FEBRUARY 1991

## IGLOOS

### ATMOSPHERE-DERIVED SHIELDING FOR LO-REM MARTIAN SHELTERS

MARTIAN “IGLOOS” By Peter Kokh

Mars, despite its precious endowment of thin atmosphere, has a surface almost as naked to the cosmic elements as does the Moon. True, this blanket of dry ice vapor [Mars atmosphere is largely carbon dioxide] does intercept and vaporize most of the micro-meteorite rain from space. But it does little to temper the Sun’s ultraviolet fury, a harsh fact of [non] life that constrains plans for someday “greening” those arizonesque Marsscapes. In truth, even full-strength UV does not penetrate very far; glass, as most other likely building materials, can serve as an adequate barrier.

Of far more consequence, Mars’ air is no longer dense enough to appreciably absorb or neutralize the all points bombardment of cosmic rays, nor the ionizing radiation from the occasional solar flare. As on the Moon, it will be prudent for explorers and eventual settlers to provide massive shielding for any and all human spaces, fixed or mobile, in which they will be spending significant portions of their daily routines.

On the much smaller Moon (half the diameter, one-tenth the mass, and only 42% as gravid as Mars), the handy regolith, the blanket of impact-pulverized soil which covers the surface everywhere some 2 to 10 yards (meters) deep, can be heaped up over our pressurized habitats and passageways, and on top of vacuum-exposed workspace ramadas or canopies. The conventional wisdom has been that we will do something similar to the rock-strewn sands of Mars.

But this Moon-appropriate technique, while it does provide a fall-back option, is hardly the elegant choice for Mars! CONSIDER:

- 1) The windswept Martian surface may not have so universally uniform a regolith blanket. Indeed, Viking I and II surface pictures show rock and boulder peppered plains in which the sand grains may be no more than a filler. Gathering up fine material for shielding mass would be a much more difficult trick, leaving a probable rockpile surface in the source area.
- 2) Because of this, a larger area of the neighboring surface would have to be disturbed unless sand were to be “mined” from remote or out-of-sight locations, an inconvenience at least.
- 3) For both these reasons, automated deployment of surface-derived shielding in advance of the arrival of human occupants – should it be desirable to land and check out base-habitat

structures in advance – would be much more difficult to pull off on Mars than on the Moon. It would even be a tedious effort for teleoperators based on nearby Deimos [Deimos stays overhead of any Mars surface location far longer than does fleeting Phobos].

So why not look for options? Fortunately, the atmosphere of Mars provides abundant raw materials for a number of alternatives Here is its composition:

<b>COMPONENT</b>	<b>Formula</b>	<b>%age</b>	<b>Snows at °C</b>
Carbon Dioxide	CO2	95.32	-78.5
Nitrogen	N2	2.7	-210
Argon	Ar	1.6	doesn't
Carbon Monoxide	CO	0.07	-199
Oxygen	O2	0.03	-219
Water Vapor	H2O	0.03	0

( & Neon, Krypton, Xenon, Ozone, parts per million concentrations).

Now conceivably, we could provide a bladder of appropriate shape, probably of serviceable Kevlar, to either drape over habitat structures directly or over an overarching framework under which habitat structures could be tucked safely and fill the bladder with liquefied or frozen gases condensed out of the Martian air.

Voila! an IGLOO! Its a nice thought, but one look at those freezing temperatures would seem to put a damper on the idea. Such igloo-type shielding would seem to require insulation and/or refrigeration if its regassification point lay well below mean ambient temperatures. Of the above selection, only water would remain frozen or liquid through the whole range of Martian seasons. Indeed, water would be ideal for, liquid or solid, it would buffer serve as an excellent thermal buffer between interior and exterior. No insulation would be needed on either the elements-facing or the habitat-facing walls of the containing bladder. This water-filled comforter could drape directly over habitat structures, avoiding the extra bring-along weight of a separate supporting framework.

Except in the case of possible research or ice-mining stations along the edges of the polar caps (and then it would make even more sense to use water-ice!), a dry-ice or dry-snow (CO2) filled bladder would have to be foil-faced on both sides and need to be separated from the shielded habitat area by some sort of trusswork, less it act as a heat-sucking sponge.

Alas, Carbon Dioxide is more than 3,000 times as abundant as water vapor in the Marsair. In comparison, it would take a lot more up-front energy to extract the needed water, a debatable tradeoff with the rather significantly more forgiving maintenance required.

To be sure, if tappable permafrost reserves are handy to the chosen base site, the decision would swing towards water. Installation of the required equipment will most certainly require the presence of an on site crew, however. So the water-ice option, as attractive as it may be from an ivory tower perspective, presents great difficulties for the starter base, even more so if the base is erected in automated or teleoperated fashion prior to actual occupancy.

Yet if it is decided that it is too expensive to import the water supply needed for the explorers' (or settlers') consumption, hygiene, food production, and processing needs, and tapping permafrost reserves is deemed to be impractical in the near term, then by one manner or another, atmospheric water vapor will be the one remaining choice. In that case, the equipment needed to extract it must be included in the base setup cargo, as well as a power plant sufficient for the chore.

So much for a first blush assessment of igloo shielding possibilities! Now it's time to take a deeper look and do a little brainstorming. It is not necessary to limit our choices to the gases actually present in Mars' atmosphere. Other freezable volatiles can be produced out of these, such as Methane CH4, Ammonia NH3, and so on. And as we have read in the first article, methane production along with Oxygen and probably Carbon Monoxide, are high priorities for even the Mars Beachhead Base. Ammonia production, for use as a chemical feedstock for fertilizer etc., is a lower priority but will follow soon enough if any sort of permanent human presence is to be maintained on Sol IV. Ammonia liquefies at -33°C and freezes at -78°C, and

would be easier to maintain in a non-gaseous state than Carbon Dioxide. Can we do better? That is, can we find a compound producible from Martian air **a)** with a much higher gasification temperature and **b)** in much greater potential abundance than water vapor?

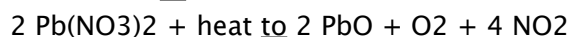
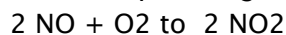
What about the oxides of Nitrogen? Nitrogen itself represents only a 2.7% fraction of Marsair constituents, but add in some of the Oxygen which comprises a whopping 60.7% considered element by element, and the potential abundance of various oxides of Nitrogen might be much greater than that 2.7%.

OXIDE	FORMULA	%age	Gas above °C
Nitrous Oxide	N2O	4.24	-88.8
Nitric Oxide	NO	5.78	-151.8
Nitrogen Dioxide	NO2	8.87	+21.2
Dinitrogen Pentoxide	N2O5	10.41	+47

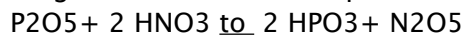
Paydirt!? It certainly looks as if either Nitrogen Dioxide (and the polymer N2O4 co-stable with it in the liquid state) or Dinitrogen Pentoxide, which is a colorless crystalline solid (might need only a wind-breaker and not a full bladder!) could satisfy both of our conditions above. Isolated within the containing bladder, either would be sufficiently inert.

Consider that in the process of producing such oxides, appreciable water for other us could also be produced as a byproduct (2.9 kg water per ton of N2O5 and 3.4 kg of water per ton of N2/N2O4). As hundreds, even thousands of tons of these oxides might be needed, this water could be a valuable asset.

What are the potential drawbacks of a scheme to produce either Nitrogen Dioxide or Dinitrogen Pentoxide from Mars Air for use as habitat shielding within a containing bladder? It will come down to the relative ease or difficulty of the production process. Here on Earth, Nitrogen Dioxide is most economically prepared by reacting oxygen with Nitric Acid (HNO3 which by the way has a potential abundance of 0.2%, seven times that of water vapor, and liquid below 83oC) or by heating a heavy metal (lead) nitrate.



Under Earthlike conditions Dinitrogen Pentoxide is most economically prepared by dehydrating Nitric Acid with Phosphorous Pentoxide.



**The salient task at hand** is to identify and test out the most Mars-appropriate of producing either of these potential igloo-makers. If a practical process can be worked out, such igloo-shielding could prove quite attractive and work to accelerate Martian development.

To recap, the advantages over sand-scrounging would be

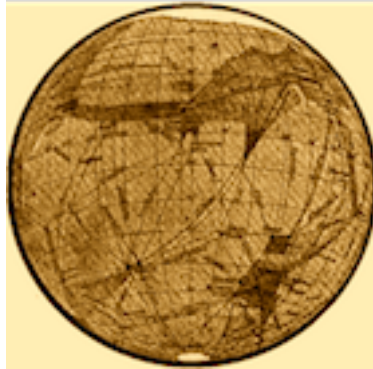
- a) Leaving the surrounding terrain undisturbed except for footprints and graded roadways – a scientific plus and an aesthetic one too,
- b) Ability to be put in place automatically prior to crew arrival, and
- c) Its compatibility with production of valuable water reserves as a byproduct.

To the writer's knowledge, this is the first suggestion of using igloo materials for shielding on Mars. If not, it is at least arrived at independently. <<< **MMM** >>>

**Note:** We wish to thank NASA scientist **Geoffrey A. Landis** for his response to this suggestion in which he points out that dinitrogen pentoxide is so unstable that it is classified as an explosive.

But while that may be so here on Earth with an oxygen-rich atmosphere, would that also be the case on Mars with its CO2 atmosphere? Are there ways to stabilize it, possibly with some additive also produced from the Martian atmosphere? If not, we could simply use pure carbon or graphite powder, which in the absence of free oxygen, would not ignite or burn.

The advantages of atmosphere-derived shielding are considerable, and it would be a pity to drop this idea without exhausting all the options and alternatives. PK



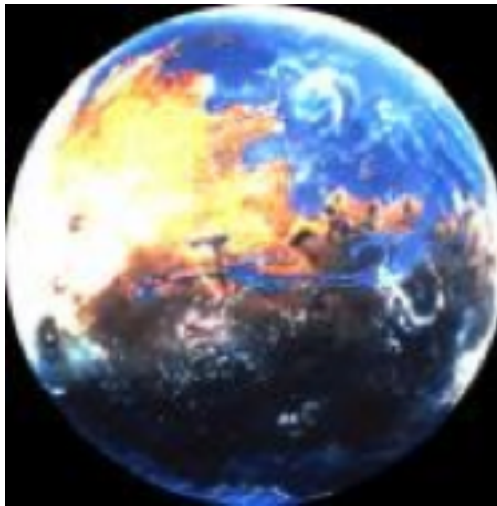
**Mars of "Lore"**

**vs. Mars of "Yore"**

**Above:** Mars as Percival Lowell saw it, criss-crossed by canals, a dying, drying world.

Mars once had a thriving biosphere and given birth to a sentient race. "Martians" had since adapted to the thinning air and dwindling water reserves, building a network of irrigation canals.

**Below:** Mars 3 billion years ago, with its northern ocean. Today it is a far more hostile place than either. Should efforts to make Mars more hospitable seek ambitiously to restore the Mars of Yore – or settle for the Mars of Lore?



**MARS: plenty of time to wait**

**but none to waste**

IN FOCUS Editorial By Peter Kokh

### **Plenty of Time to Wait**

Most of us in the National Space Society see the make-or-break importance of putting our expansion into space on a firm economic footing and we view development of lunar resources as the first step to achieving that goal. Yet most of us also have a keen interest in Mars, its exploration by human crews, and its eventual settlement. While President Bush has espoused such a goal, economic realities are certain to put off its achievement for decades, like it or not. Even a magnitude of order reduction in NASA's original cost estimate of \$500B via Bob Zubrin's "Mars Direct" mission architecture still leaves human exploration of Mars a luxury. Once the potential for off planet resources from the Moon and elsewhere to substantially alleviate Earth's growing energy crisis is more widely realized, this will change, with retrieval of volatiles from Mars' moonlets, Phobos and Deimos, part of the scenario. Martian settlement will piggyback on that resource trade or not occur at all.



Meanwhile things do not look well even for robotic precursor missions to Mars. Mars Observer, much of its original potential lost when NASA cut the NIMS instrument as a penny-wise pound-foolish budget move, is set to lift off soon on a Titan using the unproven and inadequately tested TOS kick motor. We can only hope that Mars Observer will not be yet another victim of tragicomic human error, adding to the sorry string that now lists Phobos, Hubble, and Galileo.

Meanwhile the former Soviet, now the Russian Mars program has been cut back and delayed. Until the Euro-Asian Commonwealth economies improve dramatically, we can be thankful for any missions that are actually launched.

### **No Time to Waste**

Those who wait for transportation cost breakthroughs and do nothing else in the meantime to help ensure the success of eventual Mars missions, work instead (in self-betrayal of **Meteorburst Communications** – Design lightweight equipment to be included on a Mars Surface Rover to attempt to relay signals to distant receivers over the horizon by bouncing them off meteorbursts in the high Martian atmosphere much as truck fleets now do on Earth. If successful, this would allow planetwide operations without the necessity of deploying and maintaining an expensive array of communications satellites. A good project for ham radio buffs.

**Carmonox and Methanox Engines** – Develop, debug, and improve internal combustion engines (for vehicles and generators) that can run on Carbon Monoxide and Oxygen or on Methane and Oxygen in simulated Martian conditions. These fuels can easily be extracted from the local atmosphere and cached at handy points to bring real mobility to Martian operations. A pair of good project for the automobile engine buffs amongst us, or for school projects.

**Skimmers** – Earthstyle hovercraft will not work in the thinner Martian atmosphere unless a large portion of their standing weight (with fuel, and without) is neutralized by gaseous hydrogen buoyancy tanks. Maintaining stability in maneuvering, and maintaining ground clearance range as fuels are used up will be a design challenge. If you have the capacity to tinker up a suitable Mars skimmer and don't, don't cry when our people on Mars are dependent on tortuously slow walkers or crawlers when they could have been making tracks.

**Canals for Polar Meltwater** – One should never put all one's eggs in one basket. As permafrost may prove not to be an easily recoverable resource, we need to brainstorm how to access the much greater water reserves within the planet's polar caps. Do we truck quarried ice to distant bases and settlements? Or do we finally build the vaunted canals of Mars, once prematurely accepted as fact? If so would these be pressurized conduits carrying melted ice water with periodic pumping stations and measures to keep the water from freezing (such as solar heat-attracting and storing surfaces)?

### **CHEMICAL ENGINEERING PROJECTS**

**Igloo Type Shielding** – Dinitrogen Pentoxide (N<sub>2</sub>O<sub>5</sub>) produced robotically from the surrounding atmosphere without disturbing the surrounding soil of the base or settlement site, would make deployment of either, a much simpler task and produce other useful volatile feedstocks as byproducts. We need to brainstorm the most appropriate chemical pathway for producing this stable radiation-shielding powder under Martian conditions and with a minimum of tending.

Once we have a much, much better handle on what types of mineral and chemical compositions occur in how much relative abundance in the various areas of Mars, it will be time to start brainstorming the processing of building materials and other products from local resources. As of now, such work would be premature – garbage in, garbage out.

**Climatic Engineering by design** – By now we know, having learned the hard way, that human industrial activity has a definite changing effect upon the terrestrial biosphere. While the effect of our presence and industrial activities on Mars will be minuscule at first, they will be real. On Mars the situation will be just the opposite. We will want to maximize, not minimize, climatic change-effecting byproducts of our activities. But first we must decide what our "terraforming" goals are. Some of the potential pathways may be mutually exclusive. It will be

important not to put in place operations that will unwantedly commit us to temporary but “dead-end” greenhouse improvements. See the article that follows. The result of this discussion should be to have in hand, when we finally do set up on Mars, a well thought-out **strategic exhaust gas policy**.

### **AGRICULTURAL PROJECTS**

**Mars-Hardened Plants** – At the present epoch, Mars is too cold, too thin, too dry, and too naked to raw UV to support any kind of plant life useful to settlers that we can easily imagine. Yet condensed and warmed in moisture tight greenhouses under UV resistant glass, Mars’ Carbon Dioxide – Nitrogen atmosphere (95%, 3% respectively), a small amount of Oxygen added, should support agriculture easily enough. It’s not too early to begin breeding and bioengineering (transplanting genes that promise success) plants that “thrive” in such conditions, gradually hardening them to ever thinner, cooler, drier, and less oxygen-rich conditions until one day, as human planetary engineering improves the climate on Mars, they can establish themselves outdoors and spread, creating the first (in a very, very long time, to be sure) Martian ecosystems. Meanwhile crops grown in such conditions will provide food, fiber, and feedstocks much more cheaply than those that have to be babied in more Earthlike greenhouse conditions.

An important consideration in the above scenario is the choice of plants that are not dependent for pollination on insects or other animals that could not survive in such anaerobic (oxygen-starved) conditions. Mars will have flora outside the greenhouse long before it’ll have fauna outside the zoo.

### **PROBE INSTRUMENTATION PROJECTS**

If we are going to settle Mars, living off the land in true frontier style, we must have in hand a much better picture of the nature and geographical extent of potential Martian resources. Our past probes, and those now in the works, both U.S. and C.I.S., are aimed less at resource identification and mapping, than at the intellectual self-gratification of the principal investigators enlisted in the effort. This knowledge is not spurious. It does provide a foundation for further exploration. The point is that if we do not see to it that future probes are adequate to the job we who would settle Mars need them to do, we cannot sit idly by and leave the choice of instruments and the scope of missions to planetary scientists planning alone.

**A Permafrost Explorer** needs to be brainstormed. By first scouring over existing Landsat thematic imagery to find clues to Siberian, Alaskan, and Canadian permafrost – here on Earth where ground truth checks and calibrations are an easy matter, a project team should be able to get a handle on how to design a Mars probe that would do the trick, outlining the extent and perhaps giving clues to the thickness of subsurface ice-laden soils on Mars. A spin-off precursor dedicated Earth Permafrost Explorer would be a funds-attracting possibility.

**Carbonate Explorer** – Orbiting thematic mappers might be optimized to expose calcium carbonates (limestones) in the soil and other depositories of carbon dioxide that could be used to rethicken the atmosphere. It is even possible that there exist karst regions of long dead limestone caves preserved through the disappearance of running water.

**Thermal Explorer** – An orbiter could be instrumented to map the relative heating and cooling (post sunrise and post sunset) capacity of various areas and to reveal geologically active hotspots that could be tapped someday for geothermal power production.

Future topographic mappers could be made sensitive enough to reveal ancient shorelines and beaches, tiny headwater sources and eroded badlands. Chemical mappers might be made sensitive enough to reveal salt deposits, clays and other rusted and hydrate-rich soils as well as hydrogen depleted soils.

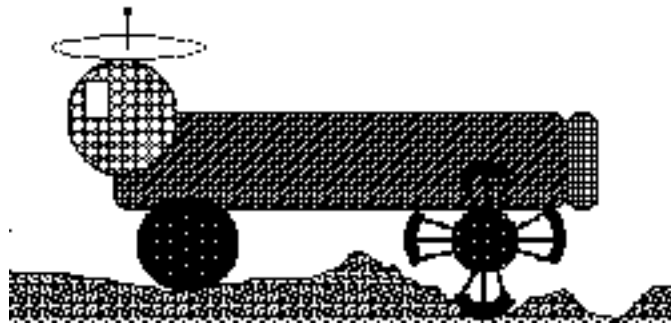
The implications for all this knowledge for base- and settlement-siting, for architecture, for industry, and for agriculture cannot be underestimated. Without such knowledge, we will founder about blindly, losing decades. NSS has several members with at least some of the germane expertise to take a more aggressive tack in planning the future of Mars precursor missions so that when we do go to Mars, we will have gone to stay, really.

These are just a few items of an ambitious homework agenda to make the waiting years anything but wasted ones. As we identify more in MMM, we will add them to this list. But the choice is up to us as individuals and subgroups, since the NSS Board seems disinterested in doing anything other than affecting public policy. PK

## INVENTORS WANTED

Serious would-be explorers of Mars have been busy developing a variety of wheeled and walking vehicles and robots to cover the boulder-strewn expanses of Mars.

The trouble with wheels, is that they are too easily defeated by a host of obstacles. Mars has no roads. Yet walkers can negotiate easy terrain at only a snails pace. So why not combine the virtues of both? Tinker a walking vehicle that can let down a set of wheels when the way gets easy, or a wheeler that can switch to legs, or whose tires can sprout feet?



**To date, the discussion can be summed up by the phrase “garbage in, garbage out”**

By Peter Kokh

When the popular wisdom that Mars was a dying planet populated by an ancient race that has struggled resourcefully to keep apace with the advancing desiccation of its lands and the thinning of its air with a grand engineering scheme of canals to bring melt water from the polar caps to thirsty equatorial croplands and of atmosphere plants to keep the air as thick as possible – when this notion finally fell before the onslaught of better telescopes, less romantic observers, and an armada of visiting probes, many a writer made up for his aching disappointment by concocting schemes to make this drier than we thought, colder than we thought world something more like Earth. “Terraforming” is the word in currency. And the number of daring bold schemes is legion.

There are two things wrong with these schemes. First there has been little if any consideration for where the planet has been (should the goal be rather one of restoring the pristine youthful Mars of yore i.e. “**rejuvenaissance**” rather than “terra”-forming, bringing it to a state alien to its experience?)

Second there has been much detailed consideration of importing apparently missing volatiles (notably water-ice and oxygen) and little consideration for what resources are actually banked on the planet itself in one form or another. Indeed we do not know the answer to that and a whole armada of probes will be needed to tell us what level of improvement we can achieve working with the grain of Mars, rather than against it.

Indeed such information may well make clear that we could, without grandiose schemes to import ice from Hyperion or elsewhere, ease Mars back, if not to the ocean-mantled days of its youth, at least to the marginally survivable world we thought was our neighbor some decades ago. Yes, why not “**Lowellification**” after Percival Lowell whose inventive picture of Mars so many had so eagerly swallowed hook, line, and sinker – a vision of broad irrigated croplands beside wide open canals, of the spring advance of green from poles to equator, of air not so thin that a simple breathing mask wouldn’t do, of deep blue skies to offset the rust-hued sands.

In fact, we may not need to import ice from elsewhere in the Solar System to give Mars new seas. We won’t know that until we’ve orbited a **Permafrost Explorer** and a companion fleet of ground truth seeking robots. Yet no nation has gotten past the “wonder if” stage of curiosity about permafrost. Without advocacy we may never get to know. For it is the relics of the past, not the foundations of the future that causes planetary scientists to itch, and seek federal scratching aids.

In truth, we may not need to import vast quantities of oxygen and nitrogen to transform the atmosphere if orbital and surface exploration reveals vast buried fields of carbonate rocks or even limestones. We haven’t heard of any plans to research these pregnant possibilities. For if we could thicken the given carbon dioxide atmosphere, we’d have a warmer Mars, one on which some frozen water reserves would melt and stay liquid, and one on which, a trace of oxygen added [%?], plants not dependent on animals or insects for pollination could thrive – even if we still could not breathe the stuff ourselves.

And if, no thanks, we would rather move towards an oxygen-laden nitrogen-buffered atmosphere like the one in which we have ourselves evolved, we may have an assist of unknown potential in the surface peroxides of unknown depth and extent that the Viking experiments hinted at. Can we get a handle on this question from orbit with the help of calibrating ground truth devices on the surface? Those who would go beyond exploratory orgasms to real settlement, owe it to themselves to advocate the missions that will tell us yea or nay.

We may or may not ever have enough raw power at our disposal to undertake the grandiose terraforming schemes bandied about in the past three decades. But we will certainly have an effect on Mars, as we have had on Earth, by our growing industrial presence there. Even before we have the wherewithal to begin tackling a more modest program of “Lowellification”, we will have the option of designing our industrial processes to maximize the kind of benign exhaust “pollution” that would slowly build up to the threshold for permanent climatic change for the better.

Decisions will have to be made in the next few decades, as soon as possible, about what our goals are for Mars – for the various paths are not all stages of one grand scheme. If we will settle for a much-easier-to-implement thicker CO<sub>2</sub> atmosphere with a relatively small amount of free Oxygen and accept a Mars-hardy vegetation without wildlife (we’ll have indoor pets and “middoor” urban wildlife to be sure) then the industrial protocols we need to put in place from the gitgo will be quite different from those that would support a path to a more Earth-like final result.

Before we pick sites for our settlements, we had best make sure they are not smack in the way of some eventual river, or on the bottom of some future sea!

If we purposefully take the first humble steps to a future wetter Mars, then, before we pick sites for our settlements, we had best be sure they are not smack in the way of some eventual river, let alone on the future bottom of some sea to be. Indeed, we have a very poor map of Martian topography and the relative elevations of various areas. Mars was not wet enough long enough to have developed a mature drainage system – even if it did have a pole-

girdling northern sea, Oceanus Borealis, and even if it did have catastrophic flooding in a few scattered episodes. Mostly Mars will be a place of separate unlinked basins whose lowest sills have never been breached. Not only do we have to have an excellent basin map, we have to know what the soil composition of various basin sills are, and the ease at which water can cut a channel through them. Only with a lot more information than any curiosity-scratching planetary scientist has ever proposed to seek could we program a computer to sketch the likely evolution of Mars future drainage systems.

Not only do we not want to place a major Martian settlement in the way of some future watercourse, neither would we want to isolate it in some future boondocks nowhere near one of the future rivers, lakes, or seas. There are a few safe bets, of course: on the rim of Valles Marineris, or on the upper flanks of the deep Hellas basin.

Any intelligent plan to settle Mars needs to know what resources are available and where they are to be found, in search of a healthily diversified economy. By these standards, we have not yet done enough homework that any plan for opening Mars could expect more than a pathetically flunking grade. The location of future Martian towns and cities, the “language” of any native architecture taken from the building materials that can be produced from indigenous resources in various soil provinces of the planet, even the kind of “forests” and “scrub” that we may someday be able to develop to grow wild and free under Martian skies, and the produce and fiber we may be able to harvest from such de-tamed varieties – all hangs in the balance. For it will depend heavily on the informed decisions we make on the direction of planetary changeover that economic micro-decisions will move us towards. The pace of that change may be slow but it will be inexorable.

Above all, we must be sure that we do not develop habits on Mars that start us up some dead-end canyon of foolish short-lived improvement. We must leap into the future from a platform of solid investigation.

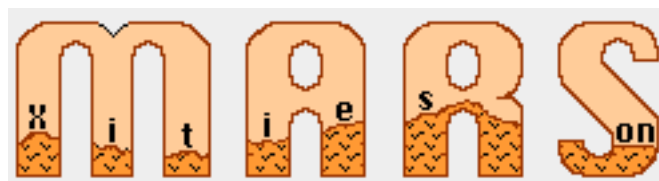
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### **Terraforming, Rejuvenaissance, Lowellification?**

The burden is ours, not to decide, but to begin the methodical accumulation of the information on which an informed and timely decision can be based.

Terraforming, Rejuvenaissance, Lowellification – whatever course we would choose – are not mere exercises of fantasy speculation. Nor do they represent choices we can leave to our successors in some latter century. The time is upon us, not now to decide, but now to begin methodically accumulating the information on which an informed decision can be based in a timely manner. Once a goal has been agreed upon, there will be time enough to decide upon the actual means. Meanwhile, sorry to disappoint those looking for an ‘MMM special’ quantum leap in speculative planetary engineering. As we said, at the present moment it’s a case of garbage in, garbage out. And if those of us who ought to care, do not take needed steps, that situation will continue.

We can chose to be the ancestors of generations of Martians yet to be born. <MMM>



XITIES ON MARS

By Peter Kokh

The first settlement on Mars will probably be built on some committee-chosen site that has no justifying rationale at all to anyone looking at Mars from a long term global perspective. Such is the way governments do things. Xitizens and business people looking to found follow-

up settlements will be much more strongly motivated to choose sites that offer distinct and inarguable economic advantages. For example, a position astride an obvious future traffic route, or near known or strongly suspected local resources of Mars—global significance, or near local energy access sites (polar meltwater—run hydroelectric? geothermal?) or, convenient to premium tourist attractions.

It often seems, even to lunar development advocates, that the Moon is very homogeneous and monotonous, that, to put it tritely, “when you’ve seen one crater, you’ve seen them all.” Yet various lunar sites do offer distinct advantages and the Moon cannot be developed in any rational way by a single base or settlement no matter how respectably sized and thoughtfully situated.

If that is true on the Moon where eons of geological processes in the presence of water did not occur, the economic geography of Mars, where water flowed freely for perhaps a billion years, is likely to be far more diversified in its economic relevance. Strategic metals may well have begun to be concentrated into ore bodies in various places. These may be exposed here and there in the walls of various canyons, favorite early sites for prospecting. The permafrost will be much more accessible in some areas than others. Very low areas like the Hellas basin will have noticeably higher atmospheric pressure, etc.

At this point we have a much better idea of the kinds of building materials that we can make from Lunar resources than may be possible from Martian ones. Given the almost certain high degree of variation in mineralogical content from place to place on Mars, even the most educated guesses as to the kinds of construction products we can produce on site are in all honesty little more than exercises of unanchored speculation. As a result, far more than on the Moon, various Martian towns may differ markedly in architectural appearance.

Beyond such a blatantly general statement, it is still possible to say some interesting things about future Martian Xities. First, since the degree and mix of exposure to the cosmic elements differs, shielding requirements will be both less and different from those on the Moon. The thin atmosphere is a poor blocker of cosmic rays and it has little screening effect on the strongly antiseptic solar ultraviolet radiation. But this tenuous envelope does stop most micro—meteorites and the danger of impact decompression accidents may be a bit lower. There is every reason to believe that the air pressure can be increased substantially by using Mars’ own indigenous resources.

Shielding needs can be served in the same manner as on the Moon, using local regolith. This will be harder to accomplish if all sites are as boulder strewn as the two visited by the Viking probes. But there is also the elegant possibility of processing an insulating powder directly from the atmosphere – Dinitrogen Pentoxide or  $N_2O_5$  [see MMM # 42 FEB ‘91 “IGLOO Shielding on Mars”. See MMM Classics #5] To keep it from blowing away in the Martian winds, this powder would have to be covered with an anchored tarp or placed in bags, or simply in sufficiently voluminous hollow walls and roofing.

One site that has a lot going for it, the West slope of lofty Pavonis Mons on the equator, may also come equipped with ready made shelter in the form of innumerable lava tubes honeycombing the bulk of this great shield volcano. [cf. MMM # 18 SEP ‘88 “Pavonis Mons”. MMM Classics #2]

[See request for proposals at the end of this article.]

While there are extensive dendritic valley complexes most likely carved by flowing water billions of years ago, a Martian analog of a Lunar rille bottom settlement [as in LRS’ ‘89 Prinztown design competition entry] may be inadvisable if there is any chance at all that through human action the waters could flow again. Yet, as the atmosphere thickens slowly through planned industrial out—gassing and more swiftly through deliberate direct action, once the Martian economy can support such an effort, the settlers will be able to spend more and more time outdoors without overexposing themselves.

While shielding will still be a must, Martian xities need worry less about being airtight, on two grounds. First, leaking oxygen into the surrounding atmosphere will help contribute to desired slow change in atmospheric composition. (On the Moon, similar leaks would degrade a

scientifically and industrially invaluable high vacuum.) Second, whereas any leaks on the Moon would result in the loss of Nitrogen which may have to be imported to the Moon at great expense, similar leaks on Mars will lose nothing that can't be replaced locally.

While the practical differences are slight, Martian settlers may be less accepting of a "mole" type life (even with piped in sunlight and periscopic picture windows) than will be frontier folk who settle the harsher Moon and asteroids. Domed xities – even if the dome-facing walls of the buildings inside have to be shield-thick – may be the Martian settlers' common dream vision of the future, with some slow relaxation on the annual permissible number of unprotected hours outside.

Given the comparatively relaxed concern with closing the atmospheric and water cycle loops on Mars, smaller rural outposts will be much more practical than they will be on the Moon where there will be a much stronger biospheric advantage to size.

[MMM #15 MAY '88 "Rural Luna." MMM Classics #2]

Because wood and paper and plastics do not contain elements that are deficient on Mars, such materials can provide some of the building materials and furnishings and arts and crafts objects used in the settlement. In that respect, Martian burgs will be far more reminiscent of those on Earth than the glass, metal, and ceramic dominated lunar towns and habitats. Along with this benefit will come increased danger of fire.

Finally, unlike almost everywhere else in the Solar System beyond Earth [Europa and Titan may be two eventual exceptions very far down the road] Mars may someday (again?) sport a global biosphere of genetically nurtured adaptations of the hardiest Earth plants. Thus where all other Xities provide a firmament between contained biosphere and sterile and barren surroundings, on Mars xities will contain oases of Earth life surrounded outside by fledgling Mars-hardy adaptations. Towns on the red planet may actually someday get some of their food and other agricultural needs from outside their xity biospheres. <MMM>

## Attention Technonuts, Software buffs REQUEST FOR PROPOSALS:

**Problem:** How could Microbot Lavatube Mappers do their job within the maze of lavatubes that probably honeycomb Pavonis Mons and other Martian shield volcanoes if they're at all like their much smaller cousin on Earth, Hawaii's Mauna Kea/Mauna Loa (i.e. the Big Island, where incidentally they could be field-tested – as well as in the Oregon Moonbase) without losing their bearings underground, and without losing contact with their central control and information dump?

**Answer:** Let us know how you would design an army of robo-ants to thoroughly map and explore the suspected lavatube complexes on Mars. Assume that the mechanical critters will deactivate when they reach an obstacle or dead end and not return for debriefing. The "Reporting Center" may be on the surface or in synchronous orbit above the mountain.

MMM will publish the best suggestions submitted. COPYRIGHTs remain with the submitter, as usual. \*

**GLOBAL ACCESS**

to MARS the WORLD

By Peter Kokh

We will not have established a real permanence on Mars until we have made a start on an network of strategically scattered settlements, each differently advantaged by the geography and/or geology and mineral wealth of its site – as a down payment on a Diversified Economy that can supply a healthy percentage of its own needs and produce enough goods for export to purchase what the Mars Frontier jurisdiction cannot yet provide for itself. It is not enough to go beyond human exploration to the establishment of an outpost, however ambitiously designed. The permanence of that outpost will be so much wishful bravado against the harsh economic night until our presence on Mars becomes a real, rooted global occupation. As we've pointed out, we have a lot to learn about Mars, information that will not be gathered from the idle curiosity scratching probes now in the planning stages, before we can begin to glimpse what such a network of frontier towns would look like or the details of its economy.

What we can do, while we are trying to escape owning up to our responsibility to get involved in advocating the needed set of Mars Resource Explorers, is to brainstorm, tinker, and field test various potentially promising means of transportation that settlers can use to negotiate their roadless and trackless raw new world without having to stop to build the traditional road and rail networks. These will come in due time as the initial experimental traffic settles into patterns and volumes that justify their construction.

### Aviation – “Ares Aero”

Several promising suggestions have already been made. Several writers have pointed out the possibility of aviation in the thin Martian air. Baseline “sea level” air pressure on Mars is equivalent to that 125,000 feet up (38,000 meters, or 24 miles) here on Earth. A neat trick, but well within the envelope pioneered by a number of experimental aircraft to date. The most challenging aspect of aviation on Mars will be taking off and landing. Without lift-assist, such maneuvers may have to be made at speeds up to 700 mph or 1100 kph. Launch track acceleration might help, but landing at such speeds would present a formidable performance assignment for Firestone or Goodyear.

For this reason, much of the discussion now centers about combination dirigibles and aircraft in which enough of the weight of the craft is neutralized to permit operation at significantly lower speeds. On Mars where there is no free oxygen, certainly not in quantity, to support combustion, designers can specify **hydrogen for buoyancy** with four times the lifting capacity of helium, and far more readily available to the technology of the early settlement.

There is a primer discussion of these possibilities in The Case for Mars II proceedings (1985) pp. 489–96 “Dirigible Airships for Martian Surface Exploration” [AAS 84–176].



Thick Delta Wing holds hydrogen gas, and is shaped for speed. M. Clapp

We strongly encourage space advocates who may also be aeronautical engineers to get involved in this preliminary brainstorming, so that all the potential pathways can be explored. At least at first, settlers would need a family of “lightened” aircraft that could operate with a minimum of ground support, as they did on Earth in the pioneer days of aviation during the Oughts, Teens, and Twenties.

Presumably, such aircraft would have rocket engines (the air is too thin for props except for ultralight drones) be fueled by burning methane and oxygen, both supplied in tanks since oxygen can't be extracted from the air in flight at volume rates anywhere nearly sufficient. Such a fuel will require a substantial ground installation to support each refueling site.

This creates a burden. Either we must develop a compact efficient fuel-processing plant that can be produced in quantity on Mars (or at least the more massive, simple, and most tolerance-forgiving of its components) for drop-off-and turn-on deployment at uncrewed sites. Nuclear or solar power could supply the energy needed.

The alternative is to use an aircraft engine that can run on a fuel that the aircraft can produce with a much smaller and lighter weight power plant on board the craft itself.



## **NIMF Nuclear rocket using Indigenous Mars Fuel**

As already reported in MMM # 30 NOV '90 "NIMF" [Available by SASE + 50¢ from MMM Reprints c/o the LRS P.O. Box.] Martin Marietta's Robert Zubrin [a candidate for the NSS Board of Directors] first suggested how a Mars landing craft could refuel itself from the Martian atmosphere with an on board power plant and use that fuel to make exploratory sorties to distant sites on the planet. Second he suggested (with the help of illustrations by Martin Marietta artist Robert Murray) two configurations: a ballistic hopper, and a winged shuttlecraft that looks a lot like its currently flying Earth-LEO ancestors Columbia, Discovery, Atlantis, and Endeavor. This craft would use 4 VTOL (Vertical Take Off & Land) engines to allow Harrier-like landings and ascents to and from Mach 1 flight. This avoids what could otherwise be an extremely heavy burden for the early settlements: grading and paving landing strips. Whatever your reaction to the use of nuclear power plants on Mars, this is the most versatile Mars-global transportation system yet suggested, one which can be put into place at the very outset and used to establish scattered sites, not merely support them once established.

## **Ground Effects Vehicles – the Skimmer**

For many exploration and routine transportation needs it would be far more useful to (also) have a swift means of surface, or near-surface, transportation. The two sites we've visited via our Viking proxies have displayed daunting strewn-fields of variably sized boulders. We don't know how typical this is of Mars but our best guess might be "very". This will make the going rough and slow for wheeled vehicles, though several interesting designs are in circulation and a number of contractor and university built prototypes actually field-tested. Many designers have despaired and turned to walking vehicles instead. Whatever the view from the ivory tower, to the explorer and/or settler on Mars, either choice will provide exasperatingly slow, tedious, and patience-testing travel at best. Without going to all the trouble to grade roadways to places we may not want to visit again any time soon, there has to be another way. Mission planners on Earth may not care, but those of us who would earn our place as spiritual ancestors of the actual settlers to follow, should.

Can a Mars hovercraft be built? Remember the air is very thin and even compressing it somewhat under flexible skirts is not likely to produce enough lift to do the trick – unless, that is, we "lighten" the effective marsweight of the vehicle itself by hydrogen-filled buoyancy tanks. Even so, we are left with some interesting challenges. First, whereas traditionally supported ground vehicles can be "loaded up" with fuel and cargo to the fairly generous limits of its suspension system, a Martian "skimmer" which had say 90% of its weight neutralized by hydrogen tanks or ballonets may not be able to operate effectively if it was heavily fueled, or took on an honest load of cargo. A skimmer which can perform well on near-empty once around the parking lot but not at all under real service conditions would be useless. One approach would be to mate extra buoyancy tanks to each cargo container to be loaded and subsequently unloaded. But that still leaves the problem of how to compensate for fuel weight loss while operating. Of course, valving out some of the hydrogen would compensate – and that may be the only ready answer.

Second, supposing that the weight of craft, fuel, passengers, and cargo is say 90% (or whatever the best figure turns out to) hydrogen-neutralized, can it negotiate the usual size range and spacing of the ubiquitous rocks and boulders?

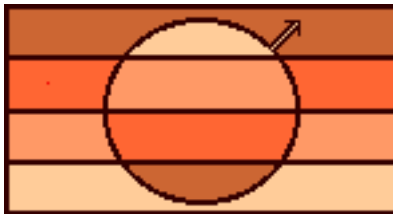
Third, how well can it maneuver? Lightening the weight does not reduce the momentum! Our guess is that all of these challenges can be met, once the sofa cushion approach is abandoned. Designing and debugging a Mars skimmer would be a great competitive task for college engineering classes (and fraternity members who may want a diversionary break from elbow-bending), in a design challenge with a prize, in an event worth rerunning (like the Australian solar-powered car race).

Skimmers could do for Mars what the automobile has done for us – provide cheap on demand mobility. They could be configured as individual/family vehicles, as motor coaches

(Martian Greyhounds), and as Trucks (Lorries, if you will). Aircraft will do a lot to help establish Mars as a multisite world. But only ground vehicles can really make things tick.

Eventually roads will be built – at first within the individual towns and outposts, then serving the immediate vicinity, finally linking distant communities. But for a some time in the early frontier decades, it will help a lot if a simpler infrastructure–light means of transportation can be made to work until the infant Martian economy is well enough along on its agenda of growth and diversification to permit the diversion of substantial resources to road– or rail–building and other infrastructure–heavy transportation modes. If you are a Mars person with technical ability, why not tackle some of the above challenges? **MMM**

**MMM #62 FEBRUARY 1993**



**A Flag concept for a Future Mars Territory**

In the draft design above, the astronomical (and astrological) symbol of Mars (and masculinity), the sphere with upper left arrow, is placed against a color–reversed background with four color bands from a Mars landscape palette: (from light to dark) salmon, peach, burnt orange, and ocher (the arrow in orange–red).

## **Picking Town Sites on Mars: Climate Considerations**

By Peter Kokh

Our first exploration beachhead outpost on Mars is likely to be chosen for purely scientific reasons. What site would be most conveniently central to the areas of Mars that most pique our geological, geochemical, and archeobiological interests? Mission planners at NASA, and their purse–string–holding second–guessers in Washington and other participating capitals are unlikely to give a nanosecond’s consideration to the needs of the follow–up “permanent settlement” which is the quite different fountain of interest for the great majority of avid Mars supporters.

Not that these two separate lists of attractions don’t overlap. They do. Many of the top attractions for prospective Mars geologists (areologists) must also be prominent on any list of must–see tourist attractions. And proximity to certain tourist draws is a strong economic plus for a townsite.

Tourism, however, must be secondary to considerations of economic geography.

- ✓ **Where are the most easily accessible resources** necessary to support earliest possible self–manufacture of the greatest bulk of the settlement’s material needs?
- ✓ **What regions offer easiest early–method access to sources of fresh potable water**, either from permafrost reserves or “by canal” from the polar ice caps or simply from atmospheric extraction?
- ✓ **Where do potential prime settlement sites “cluster”**, if anywhere on the planet, affording the least difficult mutual commerce?

✓ **Are there easily negotiable surface routes to and from an otherwise promising site?**

By our read, these considerations ought to be primary if and when a multi-governmental (or para-governmental?) decision is made to follow up human exploration of Mars with its opening as a settlement frontier. Later on, once a number of townsites are established, two considerations will come into play when it comes to the competition between the early Martian Towns for prospective new settlers.

✓ **Where is the economy booming?**

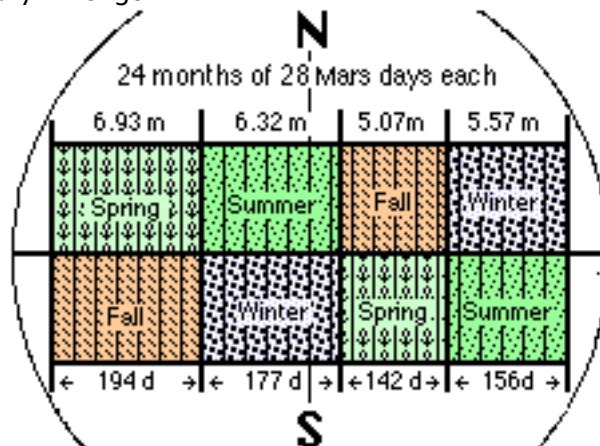
✓ **Where is the local climate least hostile?**

The consideration of climate will become even more important once consensus is reached, either before, or after, the opening of Mars to settlement, on the wisest goals and most attractive means to the “terraforming” or “rejuvenaissance” of the planet. While current climate differences between prospective sites may be moot (you can’t go outside in shirtsleeves and/or without a mask to bask in the sun anywhere) when and if the climate is made to improve some locations might quickly emerge as the “Floridas” and “Hawaiiis” of Mars.

To give us some clues to where these future balmy regions may lie, we need first to consider Mars’ Season Cycle. The Fourth Planet is tilted on its axis by some 23° 59’ relative to the plane of its orbit around the Sun, amazingly similar to Earth’s own 23° 27’. Consequently its “temperate” zones have marked seasons, a succession of Winter, Spring, Summer, Fall etc., just as ours do. However the range of temperatures more closely follows that on our own Antarctic Continent, that is, from well under a hundred below Fahrenheit during midwinter nights to a few midsummer early afternoon very localized flirtations with the thaw point.

So just hug the equator, you suggest? Its not as simple as that. While Earth’s orbit is mildly eccentric, taking us in as close as 91.4 million miles to the Sun in early January (“perihelion”) and out as far as 94.6 million miles from the Sun in early July (“aphelion”), a difference of only 2.8%, Mars’ orbit is much more elliptical so that it ranges from 128.5 to 155 million miles out, a difference of near 21%.

Further, neither Mars’ winter or summer solstices, nor its vernal (spring) or autumnal equinoxes line up neatly with its perihelion or aphelion dates. The consequence is that the four seasons differ dramatically in length.



**MARS’ UNEVEN SEASONS:** Mars’ orbit is very eccentric, swinging out further from the Sun (traveling slower) during Northern Spring & Summer (Southern Fall & Winter) and in closer to the Sun (traveling faster) in Northern Fall and Winter (Southern Spring and Summer). The results are a TRADEOFF.

- ✓ There’s more time (13.25 months) to enjoy a cooler Spring and Summer north of the equator, but less time to suffer through a less cold Fall and Winter.
- ✓ There’s less time (10.64 m) to enjoy a warmer Spring and Summer in the southern hemisphere, but more time to suffer through a harsher Fall and Winter.

How would these curious facts affect local climates, and future climatic potential, of various potential settlement sites? While the terrain may be both more interesting and easier to negotiate from the Martian equator northwards, the warmest midsummer days are likely to occur at low elevation sites (well below Martian “sea level”) from the Equator southwards to middle southern latitudes.

Post-Mariner or post-Viking maps of Mars show a large deep impact basin named Hellas Planitia stretching from 29° S to 58° S and from 273° to 312° longitude. Its ramparts lie a couple of kilometers above mean Martian altitude, but the northwest central part of the basin lies as much as 4 kilometers below that mean level. Here, about 38° S lies Mars’ equivalent of our “Death Valley”. And here, as the atmosphere thickens via human intervention, will it first become possible to bask in the sun outdoors on midsummer afternoons. Hellas is Greek for Greece. The former sea basin could live up to its name and host the first “flowering” of “Martian” civilization.

By sheer coincidence, Edgar Rice Burroughs placed his “capital of Barsoom”, Greater Helium, in the area of the Hellas basin. <MMM>



## “Fast Track” to “Federal” Autonomy

By Peter Kokh

### **There is no point beginning settlement if we are not prepared to go all the way. The “Umbilical” Paradigm Won’t Work**

Mars ranges 150 to a thousand times as far away from Earth as does the Moon. Launch windows to the Red Planet open every 25 months, rather than daily as with the Moon. Replacements and resupplies must be planned well ahead and generously cached on the frontier itself, not in some near-Earth warehouse. In effect, “umbilical cords” connecting the Martian frontier with the home world will not work since they cannot be in continuous service. Instead, a “yolk sack” system of strategic reserve supplies and anticipated next-step development needs to “nurse” the settlements through the long periods of interrupted access will be the approach that works.

As for rescue and relief, much as in that cinema cliff hanger standby, the suddenly pilotless airplane, “talk through” assistance will be all that Earth, or the equally remote Moon, can routinely offer. Not only day to day decisions, but week to week and month to month ones will have to be made locally without the hollow threat of any veto power from 9 to 34 enforcement-months away.

The upshot is that the demand for effective levels of local settlement autonomy will present itself at a much earlier stage on Mars than on the Moon. This will not be merely about exercising political will. It will be a logical consequence of the remoteness of the frontier. Any sane Earth authority involved in the Opening of Mars will grant such autonomy even before the settlers on the scene are ready to petition for it, much like a mother bird insistently pushes its hesitant fledglings out of the nest. The history of the Mars Colony should not follow closely the precedents of previous waves of Earth-bound colonization.

### **Prerequisites for Autonomy**

For the Moon, where logistics allows the “umbilical” approach, it may be possible to simply draw up a list of prerequisites for phase by phase realization of increasing degrees of home rule leading to eventual full sovereignty. These levels may or may not be reached. For Mars, in contrast, it will behoove the authorities on Earth both to relax any “requirements schedule” and work single-mindedly to see that it is met in full as soon as possible.

A plurality of towns offering some measure of economic diversity with interdependence as well as effective occupation of an appreciable sector of the planet with the real opportunity to expand both presence and self-reliance through the combined capacity of the settlements to self-manufacture the bulk

of their physical needs should be Aim One. Achieved goals that will enhance settler prospects for a thriving if small “planetization”, such as the establishment of a full University, running up a multiyear trade surplus (or yolk–endowment handicap), meeting set population size milestones, successful rearing of a healthy second native–born generation, etc. might be relaxed or waived. Rather, once the infant colony is moving securely on the right track on all fronts, achievement of desired phases can be anticipated and political autonomy granted. This is a real gamble, but it is a gamble that must be taken.

### **Early Federalism**

One settlement a “World” does not make! We have already mentioned the need to have our eggs in several baskets and the need for cultivating the roots of a diversifying interdependent economy. Even if the Mars Republic begins with only one functioning local state or province, it will do well to have a federal structure in place. This will help curb later interregional territorial disputes, establish a federally administrated regime for yet–to–be–settled areas outside functioning regional economies, and set up patterns by which new areas of the planet can be opened by those seeking to start out fresh, not under the thumb of existing states or provinces.

Isolation of individual towns, even clusters of towns, could be significant. A federal pattern will encourage variety in social, institutional, cultural, infrastructure, and construction lingo. At the same time state or provincial sovereignty will be limited from the outset and the terrestrial pattern of warring jealously “independent” nation states avoided.

Federal structure will need a regime of federal lands: planetary scenic and geological parks, especially strategic mineral and resource reserves (the ice caps, at least) some of which must be transferred to local state or provincial authority upon the setting up of same, others which would remain federal preserves. The federal government would control off–planet trade, at least, and have title to the moonlets Phobos and Deimos.

To avoid sure conflicts, establishment of state or provincial boundaries ought to follow preset guidelines. One, looking forward to a future epoch of terraforming or of the “rejuvenaissance” of Mars, might be the following of clear–cut “divide” lines between potential drainage watersheds. This would establish logical commonalities of future ecological responsibility. [How different the political map of Earth would be, if on all continents, frontiers were those of great river basins. There would be countries large and small as now, but they’d look quite different from the arbitrarily drawn nation–states we have today.]

Mars should be opened with a chartered Mars Settlement Company already in place. Prospective settlers could buy shares in the Company beforehand, giving them voting rights. A constitution and federal framework covering most of the anticipated pitfall efforts could be agreed upon by all shareholders before the first band of settlers leaves Earth. The alternative is to trust that through on–the–spot conflict resolution, sensible arrangements will spontaneously spring up, with no loss of life, derailment of effort, or resistant residue of ill feeling sure to cause trouble for generations to come. Other things that can be agreed upon by the Company beforehand are official language, frontier legal code, etc.

There is no point beginning settlement if we are not prepared to go all the way. And thus a sensible, well–considered and deliberately pursued plan is the way to go. **MMM**



## **CANALS on Mars: from Self–Deception to Reality**

By Peter Kokh

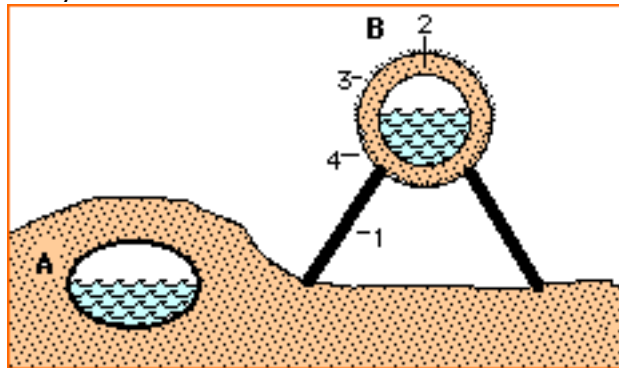
The “canali” or ‘channels’ ‘discovered’ on Mars during the opposition of 1877, by the Italian astronomer Schiaparelli, and subsequently embraced and promoted as sapient–made watercourse canals by Percival Lowell, were never more than wishful thinking grounded in optical illusion. Supporting evidence of “seasonal” color changes (darkening and thickening “irrigated vegetation” strips between the polar caps and the equator were shown by Carl Sagan to be seasonal redepositions of darker and lighter dust or sand by the prevailing trade winds. The Mariner and Viking probes showed the canals themselves did not exist and that climactic conditions on Mars have been too extreme to allow liquid surface water for a billion years or

more. Further, surface-drenching solar ultraviolet made the vegetation allegedly hugging the canal routes quite impossible.

At the same time a taunting picture emerged of a once water-rich Mars with an ocean, some small seas, great rivers, islands and shorelines. Some of this once generous endowment must remain: in the polar caps, in permafrost, and in possible subterranean reserves. If the canals never existed, the rationale of transporting water equatorwards from the polar caps, now known to be mostly water ice, remains intact: a tempting goal for a future human Martian Army Corps of Engineers.

Actual and proposed terrestrial models exist. Water has been rechanneled on Earth by canal and aqueduct for many millennia. And there have been grandiose schemes to do even more on unprecedented scales: Wally Hickel's fresh water pipeline from Alaska to California; proposals to divert Great Lakes water to the arid Southwest; abandoned Soviet schemes to reverse the flow of 3 great Siberian rivers (Ob-Irtysh, Lena, Yenisei) currently emptying into the Arctic Ocean (a scheme sure to trigger a real ice age by increasing the ocean's salinity).

Any logical canal route on Mars would have to follow land contours – valley routes with pump portages over frequent sills in Mars' immature drainage topography. We do not yet possess an adequate topographical map of the planet with accurate elevations. Hopefully, Mars Observer will improve our knowledge here to the point where some candidate routes can be sketched out, for later survey confirmation.



**ALTERNATE THERMAL STRATEGIES:** In (A), the sealed canal aqueduct is placed in a trench and covered over with shielding soil. But this will only tend to keep it as warm as the surrounding permafrozen soil. In (B), as with the Alaska oil pipeline, the aqueduct is raised over the permafrost from which it is thermally insulated by special nonconductive stilts (1). It is then jacketed by some sort of eutectic thermal mass (2) with its upper surface (3) coated IR-black to passively soak up what little solar heat is available, and its lower surface (4) silvered inward to help retain heat and prevent its radiation toward the cold ground. Here the goal is to use passive solar to keep the jacketing thermal mass just over the freezing point.

While we might romantically choose to call them canals in deference to the shattered dreams of yore, the proposed aqueducts will almost certainly be enclosed to help meet the daunting thermal challenge of keeping the water liquid. It must flow over very long stretches throughout which Antarctic-like temperatures prevail.

The thermal mass could be some ceramic or concrete solid. It could also be some eutectic compound, if a suitable one can be processed from Martian soils, that stores surplus daytime heat by changing phase from solid to liquid, resolidifying as it surrenders that heat when needed at night.

The atmospheric pressurization within the enclosed pipeline could use the available CO<sub>2</sub> ambient atmosphere as is, or with additive gasses that help retain heat. The inner surface of the pipe could be coated to be ice-repelling. The freezing point of the water in transit could be lowered by antifreeze additives if some can be formulated for local manufacture that can be easily removed at outflow points to render the water potable again. Could percussion sound waves or microwaves help keep sub-freezing-point water liquid? All the options must be

investigated to zero in on those that are workable under Martian conditions, and for which the raw materials needed are locally available, and the components locally producible: Made on Mars.



**CANAL ROUTING ON MARS:** A number of feeds (2) from the edges of the North Polar Ice Cap (1) could feed into a main pumping station (3). From there, an arterial canal (4) would follow logical land contours on its route southward feeding into a number of midcourse delta diversion areas (5), and crossing passes and divides via pumping stations (6) to a final delta dispersal area (7) in the equatorial regions (8).

Considering that Mars' celestial north pole lies in the constellation Cygnus, the Swan, a few degrees from Deneb, the principal pumping station near the polar cap edge might be colorfully named "Swan Lake". Here the water ballet begins.

Manufacturing plants (Schiaparelli Manufacturing and Construction Company?) to produce the components needed (pipeline sections of varying diameters and couplings, thermal jacketing material, IR-black coatings, 'silvering,' stilts, pump station machinery, etc.) might be best located at some midpoint along the route (5). Settlements would preferentially cluster at (3), (5), (6), and (7). Permafrost water extraction along the arterial (4) could serve as a supplement to usage at midcourse diversion areas (5) with surplus fed into the canal for use 'downstream' (i.e. a cogeneration scheme).

Will more than one such canal be built? That depends on the number of feasible routes and the number of economically attractive townsites each would serve.

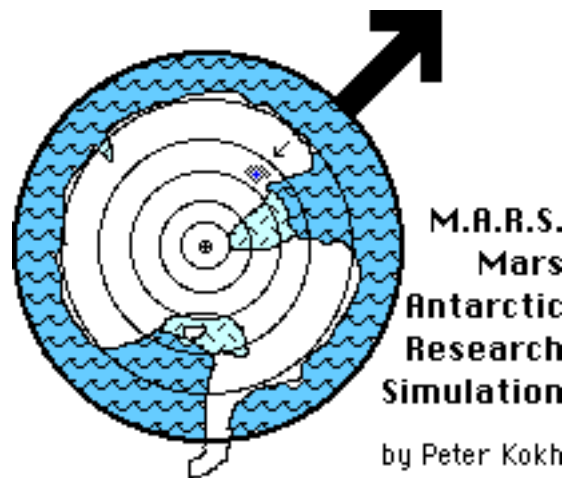
Prosaic names could be chosen: the Trans-Utopia Canal, the Chryse-Marineris Canal, etc. There are many who would prefer a fresh start that makes no allusion to the tainted past of runaway Mars speculations. But why not dip into the available pool of names from Lowellian canal mythology? Unfounded early public daydreaming aside, Mars will need all the 'romance' we can give it. <MMM>

**Some Lowellian Martian Canal Names:**

Indus, Oxus, Euphrates [also on Earth], Nilosyrtis, Chryse, Phison, Hiddekel, Gehon, Candor, Antæus, Deuteronilus, etc.

**Some Lowellian Names for Canal-linked "Oases":**

Lacus Solis, Phoenicis Lacus, Nuba Lacus, Lunae Lacus, Charontis, Læstygon, Zea Lacus), Ismenius Lacus, etc.



### MARS ANTARCTIC RESEARCH SIMULATION

The comparison of Antarctica and Mars has long been made. The icebound continent is as close to “another world”, one other than our everyday experience, and well off the tracks of common tourist travel, that most humans can ever hope to visit. Beyond its isolation and “difference” are the further similarities of very similar temperature ranges, abundant frozen water, constant winds, and breathtaking trackless scenery.

Beyond that the comparison gets stretched. Antarctic shores are washed by a cold nutrient-rich ocean dense with life. Its shores team with penguins, skuas and seals and occasional other wildlife visitors. Above all, the cold brisk ever-blowing air above the ice is thick, sweet, and breathable.

While there are water-ice sheets on Mars as well – at both poles (the belief that they are composed mostly of carbon dioxide snows and frosts has been long disproved), most of the planet’s surface is bone dry, presumably with large expanses of subsurface permafrost of unknown thickness, moisture content, and salinity. Yet here too Antarctica offers a strikingly Mars-similar area in the “Dry Valleys” of the TransAntarctic Mountains west of McMurdo Sound, site of the largest human community (if you can call an ever changing collection of single adults a community) in this Southern World.

The Dry Valleys exist because, amidst all this ice, Antarctica, in terms of annual precipitation, is the driest place on Earth. Precipitation has to come from occasional incursions of winds off the ocean, but here the prevailing winds blow everywhere northward from the downdrafts at the pole. In the Dry Valleys there is seldom any precipitation, the march of the ice sheet and glaciers are blocked by mountain ramparts, and the eternal winds are extremely desiccating, enough so to quickly and enduringly mummify any seals, penguins, or skuas unfortunate to wander into the foodless area and die.

Taylor Valley, 2–3 miles wide and 20 miles long is the most accessible, as it reaches down to the Sound. About forty miles inland to the east is 3x6 mile Beacon Valley. To the north of Taylor but approaching no closer than 15 miles to the Sound lies the largest ice free expanse: Wright Valley, connected by dry Bull Pass to 10x18 mi. Victoria Valley. Taylor, Wright, and Victoria all have small frozen lakes and ponds (something the thin air pressure on Mars won’t allow).

In these areas – inside surface rocks! and on the beds of the permanently ice covered lakes – lie the most extreme surface or near-surface environments for living creatures on Earth, and amazingly life, be it only microbial, has established a stable if shallow and lethargic foothold. Some Mars-Life enthusiasts have been cheered by this and cling to the belief that we might find similar pockets of microbial life on Mars. But that requires a leap of faith, for just because life has encroached there from neighboring areas teeming with it, offers no comfort to those who would think that life could therefore originate in such areas. Nonetheless, the Dry Valleys are a unique natural laboratory in which we can both experiment with techniques to



search for life hiding and holding out on Mars, and at the same time gradually develop “Mars-hardy” plants and other creatures from terrestrial stock by a combination of breeding and genetic engineering.

Beyond this immensely useful biological work, some of it no doubt leading to the enrichment of life on Antarctica itself, lie other areas of endeavor by which we can prepare ourselves for the opening of Mars. “Little Mars,” if established here, would be the most Mars-similar area on Earth in which to experiment with Mars-appropriate exploration, construction resource-extraction, processing, and manufacturing methods and technologies, allowing us to test concepts for shielding and thermal management as well as debug vehicles that can handle the dry cold. Plans for single habitat outposts as well as more ambitious base-town complexes can be tested.

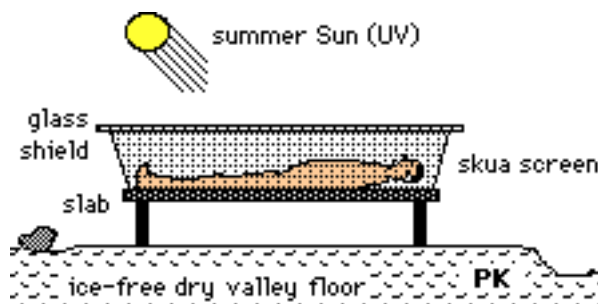
At “Little Mars”, we could test out the “yolk” caché system as a logistics substitution for the “umbilical” support system. Actually we have a head start on this for we currently build up stockpiles of needed provisions and replacement parts in order to allow our various Antarctic bases to get through the winter when the near daily inbound flights from New Zealand and elsewhere are cut off for several long months.

The concept of a “Mars Spring Training Camp” on Antarctica is already beyond the talking stages with strong support from the Planetary Society and the biannual Case for Mars Conference people as well as real, if budget-hamstrung, interest from NASA and the National Science Foundation, the agency running the U.S. Antarctic Program. NSF interest is in improved waste processing and energy production technologies as well as telescience capabilities that may help reduce the number of people needed to run scientific experiments. A pilot program with a teleoperated cable-tethered rover probing the bottom of Lake Hoare was set for October-December 1992.

While the concept of commercial enterprise involvement continues to receive no more than the most hypocritical of lip service from NASA – giving the lie to their occasional noises about the desirability of following up initial human Mars exploration with real, committed “for keeps” settlement, “Little Mars” could also serve as an “incubator” for future Martian enterprises. If processing and manufacturing experiments are made, some trial products could be in the form of salable arts and crafts. This would help illustrate the concept of Martian settlers providing for their own needs and developing a uniquely Martian consumer culture of their own. In the process it would help deepen and widen spotty public (and commercial!) support for opening Mars. In time perhaps an appreciable part of the continuing operating costs of “Little Mars” could be defrayed in this manner, and this would help to make the base less vulnerable to fickle ever-shifting budgetary whims.

The “Little Mars” concept is worth serious support. While much equipment destined for a Mars effort might better be tested on the Moon, some of it will find a more adequate – and much cheaper – testbed in a test site in one of Antarctica’s handy Dry Valleys.

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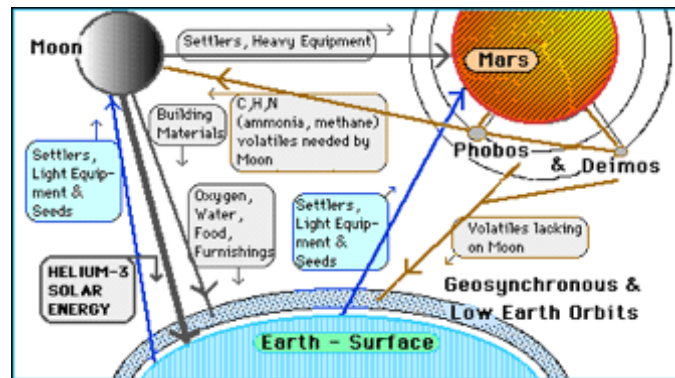


ETERNAL REST IN ANTARCTICA?:

One unusual idea for a cost-defraying enterprise that could be run out of a Little Mars base in one of the **Antarctic Dry Valleys** (perhaps accessible Taylor) is a “Desiccatorium,” a place where people could be laid to rest in the open dry frigid air facing the brilliant winter starscapes above, as their bodies were allowed to naturally mummify.

Faces and other exposed skin would need to be sun-shielded by UV-opaque glass lest the flesh blacken from UV exposure. Screening to ward off scavenger skua birds would have to cover all exposures to the open air.

If people are willing in enough numbers to have their cremated remains placed in an orbital mausoleum-satellite, they would go for this too.



## Inner Solar System Trade Routes

By Peter Kokh

The above schematic “map” is one plausible scenario showing the development of trade traffic between Earth, Earth orbit (LEO, Geosynchronous, L4 & L5), the Moon, and Mars and its moons during the early decades after the opening of the space frontier.

Asteroids are not explicitly included in this schema. Asteroidal resources stand to cut into raw materials sales from the Moon, but may hurt sales of volatiles from Phobos and Deimos even more, leaving “Greater Mars” with that much less purchasing power.

The scenario begins with the investment of settlers, capital equipment to process lunar materials and fabricate needed items for local use and export, and seeds. The payback is in building materials, oxygen, water (lunar oxygen probably with terrestrial or PhD hydrogen), and food which can be shipped to LEO and other space outposts more cheaply from the Moon than from Earth because of its high lunar oxygen content. Helium-3 is a potential export of great importance if fusion power is realized.

Lunar raw materials are used in space construction for LEO facilities (space stations, orbital factories to make micro-G products for Earthside markets, and orbiting tourist resorts) and for construction of Solar Power Satellites and the space habitats needed for their construction crews.

The Moon is seriously deficient in hydrogen, carbon, and nitrogen. These elements can be imported to the Moon and to space construction sites more cheaply from Phobos and Deimos than from the deep gravity well of nearby Earth.

If Phobos and Deimos (“PhD”) are relied on rather than Earth-approaching asteroids for this supply, and if PhD is regarded as an integral part of the Mars economic area, then any profits realized at PhD from this volatile trade can be used to help finance activities on the Martian surface, paying the way for settlers and needed equipment. Lighter capital equipment might come from Earth, heavier items, once they are available “made on Luna”, are more cheaply shipped from the Moon.

Every part of this scenario is a current plausibility, given what we now know about the Moon, Mars, Phobos, and Deimos. At the same time, every part of this scenario needs work. We are a long way from listing, let alone designing, the most efficient, lightweight, yet capable

complex of capital equipment needed on the Moon to make the best, quickest use of local resources with the least human labor. We only have general ideas how to process lunar materials and what we can make from them. We have yet to plan the best paths of diversification of lunar industry.

We do not know what sort of factories using lunar raw materials can make what sort of marketable micro-G products for Earthside consumption. We have not yet identified the best means either for capturing solar power with cells made of lunar materials or for beaming it down to Earth's surface. Our ideas on how to build things in space like SPS or settlements are sketchy and vague and full of pitfalls.

Nor do we know how we will process PhD materials. Most space supporters think it is NASA's job to put all these pieces of the puzzle together. But guess what? In short, we must collectively get off our butts.

PK

## ICE $\leftrightarrow$ WATER CYCLE ENGINES Possible engines for Mars Rovers?

By Francis Graham, Editor of Selenology  
(Quarterly of the American Lunar Society)

The nature of Mars differs markedly from Earth in its having no free oxygen in its atmosphere and shade temperatures which are extremely low. As we begin to explore Mars, it is natural that we should select those electromechanical components with which we are familiar on Earth and which can be adapted for Mars. However, in developing space economies, it would not be unusual to develop mechanisms that would be poorly functional on Earth (if at all) but could well be functional on the planet Mars or elsewhere, where the nonterrestrial conditions can be best used. Reflecting on this possibility, one is led to a variety of Mars-specific categories. One such category is heat engines designed for Mars.

### The Ice-Water Cycle Engine

In attempting to choose a design for a heat engine for Mars, the conditions of electrical power from the sun and low temperatures ( $-75^{\circ}\text{C}$ ,  $-103^{\circ}\text{F}$ ) were the major ambient factors. The lack of oxygen made internal combustion engines impossible [unless the oxygen is provided from an onboard tank]. A steam engine is possible, with a large solar concentrator providing the heat. But on Mars, it is possible to go over to the other phase transition, water $\leftrightarrow$ ice, with a weight saving over steam pressure fittings and only a small loss of efficiency. A heat engine cycle across the liquidus $\leftrightarrow$ solidus line using H<sub>2</sub>O as a working fluid, i.e., an Ice-Water Cycle Engine, offers advantages.

The Ice-Water Cycle Engine is a cylinder filled with water and a piston. When the water freezes, it expands, and work is done against the piston. The solid is then returned to the liquid phase by joule resistance heating. Energy is thus transferred from the solar panels to the atmosphere through a phase transition which also produces work. The greatest advantage is the large force on a piston of modest area; the slope of the equilibrium curve is so sharp ( $dP/dT = -130\text{ atm/K}$ ) that enormous forces can be generated by the expanding ice. The limit is reached when higher phases of ice with a specific gravity greater than 1 are produced. Operating between  $-17^{\circ}\text{C}$  and  $0^{\circ}\text{C}$  [ $1.4^{\circ}$  to  $32^{\circ}\text{F}$ ], 2100 atmospheres ( $2.1 \times 10^8\text{ pa}$ ) can be generated on the piston. This makes the ice-water cycle engine ideal for situations on Mars where crushing, pulverizing and heavy lifting are desired. It also has a weight saving over electro-inductive/hydraulic systems, especially valuable on automated Mars rovers which must be lifted up from Earth.

A small operating ice-water cycle engine was constructed and tested at the Allegheny OIC1 technical school in McKeesport, PA during the winters of 1978-79. Piston return was

facilitated by a simple oblique spring after melting was performed by an external coil connected to an automobile battery. Cycle times were about 90 minutes<sup>2</sup> depending on the external temperature and the battery was drained rather rapidly. These test were not rigorously scientific but were simply designed to see if the concept worked at all.<sup>3</sup>

#### Calculation of Engine Efficiency:

heat into the engine is  $-79.9 \text{ cal/g} = 333.1 \text{ J/g}$ . The work function is generally

$$W = \int_{V(P,T)} P dV(P,T)$$

Considering the upper pressure limit of 2100 atm ( $2.1 \times 10^8 \text{ Pa}$ ) and the volume change of  $\Delta V = 0.093 \text{ cc/g} = 9.3 \times 10^{-8} \text{ m}^3/\text{g}$

Then

$$\int P dV = P \Delta V = 19.53 \text{ joules/g}$$

For which the thermal efficiency is

$$\eta = \frac{W_{\text{out}}}{Q_{\text{in}}} = \frac{19.53}{333.1} = 5.8\%$$

$$Q_{\text{in}} = 333.1 \text{ J/g}$$

This is comparable to the actual efficiency of a steam engine. Due to thermal gradients, the actual efficiency of an operating ice-water cycle engine will be somewhat lower. Additional controlled experiments are required.

In conclusion, solid/liquid phase heat engines may well become part of a menu of technology useful to applications in space economies. Undoubtedly, many other possibilities on that menu specific to extraterrestrial conditions remain to be discovered. <FG>

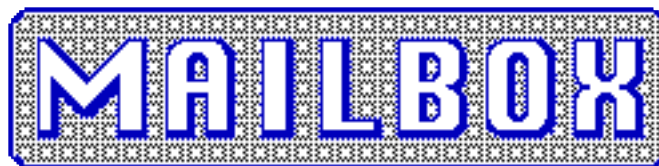
#### Footnotes:

- 1 Opportunities Industrialization Center.
- 2 In a phone conversation 1/15/93, Graham suggested that this long cycle time could be brought down at least to a few minutes by using an internal heat source, perhaps a laser, in combination with a very heat conductive outer cylinder. The idea of his experiment was just to see if it worked at all, not to optimize the engineering.
- 3 A rather thorough patent search showed no prior work on this type of device. Graham welcomes hearing from anyone else who has thought or tinkered along similar lines. Write him c/o MMM.
- 4 Graham also reports on solid-liquid Bismuth engines suitable for use on Mercury. MMM will publish that article separately.

**Acknowledgements:** The author wished to thank Dale Amon, Hans Moravec, and Norman Wackenhut for fruitful discussions, and the Allegheny OIC for many kindnesses.

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- (1) Kennedy, G.C. and LaMori, F., in Gray, D.E., ed., **American Institute of Physics Handbook**, McGraw-Hill, NY: 1963
- (2) Loebel, R. in Weast, R.C. **Handbook of Physics and Chemistry**, CRC, Boca Raton: 1980, p. B-253.



Letters to [kokhmmm@aol.com](mailto:kokhmmm@aol.com)



**Growing the Economic Case for Mars**

Your editorial in the February issue of MMM was very challenging. But in the very next issue [March # 63] you gave clues to what just could be a major part of an answer.

Earth is so much more “industrially fertile” a world than the Moon because billions of years of very active water-involved geological processing have concentrated many of the trace elements modern technology has grown dependent upon into ore and mineral veins from which these elements can be extracted rather “economically”.

Mars represents an in-between case. Full-blown plate tectonics never developed, witness the magma-hot-spot-stuck shield volcanoes, probably because the once abundant surface water reservoirs disappeared too fast or were too localized (in the northern hemisphere). Yet it is quite evident that considerable rifting has occurred.

At this stage we cannot be confident that any of the element-leaching ore-body-building processes that occurred on Earth also occurred on Mars. But if such processes did operate, even for a short time, there just may be a few scattered lodes of sundry ores of real economic value.

Not only would this be a boon to any future settlers on Mars for their own purposes, it might give them an additional cost-competitive export to the Moon, which is deficient in copper, lead, zinc, tin, gold, silver, platinum, mercury, chlorine, fluorine and the other halogens, germanium, gallium, arsenic, tungsten and other hard-to-do-without elements needed in small amounts. If such treasures could be launched cheaply in processed or crude ore form to Mars orbit, say by a launchtrack up the west slope of mighty Pavonis Mons [MMM # 18 SEP. '88] and then transshipped to the Moon at a cost break over shipments out of Earth's much deeper gravity well, future Martians may find a better way to integrate themselves more thoroughly into a Moon-anchored economy supplying Earth with space-based energy.

Until we can do a thorough orbital chemical mapping of Mars and back this up with ground truth prospecting of promising sites, we can do no more than hope that such geologically-provided mineral concentrations exist. I would prioritize the search in two areas: (1) the craters and slopes and lavatubes of the great shield volcano massifs where any crustal material further processed in the magma might be found and (2) the walls of the crisscrossing canyons of the chaotic labyrinth terrain at the head of the Valles Marineris rift-canyon. These walls might be the best place to see whatever treats lie in the exposed strata

Thomas Heidel,                      Milwaukee, WI



### **Developing “Mars-hardy” Plants**

More than once you have mentioned the possibility of breeding plant varieties that could survive out in the open on Mars – once the carbon dioxide atmosphere had been thickened somewhat by incipient terraforming activity and temperatures rise seasonally high enough to allow liquid surface waters.

Some research has been done to support the belief that the physiological needs of plants in near-vacuum conditions are less rigorous than those of humans. Some cultivated plants have been known to thrive in vacuum jars with atmospheres as low as 30 Mb [3% Earth normal (1 bar), whereas Mars' atmospheric pressure varies seasonally from 7–10 millibars, 0.7–1.0% Earth normal].

Also the ease with which many plants adapt to higher UV levels at high altitudes suggests that they may be further adaptable. And some succulents and cacti can withstand higher radiation levels than exist in any natural environment on Earth. So the development of radiation-resistant crop strains should at least be possible.

The environment on Mars, even at enhanced pressure levels, will remain highly desiccating and “space-exposed” both to UV and cosmic radiation. This suggests that high altitude succulents, if there are any, may be a good place to start in any attempt to breed “Mars-hardy” vegetation.

Michael Thomas, Seattle, WA



## Lowell's Canals; Ice-Water Cycle Engines

A list of Lowell's canals from Acalandrus to Xanthus (there are 183 of them!) along with a map can be found on pp. 145-6 of Lowell, P., Mars (Longman, Green & Co., London 1896).

Many thanks for publishing my article on Ice-Water Cycle Engines. I don't personally have the resources to engineer prototype space liquid/solid cycle engines or experimental methane-hydrogen sucking jets which carry oxygen. Yet I have felt these ideas should be at least described.

Please let me know if there are any nibbles - supportive or critical on either of these ideas. If an idea has a flaw, I sure want to know that too. Perhaps one of the nibbles will lead to an opportunity to continue this line of research.

Francis Graham, East Pittsburgh, PA

MMM #73 MARCH 1994



## Urbs Pavonis: The Peacock Metroplex The Site for Mars' Main Settlement

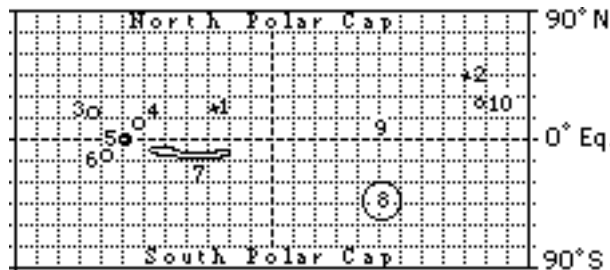
By Peter Kokh with Bryce Walden

### Pavonis Mons' Economic Importance as a Launch Site

In MMM #18 SEP '88 pp. 6-7 "PAVONIS MONS: Very possibly the most strategic mountain in the Solar System" [republished in MMM Classic #2.] We (Kokh) made the point that the combination of Pavonis' great height and its position astride Mars' equator destined it to play a major continuing role in the development of any Human Martian frontier.

First its west slope could host a launch track, one far better advantaged than any up remotely similar candidate mountains on Earth: Mt. Cayambe in Ecuador, Mt. Cameroon and Mt. Kenya in Africa, Mt. Kinabalu in NE Borneo. The gentle slope of Pavonis reaches at least three times higher than any of these. Nor are there the torrential west slope rains that plague all the Earth sites mentioned.

Add in the lower gravity that must be overcome, with an escape velocity 38% that of Earth's, and the West Pavonis Launch Track (WPLT) promises to be the export workhorse of the Martian economy. Since once such a launch track is installed, it will make no sense to export from Mars from any other site, Pavonis is likely to be central to a major part of the Martian pioneer settlement population.



A Mercator Projection of MARS with grid lines 15° apart. KEY: 1-2 the two Viking landing sites; 3 Olympus Mons; 4-5-6 the 3 great Tharsis Ridge shield volcanoes: 4 Ascaeus, 5 Pavonis, 6 Arsia; 7 the Valles Marineris; 8 Hellas basin; 8 Syrtis Major plain; 10 Elysium Mons

While thanks to its tenuous atmosphere which permits aerobraking, it actually requires less fuel to soft land the same payload on Mars as it does on the Moon, Mars is behind the economic eight ball when it comes to exports with which to pay for imports. Volatiles (methane and ammonia, containing precious hydrogen, carbon, and nitrogen; other HCN feed-stocks) shipped to the Moon, LEO, and Space Settlements from its moonlets Phobos and Deimos are Mars' one real salable asset. Any manufactures made in the Martian Settlements themselves and intended for export, will either have to be something of very unique value made nowhere else, or find a way to compete on price via dirt cheap launch, i.e. up the "Pavotrak".

(Someday, if Deimos can be "nudged" just 1900 miles closer to Mars into a synchronous orbit above Pavonis, and if Phobos' orbit can be moved out just 271 miles to cycle three times a Mars day exactly, and given just a little inclination with non-precessing nodes (much the bigger trick), then a Pavonis-Deimos Elevator could be built spanning a distance only 4/9ths as great, against a gravity load only 3/8ths as great as a similar elevator on Earth, thus requiring much less exotic materials.)

### **Pavonis Mons as a Major Settlement Site**

What we say here holds true of the other great shield volcanoes on Mars: Olympus, Ascraeus, Arsia, Elysium, etc. But Pavonis' equatorial advantage gives it an enormous edge.

In the previous MMM article cited above, we had also pointed out that the basaltic Pavonian slopes would allow us to build shelter with materials and methods with which we would already be familiar from our lunar experience. It is right here, on the topic of settlement construction, that we want to look at Pavonis again, and speculate about the "annexation" of this site into the Human-Gaian Diasporal reach.

Enter into play another trump card. Shield volcanoes, like Earth's largest, the Hawaii Big Island Mauna Loa - Mauna Kea complex, are built up of layer upon layer of relatively "runny" (melted tar-like) broad sheets of extremely fluid lava of low silica and gas content and very high temperature (1100°C = 2000°F). This is what gives shield volcanoes their gentle slopes in the 3-5° range (as opposed to the more photogenic classical cone shaped volcanoes like Fuji). Part of the process by which these layers are laid down results in the formation of numerous lavatube conduits. The Big Island is "laced" with them, with 482 now listed and more being formed in each eruption. In the continental U.S. the Medicine Lake Volcano in northern California is another well-studied example.

Ronald Greeley, in his paper "Lava Tubes in the Solar System" (in G. Thomas Rea, Ed., 6th International Symposium on Vulcanospeleology, National Speleological Society, 1992) proposes lavatubes on Mars. In high-resolution images from the Viking Orbiter spacecraft, open channels and roofed channel segments are clearly visible as radial patterns around the summit caldera of Hecates Tholus, a shield volcano more than 200 km across, for example.

"Many of the lava flows that built both the shield volcanoes and the plains [of the Tharsis Ridge] were emplaced through lavatubes and channels. Some volcanoes such as Alba Patera, are enormous structures covering thousands of square kilometers and are composed of individual lava flows fed through extensive tube and channel systems" (p. 226). Greeley does not single out Pavonis Mons. He also says While lunar basalt is enriched in titanium, some Mars basalts may be komatiitic flows, "magnesium-rich."

To judge by the cross-section of lunar sinuous rilles which are collapsed lava tubes, lunar tubes are very much larger than those we have found on Earth, perhaps 50-100 times as high and wide and long. This may be due in part to chemical differences in the lava but probably has more to do with both the great volumes and depths of the sheets and with the much lower 1/6th gravity. We might expect Martian lava-tubes (gravity 3/8ths Earth standard) to be of intermediate size. Caverns tens of kilometers long and tens of meters wide would be very handy ready-shielded volumes indeed within which to place residential, commercial, industrial and agricultural areas of a major settlement complex.

Unless and until proven differently by a ground expedition, the expectation should be that Pavonis is honeycombed with many thousands of miles of lavatubes. In addition, we can

conjecture about the chemical composition of the host terrain on much more solid grounds than we can about other sites on Mars. Therefore we can also plan now, a suite of building materials industries based on local resources.

[I had put the question to my friends Bryce Walden and Cheryl York of Oregon L5 (members of the National Speleological Society, the other NSS, and the principals behind the Oregon Moonbase effort in a natural lavatube, outside Bend, of which they gave me a royal tour in July of '92.) "What percentage of the volume of a typical shield volcano is void, i.e. lavatube? That is, how large a ready laid out metroplex area might we find within Pavonis?"

Bryce sent back by email a veritable treatise on the subject, carrying his calculations, based on the Medicine Lake example, through some 58 equation steps! All the other sources cited in this article are contributed directly or indirectly by Bryce.]

### **The Argument from Medicine Lake (Bryce Walden)**

Rogers and Rice, in "Geology and Mineralogy of Lava Tube Caves At Medicine Lake Volcano, California, give "over 300 caves" ranging from "short grottos under ten meters long to braided systems nearly ten kilometers long. Passage sizes range from 0.25-meter high crawlways a meter wide to 'dirigible passages' up to 25 meters in diameter." According to the authors, these caves represent 18% of the total lava tube volume originally formed (the others collapsed or were filled; that number is mostly derived from collapse trenches).

Medicine Lake is "a large shield over 33 kilometers in diameter which attains an elevation of 2,417 meters." Interestingly, lavatubes appear to form "in a zone on both the northern and southern flanks at approximately 1,370 meters in elevation ... with 1,250 meters taken to represent the base altitude of the volcano, leaving a net height of the volcano of 1,167 meters.

The average of the cave sizes quoted above is 5 km long with a diameter of 12.75 meter. We (Walden) estimate the actual average cave would be more like 1 km long with a 5 meter diameter. This is the approximate size of each major side of Young's Cave at the Oregon Moonbase, and comparable in size to many caves in Lava Beds National Monument. This yields a volume of a cave cylinder of 19,635 cubic meters per cave or 0.0000196 km<sup>3</sup> or a total of 0.00589 km<sup>3</sup> of "known" voids for the whole volcano.

Next, we calculate the volume of the volcano to be 332.7 km<sup>3</sup>, consisting of an upper "shell" volume of about 37.59 km<sup>3</sup> including the 150 feet (45.72 m) nearest the surface from which all our evidence is taken, and a 295 km<sup>3</sup> "core volume" remnant, to which the argument might be extended.

Of the older caves deeper in the mountain, many will have collapsed or otherwise filled in over time, so this quotient won't hold for the whole volcano. If we estimate the core volcano originally did have a similar void quotient but has been 85% filled in by erosion, collapse, or subsequent flows (Cheryl York thinks this may be pessimistic, perhaps only 50% have been filled, but agrees with using this conservative figure at present), then the void quotient of the core would be 0.00235% and a net void figure for the mountain 0.0128 km<sup>3</sup>. Please note this is about 13 million cubic meters of void in one small shield volcano. In sum, we might project 0.00386% of the Medicine Lake shield volcano volume is lavatube void with nearly 2 caves per cubic kilometer.

### **Extending the Argument to Pavonis on Mars**

Now Pavonis Mons has a volume 700–1000 times larger than Medicine Lake. (Pavonis is 7 times the diameter of Medicine Lake, covering 50 times the area and is perhaps 15–20 times taller). Taking the smaller figure and extending the same argument, we might expect 10 billion cubic meters involving wider, higher, longer caves spaced further apart. If we postulate an average Martian tube interior ceiling height of 30 meters, that gives us a floor space of about 150 million square meters = 333 square kilometers = 128 square miles, the size of an American central city in the 1,000,000 population range – in a host mountain with a footprint of 40–45,000 square miles, bigger than Iceland and comparable to the size of states like Ohio,



Kentucky, Tennessee, Virginia, Mississippi, Louisiana, or New York. (For comparison some other American states in thousands of sq. mi. are: CO 104, OR 96, MN 80, WI 55.)

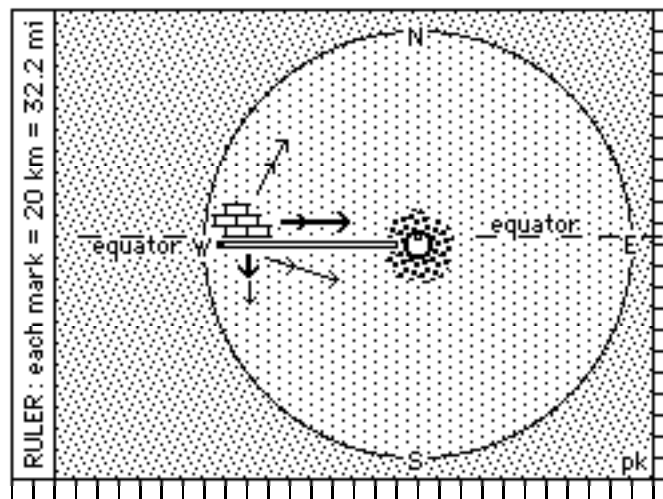
Pavonis (genitive form of Pavo, Latin for Peacock) covers an area about twice that of the BosWash Megapolis with its 40 million people. Since the lavatubes are not cheek by jowl, the potential population of the Peacock Metroplex will be significantly smaller than that. Add in the fact that it has to include within this shielded area support agricultural areas that will perhaps occupy the major fraction of available space (unless this function is taken care of in surface greenhouses – bear in mind that glass protects against UV damage and only seed corn need be protected from radiation.) We still come up with a ready to build-within protected area that can be home someday to tens, perhaps hundreds of thousands of Terro-Martians. As the economy expands to include similar satellite communities in other “Montes” shield volcanoes like Olympus, Ascraeus, Arsia, Elysium, etc., the volcano-hosted urban population of Mars could soar into the millions.

Because these pre-excavated areas are so spread out along the surface of these enormous volcanoes, they are likely to be incorporated as a number of separate communities representing individual tubes or convenient clusters of tubes, all sharing some Metroplex functions in common. We’ll find names like Pavo Heights West, Pavo Cliffs, Caldera Crest, Rim Town, North Peahen, and many others whose names make no reference to the host site at all.

In addition, of course, there will be a scattering of “conventional” surface-trenched towns plying the mineral and other pluses of various sites. We’ll have a better idea of where such specially advantaged spots might be after future robotic missions complete geochemical and altimetric maps of Mars.

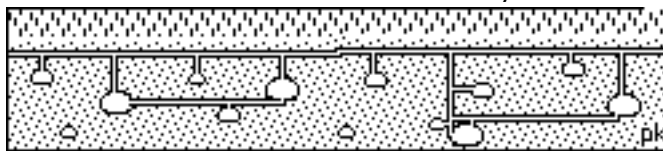
#### The Pavonis Metroplex Zone

So how might the Peacock Metroplex take shape? We could expect the initial settlement areas to hug the lower end of the Pavotrak launch track complex site and expand as the economy grows and demand arises along the track and around the mountain. Development might leapfrog areas in which lavatubes are relatively sparse or widely spaced to areas where they may be clustered. Some locations might offer enhanced concentrations of volcanic minerals. Sites near the caldera rim may support tourist activity.



**Plan of the Pavonis Mons Metroplex Area:** The lavatube-riddled shield volcano slopes cover an area about 250 mi. in diameter. The corridor for the launch track up the west face of this equator-straddling mountain is shown, along with the site for a Pavonis-Deimos Elevator Base in the caldera summit. The suggested site for the first settlement is indicated by the brick-pattern area with arrows showing logical directions of early metroplex expansion. Eventually, the entire base of the mountain could be occupied, attaining a population of up to a million citizens or more.

The lavatubes being arranged more or less radially away from the summit, locally they will be arrayed more or less in parallel. Those nearest the surface will be the first to be exploited. This suggests that pressurized cross-connecting roads might best be trenched into the mountain slope surface with access to individual tubes by elevator as illustrated below.



**Schema of lavatube habitat areas** and their pressurized connectors. (Shown: cross-section of mountain slope perpendicular to radius) Dashes at top indicate mountain slope surface and direction of the summit. Principal “cross-connectors” are most logically trenched and covered at the surface, with access to individual lava tubes by elevator banks. Cross-tunneling only makes sense between major close neighbor tubes and tube systems. Some lavatubes will be “off the beaten path” and by-passed in creation of the Metroplex.

Freight and Passenger traffic are likely to be separated especially in elevators. As to solar access, it will be possible, and more efficient in the long run to pipe in sunlight by mirrored shafts or fiber optic bundles than to use surface-available solar power (just 36-52% as intense as at Earth, depending on the time of Martian year) to produce artificial lighting tied to the sunrise-sunset period above. We might see both, with nearer-surface tubes trying direct access, deeper tubes opting to repeat surface lighting electrically. Either way, it will be more cost effective to faithfully follow the seasonally varying length of daylight than to produce a standardized day-night cycle below.

Pressurizing leaky lunar lavatubes won't be smart. On Mars where we want to alter the given atmosphere over time, we might do just that. Pavonis Mons will be one of the most interesting settlement scenes in the entire Solar System. PK



By Peter Kokh

[Followup on “CANALS on Mars: from self-deception to reality,” MMM # 62, FEB '93 pp. 6-7.]

### Lowell's List

Almost all science fiction novels about Mars written before the successful Mariner 4 and 9 missions, took the existence of the canals “observed” by Sciaparelli, Lowell, and others as a given. Either they were dust- and weed-choked ruins of a long-vanished native Martian civilization or still working water routes maintained by a handful of native survivors. And these writers gave them names from Lowell's List.

We now know such features to be illusory. Yet it is possible that future Martians tracing ancestry back to Earth will someday build canal-like aquifers to transport water across Mars. These settlers can either choose to start afresh, naming them after prominent natural features along the route – or after the mistress of the construction team boss. But they could just as easily choose to exonerate Lowell's List, thereby infusing the romance of a tradition that predates by several decades the dawn of the Martian Era (1/1/1961 = 1 Gemini 1 m.e.).

Two readers responded to my request for sources of information on the names Lowell and others had given to the lines they honestly thought they were observing. Jeff Sanburg (Skokie IL) wrote that 1908 vintage maps of Lowell's canals are to be found in Willy Ley's classic Mariner IV to Mars. Francis Graham (East Liverpool OH) sent us the complete list, an astonishing 183 names in all. Our thanks to both!

Of these 183, 89 had been “observed” less than ten times. Another 61 had been recorded less than 33 times. That leaves 33 names given to linear phenomena “seen” from 33 to 127 times each. Agathodaemon is the one observed and drawn most frequently. “Earning credit” towards immortalization as names of future human–engineered Martian aqueducts, are:

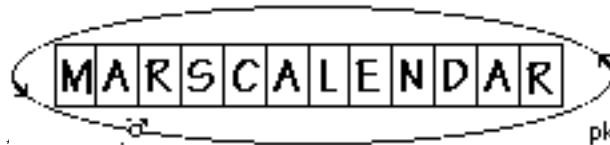
Agathodaemon 127	Ambrosia 36	Araxes 93	Bathys 69	Brontes 38	Cambyses 34
Cephisus 35	Cerberus 44	Coprates 41	Corax 33	Daemon 118	Eosphorus 56
Eumenides 103	Euphrates 36	Ganges 82	Gigas 60	Gorgon 33	Hebe 37
Jamuna 39	Laestrygon 41	Nectar 87	Oceanus 37	Orcus 35	Orontes 33
Phison 56	Pyriphlegethon 53	Sirenius	60 Steropes 46	Tartarus 42	Titan 38
Tithonius 78	Typhon 33	Ulysses 33			

Alternately, these canal names are available for water–tanker truck routes from the poles to the equatorial regions, even for the trucking firms so involved. PK

The cure for boredom is curiosity.

There is no cure for curiosity

– Ellen Parr



## MARS CALENDAR: *A Tale of Two Calendars*

“A Calendar for Mars” by Robert Zubrin, *Ad Astra*, November/December 1993, pp. 25–7

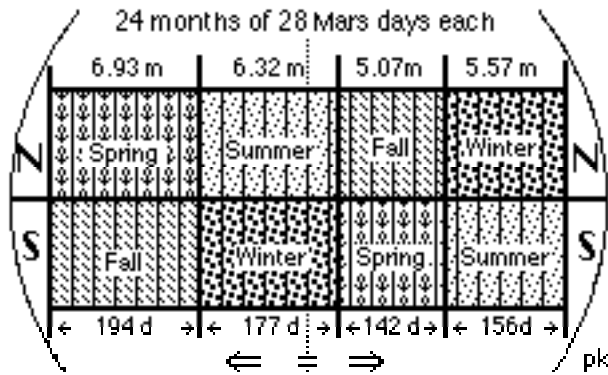
“Mars Calendar” by Peter Kokh, *Moon Miners’ Manifesto* # 19, Oct. 1988, pp. 5–6

Report and Comment by Peter Kokh

Let me begin by saying that I endorse Bob Zubrin’s Mars Calendar design – with two minor reservations – even though there are aspects of my previous suggestion that in the abstract I might prefer. In the concrete, Zubrin alone has the name recognition and prestige needed to gain widespread acceptance, perhaps even official adoption, for such a proposal. That would be a coup in the effort to raise public awareness of Mars and of its similarities and contrasts to Earth. These days, Zubrin, as much as anyone, is Mr. Mars.

In the calendar proposal outlined in my earlier article, I began with the goal of preserving the 365–day like rotation of holidays and anniversaries with which we are all familiar and comfortable. Mars’ orbital period is some 669 Mars days long (690 Earth days), a long period almost commensurate with 2 Earth years (730.5 d). So I thought to divide it into two equal “versaries” (coined from anniversary) of 334.5 Mars days each – per “Zodian”, one complete orbit, i.e. pass around the Zodiac. The logical point of division would be not along seasonal lines but between the in–leg (from aphelion, when Mars is furthest from the Sun, to perihelion, when Mars is closest to the Sun) and the out–leg (perihelion back to aphelion) portions of Mars’ orbit. While such a duplex calendar would not neatly coincide with the Martian seasons, neither does the common Earth calendar. Earth’s year begins not with the first day of spring, which Zubrin’s proposal assumes to be the logical point, but at perihelion, on January 1st when Earth is closest to the Sun. (It is cold in the northern hemisphere while we are actually at our closest to the Sun because of the ‘overruling’ axial tilt of Earth’s north pole away from the Sun at that time.)

Next I sought to honor the 28–30 day “monthly” cadence with which we are equally at ease. This means, of course, that when months begin and end can have no neat relationship to the arrival of seasons on Mars. But neither is any such neat relationship marked in our own calendar.



The 28 date months I had proposed would rationalize the traditional 7-day week, the most change resistant temporal rhythm in all human experience. Every month could begin on the same day of the week, that year. As the paired 334-, 335- date versaries called for would be together 4 dates longer than 95 weeks, a "Sunday" versary pair (or Mars year) would be followed by Thursday, Monday, Friday, Tuesday, Saturday, and Wednesday years (or by whatever other names the weekdays on Mars might one day be called) in an ever repeating cycle. However, day-date coupling could be arranged by placing an eighth "leap day" at the start of each season.

Zubrin's calendar begins the year with the first day of northern Spring (southern Fall). (Historically, Earth's calendar used to begin with March - December means literally the 10th month, not the 12th!). With three 'months' per season and 12 per Martian year, it becomes logical to denote them by the zodiacal constellations in which the Sun appears from Mars. [Ed: let's not call them "months," an inappropriate allusion to the Moon, but "zodes" ("sign" has a bad connotation).]

The advantage is obvious. Almost everyone, space aware or not (indeed especially the space-ignorant!) already knows the names of all twelve Martian months or zodes!

**Gemini, Cancer, Leo, Virgo, Libra, Scorpius, Sagittarius, Capricorn, Aquarius, Pisces, Aries, Taurus**

Choosing to enshrine these names into Mars' Calendar will at least superficially lower the threshold of comprehensibility of our dream of settling Mars for the average person on the street. That should not be dismissed as a spurious consideration, if we want someday to realize that dream. With the right publicity campaign, more and more people on hearing the name of some zodiacal constellation, will think Mars, not astrological sign.

In the Zubrin proposal, with the months or zodes varying in length from 46 to 66 Martian days or sols (the seasons varying so much in length because of Mars eccentric orbit - its angular motion much faster when nearest the Sun than when farthest) no easy weekday repeat pattern is likely. But again, overall day-date coupling could be arranged by four out-of-week days, perhaps beginning each season: Gemini 1, Virgo 1, Sagittarius 1, and Pisces 1. But Zubrin himself does not discuss the day-date question in his proposal. Perhaps future Martians might decide the disorder of our present uncoupled day-date system provides healthy variety. (But is it the wisest choice to thus pacify the eternally warring Friday, Saturday, and Sunday clans of fundamentalism?)

One of the most spirit-lifting appeals of opening new worlds like the Moon, Mars, and Space Settlements is just this opportunity to start over "afresh", to shed the more irrational baggage of history, and choose our cultural infrastructure more wisely, so that the pace of our lives might be more in harmony with the grain of nature. The unaddressed day-date question aside, Zubrin's proposal is a brave attempt to do just this. The 46-66 date long zodiacal months calibrated to Mars' eccentric season patterns and the 88% longer Martian year must establish a new, characteristically Martian feel for time, something that will echo throughout Martian culture. His calendar showcases what is so transcendently different about Mars,

providing an appropriate hanging strip upon which to time-fasten other cultural innovations: holidays, feasts, and rites of passage etc.

On the other hand, Zubrin proposes using Roman numerals to keep track of Martian years, beginning with year I starting when Gemini 1 (on Mars) last coincided with January 1 on Earth in 1961. This is a good choice for beginning the Martian Era as it is near the outset of the Space Age and the first probes sent towards Mars, i.e. when human activity near/at/on Mars began.

Decades & Years			XVIII	Years on Mars: Roman vs. Arabic	
Decades on Earth	60s	00s	1994		18 m.e.
	70s		1995		XIX
	80s	10s	1996		19 m.e.
	90s		1997		XX
	00s	20s	1998		20 m.e.
	10s		1999		XXI
	20s	30s	2000		21 m.e.
	30s		2001		XXII
	40s	40s	2002		22 m.e.
	50s		2003		XXIII
			23 m.e.		

My point is that the unnecessary choice of Roman numerals, hesitatingly familiar to many, raises an instant barrier of incomprehensibility for many others. Would Dr. Zubrin accept a friendly amendment and use the much more familiar Arabic numerals, perhaps following them with m.e. for Martian Era (e.g. 18 m.e. rather than XVIII)?

Another, equally nonessential point of this proposal evoking grave misgivings is that it chooses to redefine not just the day and hour on Mars, making them all longer than our familiar periods by a constant factor of 1.0275 (Mars' day 37-some minutes longer than ours) but also the minute and the second. This would mean that no science textbooks used on Earth could be used as is on Mars. But we do not have to use analog clocks. It should be no big deal to devise digital clocks for Mars that incorporate the longer hour and day, but that use the standard second and minute. The Mars' hour would simply advance by one every 61.65 standard minutes of 60 standard seconds. So I submit this second and last friendly amendment.

While anything done in advance on Earth can hardly be "binding" on future Martian settlers, adoption of this centerpiece of cultural infrastructure would put into place a tradition-like momentum hard to set aside. The settlers will have more urgent things with which to concern themselves. By adopting a really good Mars calendar now we can only help them.

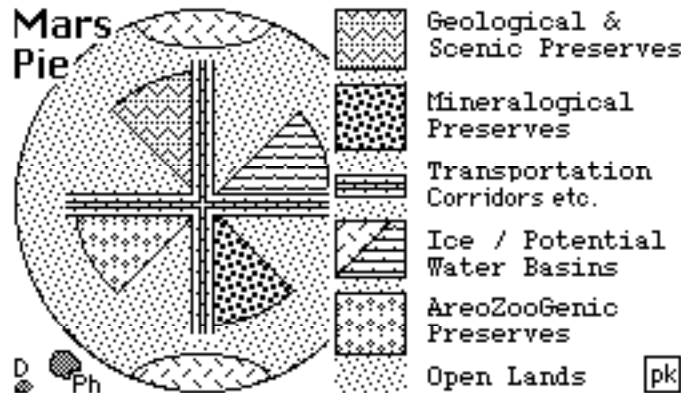
Zubrin includes an "Areogator" to equate Earth dates and Mars dates. While cumbersome, the formula-chain could easily enough be reduced to run with the press of a single function key on a specially designed calculator. Might not the Planetary Society, best positioned to market such a device, contract with a manufacturer to make such a product, thereby increasing the extent and depth of Mars awareness?

Bob's contacts with the Planetary Society are a plus here. If TPS does adopts the Calendar, if **Ad Astra** adopts it (it appears that they are so inclined), if science fiction writers adopt it, and if NASA-Russian Mars Mission planners do so - then I think it will prove to be a done deal. Engage! PK

The **MARS HERITAGE** Mars Heritage

## Zoning Resolution of 20 m.e./1997a.d.

A Proposal to The Case For Mars VI Conference to be held in Boulder, Colorado, July 1996



### Forward

In MMM # 62 FEB '93 "Federal Republic of MARS" p. 5, we spoke of the need for very early home rule for Mars (it's beyond the short range distances within which "umbilical" connections are logistically feasible) and mentioned the logic of setting up a regime of federal reserves to protect the major geological and scenic areas, major known mineral deposits, major known deposits of ice (and possibly of permafrost as well), and the two moonlets: Phobos and Deimos. This would leave the balance of Mars open to settlement and commercial resource development – under the rule of law, of course – while protecting a/the major portion of the planet's special heritage for future generations of human Martians.

### National Parks and Monuments

The Geological and Scenic Areas to be preserved as National Geological and/or Scenic Parks and Monuments could be restricted to those treasures identifiable as such from pre-human exploration missions (Mariner, Viking, MESUR, etc.) Other similar treasure spots identified after the era of human visitation has begun, might be put on a list of places which state or provincial or local governments must protect according to set standards. This would be similar to the setup in this country where not all geological and scenic wonders are part of the National Park, Monument, or Forest systems, leaving many undisputed gems within State Park and Forest lands.

There should be provision within the law for future tourist village/center enclaves in such protected areas wherever a tourist market would otherwise arise. On this list would be the great shield volcanoes Olympus, Arsia, and Asraeus (with Pavonis Mons being a likely major exception – see the article pp. 3ff.); the great Valles Marineris system of canyonlands, and other places of lesser present fame.

### National Mineral Endowment Reserves

Currently, we know little of a non-general nature about Mars' mineral endowment and much less about how any such resources are distributed over the face of the globe. It is possibly that future robotic orbiters equipped with gamma ray spectrometers and capable of generating multi-spectral thematic maps will replace current ill-constrained conjecture with knowledge sufficient to trace the outlines of the planet's "Economic Geography" to the point where we can generate a short list of sites well suited for local resource-dependent settlement.

At the same time, without follow-up "ground truth" missions to check out percentages, quality, feasibility of extraction, and other salient make-or-break details, we may not be able to further trim the list for Settlement Site #1. Meanwhile, other considerations may motivate an earlier decision such as proximity to major geological sites, or to logical surface transportation corridors, or to other potential sites (site clustering).

While obviously, settlements must have real access to mineral resources, uncontrolled there-is-no-tomorrow extraction can be avoided by federal ownership of the major pre-detected deposits coupled with a system of licensed extraction and settlement “enclaves,” In the absence of clues detectable from orbit, however, it will be difficult to protect more than a very small portion of Mars’ mineral heritage in this way. But at the least, a regime can be put in place that can be extended to cover and husband other endowment-rich areas of the planet later on.

### **Potential Water Basins and River or Canal Routes**

It is clear that the polar ice caps and at least some of their periphery should be within federal preserves. Permafrost areas are another thing. Future robotic orbital missions might possibly locate the major, nearer-surface frozen soil zones. A debate is in order whether any of these should be set-aside areas or not. Certainly there will be many smaller buried ice pockets that escape orbital detection, either because they are too small, their water content is economically marginal, or they lie too deep below the surface. These, at least, should be up for grabs.

But if someday we are to “terraform” Mars, or better and more naturally, “restore” or “rejuvenate” the planet to its previous more benign condition, then at least some low-lying areas are potential future lakes and seas. Our current altimetric knowledge of the planet is largely conjectured. Future planned missions will give us a map from which we can identify and rank potential catch-basins and even early “immature” water drainage routes. (Mars Observer would have done this.) As to the latter, a little bit of engineering here and there can prod hesitant drainage routes into more desirable paths. Even now, while the area of climate change on Mars is well beyond our horizon, we ought to be able to get enough of a handle on the possibilities to zone aside some areas as likely future basins and riverways, making sure all early settlements are on “high ground”. We don’t need to repeat the stupidity of shore/flood-plain development that is so rampantly entrenched on Earth.

### **AreoZooGenic Reservations – AZGRs**

Just as far off perhaps is the day when Mars’ CO<sub>2</sub>-rich atmosphere has thickened enough to permit drip-irrigated outdoor surface plantations of specially bioengineered “Mars hardy” trees and other plants. In advance of that day, it may soon be possible to identify favorable “fertile soil” areas, separate from other types of preserves, that might be at least partially protected as potential future National Forest lands, in so called AreoZooGenic Reservations, AZGRs (Ares is Greek for Mars).

Much more remote is the possibility of outdoor wildlife on Mars. Vegetation can handle a CO<sub>2</sub>-rich, O<sub>2</sub>-stingy atmosphere, if it is thick enough (perhaps ten times the present value on Mars of near a hundredth Earth normal). So the idea of setting aside areas, other than the AZGRs just mentioned, as “future Wildlife Refuges” has little merit and no urgency.

### **Air/Space/Surface Transport Hub/Corridor Preserves**

#### **Land Grants to Infrastructure Concessioners**

On Earth, at least in this nation’s past, designation of railroad and highway corridors and associated land grants have played a major role in opening up the American West to settlement and in largely confining it within certain stripes and pockets. It may be wise to consider something similar for Mars. It will be difficult to plan anything logical along such lines, however, until we have a clearer idea of the likely modes of surface and point-to-point transport on Mars.

Air transport, even in the thin air of today’s Mars, is a recognized possibility, especially with hydrogen bag buoyancy assist. Airport areas both for VTOL vehicles and those needing very long runways are logical set-asides in potential settlement areas offering major identifiable assets or advantages.

What about highways? What about Mag-lev or other railway routes? Given the altimetric data that should be forthcoming from already budgeted missions, it should be possible to identify a logical circum-planetary near-equatorial surface route, and even the major local route options (“the Polodona”, to borrow E.R. Burroughs’ name for Barsoom’s equator). Logical

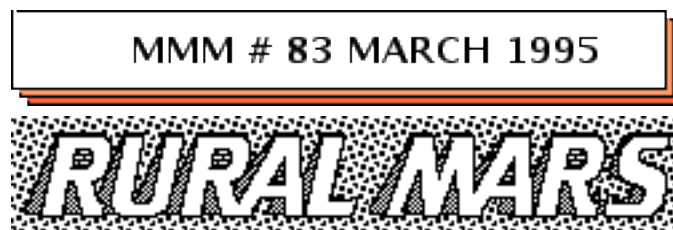
spurs to other interesting or economically promising temperate or arctic areas could also be “designated”. Where the route offers wide leeway, protection need be of only the most general kind. But where it is constricted, e.g. mountain passes, or narrow valleys, specific land reservations may be in order.

### Federal and Provincial Open Lands

Settlement sites and even old-fashioned individual and communal homesteading might be liberally permitted outside the Federal Land Reserves suggested above. Permits, of course, ought to be granted on the basis of some minimum set of demonstrated assets and capabilities lest the Mars Republic wind up with many mini-communes on the public dole. Make no mistake about it, atmosphere, ice, and permafrost notwithstanding, Mars will be only slightly less harsh a mistress than the Moon. Until some far off age of planet-wide climactic engineering, each community or isolated homestead will have to subsist outside the context of a given all-cradling biosphere, having instead to provide a minibiosphere of its own.

Prime sites for settlements engaged in mining and manufacturing and/or tourism are along the boundaries of the geological, mineralogical, scenic, ice/permafrost, and transport corridor reserves. (Tourism is likely to be a rather low income earner for a long time to come – until either Mars’ population has reached some critical mass, or Earth-Mars passenger transport costs and times have fallen some orders of magnitude.)

If state or province boundaries must, by prior law, be established insofar as feasible to follow potential watershed divides (not potential river courses which only balkanize such watersheds!), there will be put in place a complementary tool to help serve shared environmental interests and responsibility. All these features, outlined above, can be adopted within the next decade or two, before the first human visits to Mars. The settlers do not need the pain and tribulation of a “Wild, Wild, Lawless Frontier”– they will have hard enough a time without all of that. Suitable amendments can come later. PK



By Peter Kokh

Conditions and challenges facing those wanting to live outside the settlements and main “built up” areas of Mars will be significantly easier than those facing their counterparts on the Moon. For one, nuclear powered\* compact and modular “air products plants” or atmospheric refineries will provide a steady resupply of oxygen, nitrogen, water, and hydrogen, as well as carbon monoxide and methane for fuel. [Graphite powder or Dinitrogen Pentoxide for air-derived shielding is another possibility. [“Mars Igloos”, MMM #42, FEB '91 reprinted above] In many locations, a more generous supply of water and derived hydrogen and oxygen could be produced by permafrost taps.

Like it or not, compact **Nuclear** reactors will be far more efficient and attractive than solar power generators on colder, more distant Mars. After all, the Sun itself is a “nuke.” Hopefully, (a) waste disposal problems will long since have been solved, and (b) prospective Martian settlers will be less susceptible to emotional sidetracking than today’s terrestrial population.

**Geothermal** sources of energy on Mars are a total unknown, and unlikely to exist. Mars has been tectonically inactive for too long a time. Future orbital mappers may find hot spot clues.

**Wind** power will work only for extremely light loads.



**Solar** will play a role, but mostly a backup one, just the reverse of the likely situation on the Moon. This is so not because the density of sunlight is too low at Mars, but because of the periodic blanketing of the planet by global dust storms lasting months at a time.

Further, the presence of a thin atmosphere will make inter outpost travel and traffic in goods easier, by **airships and hovercraft** skimmers.

Further, as Mars is geologically more evolved and certain to be mineralogically more diversified than the Moon, prime mining locations will be more abundant, and easier to work. As to serving the tourist trade, sites abound that offer breathtaking canyonland, begging for a hotel or two.

#### **Some interesting observations can be made:**

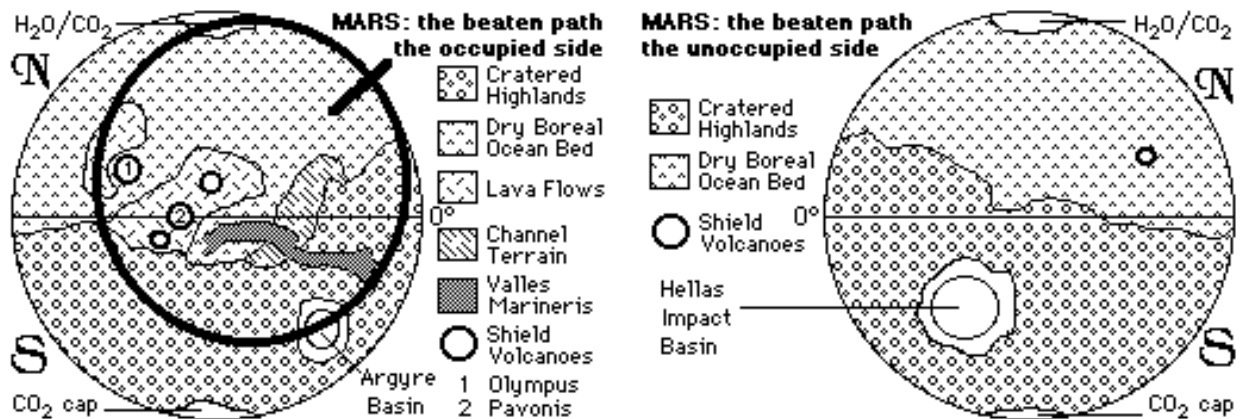
**Vehicles:** As in Siberia, vehicle windows will be thermopanes. The outer pane needs to be impact resistant against tire-thrown pebbles and rocks, abrasion resistant against dust storms, and UV blocking. Vehicles will need carefully designed dust farings or be “dustlined” [contrast with our “streamlining”] much as on the Moon, but perhaps more thoroughly. They will probably be capable of running on alternate fuels: hydrogen, carbon monoxide, and methane, along with fuel cell backups.

Radio is unlikely without an uninterrupted chain of line-of-sight relay stations along each route. If a network of global communications satellites and global positioning satellites (GPS) proves too expensive for the Mars Frontier Authority to purchase, install, or maintain, “meteorburst” communications, in use on Earth by some trucking firms, may prove just as workable and practical on Mars as well.

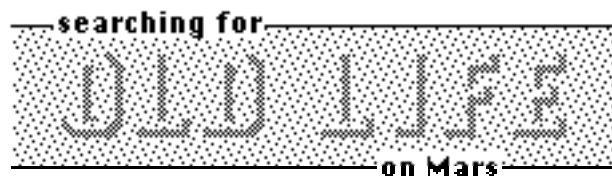
**“The Beaten Path”** will include canal or aqueduct routes from the water-ice cap at the North Pole southward to the tropics, routes between major mining and manufacturing settlements and major spaceport facilities. Sooner or later Pavonis Mons astride the equator will become one of the latter. The same or other routes will provide for one or more tourist sightseeing itineraries through National Geological Parks, showcasing the great canyons and shield volcanoes.

As the Martian economy diversifies and becomes more self-sufficient, so will the interdependence of various towns increase, each producing their own contribution to the list of available items. This network of settlements could well cluster on one hemisphere of the planet for some time. Mars does not have a lunar like polarization of nearside and farside real estate assets. The Pavonis Mons super spaceport site is handy to the other shield volcanoes of the Tharsis Ridge and to Valles Marineris and tributary canyonland attractions. Those potential mining sites and permafrost taps clustering this complex of real estate assets is likely to be sufficient to soak up all development energy and capital for some time to come. Completing a triangular Mars development area will be canal/ aqueduct routes from the North Polar Ice Cap

Rural outposts on Mars will have much greater independence as far as such basics of life as volatiles are concerned. Nonetheless, they will be as or more interdependent on one another for other goods and economic necessities. The Martian “outback” will be more like the Australian, the Alaskan, the Siberian, and the Patagonian, than the barren reaches of the Moon. It’ll be interesting all the same. **MMM.**



"The human race shouldn't have all its eggs in one basket, or on one planet. Let's hope we can avoid dropping the basket until we have spread the load" -- Stephen Hawking



### Two different questions – Two different searches

By Peter Kokh

#### **Question 1: What kinds of life forms may have had time to evolve on Mars before irreversible climactic decay, and could any fossil traces still endure?**

Mars, it is now generally believed, had a much more benign climate in the first quarter or so of its existence. For perhaps as much as a billion years after it had settled down from the throes of its formation, Mars' young atmosphere was relatively thick. It was warm enough for liquid water to pool on the surface – a whole ocean of it in fact, in the northern hemisphere. We can see shoreline traces even now.

Time changed all that. The orbit changed along with the tilt of the planet's axis with the result that Mars received less solar warmth, year in and year out. The planet's gravity only three eighths that of Earth, its atmosphere slowly and irretrievably leaked out into space with further chilling and desiccating effect. The Sun's friendly warmth was replaced by a different kind of fire, the wrath of an ultraviolet flood.

But consider the glory years, the eon or so in which, if life did in fact find a niche in which to begin, it may have enjoyed a crescendo of sorts. How far might evolution have carried Areaa (to coin a name like Gaia) before retreat set in?

We have only one known biosphere upon which to base our inferences, our own. What kinds of creatures appeared in Gaia's first billion years? Most of us will not find the answer exciting. No mammals, not even a shrew. No birds, not even a kiwi. No reptiles, not even a lizard. No amphibians, not even a tadpole. No insects, not even a gnat. No trees, not even a bush. No fields of grain, not even a crab grass. No flowers, no fruit, no nuts, no seeds. No ferns or fungi, not even a moss or a mushroom.

At sea there were no fish, not even a lamprey – no vertebrates at all. Nor any soft-bodied mollusks, not even a slug. No crabs or clams, not even a limpet. No starfish nor jellyfish, not even a hydra. No tube worms or earthworms, not even a nematode. No anemones, not even a sponge. Hard as it may seem to believe, no multi-cellular life appeared on Earth until the planet was almost four billion years old.

There were viruses, then bacteria, then one-celled organisms like amoeba, algae, and paramecia. But the more interesting of these did not appear until much after that first billion years. It took a lot of breakthroughs, a lot of genetic and physiological invention, to progress from virus to bacteria. It took even more to produce one-celled organisms.

Fossils? There would have been no creatures with bones. It is just plausible that some organisms had glassy or calcareous spicules. Singly, it would be all but impossible to find traces of their remains. But one could hope to find relics of the oozes which formed from the rain of the inedible parts of dead organisms upon the ocean floor. Fossil traces of algal mats (stromalites) have been positively identified along Earth's ancient shores. And perhaps that is all we could hope to find.

Bits and pieces of DNA? Forget Jurassic park. There were no trees to drip amber sap. There were no mosquitoes to get entrapped therein. Chances are that if we find indications of past life, they will be no more than that, "indications," and we will not be able to reconstruct much of a picture of how such Areoan life resembled, or differed from Gaian parallels.

**Question 2: Could some anemic relic of a once far richer Martian Biosphere still subsist in "oases" here and there?**

Life can evolve to survive, even thrive, in places in which it could never originate in the first place. There are plenty of terrestrial examples: hot springs; the tundra; high mountain tops; deserts; parasitically or even symbiotically on or within other creatures; in oxygen deprived anaerobic conditions in ocean bottom oozes.

In recent years we have found whole new jungles of life whose food chains begin not with photosynthesis but with methane-eating bacteria (methanogens) like those thriving anaerobically in bottom oozes. These oases surround thermal hot vents in volcanically active mid-ocean ridges in the perpetually dark abyss. Yet, these ecosystems are clearly derivative, all of their species related to ones part of photosynthetic food chains. They could not have independently originated there.

There are perhaps a few places on Mars where life, once established under more favorable conditions no longer the case, might have gradually developed the hardiness to continue to subsist, if not thrive, as conditions inexorably got less and less friendly, eventually downright hostile. Yet it is a romantic notion. As a rule, species die out when their friendly habitat disappears, even if it does so ever so gradually.

The idea of finding "a" life form (i.e. one and only one species) on Mars is absurd, however good copy it might make. We will either find a functional ecosystem consisting of a number of interdependent species linked in complex food chains, or we will find nothing. This compounds the fragility and vulnerability of species to climactic disaster.

Before the Mariner and Viking probes, many writers commonly spoke of lichens as the kind of hardy rudimentary plant life that we might just find on Mars. Actually, a lichen is a highly evolved composite plant in which a fungus and an algae live in symbiosis. Neither could survive in their tundra habitats alone. That is a clear indication that they had to arise under more benign conditions. Yet the arctic tundra is far more friendly than any climate we will find on Mars. Its temperature range, atmospheric pressure levels, and availability of seasonal liquid water would make it seem a tropical paradise on Mars.

If we do find existing ("subsisting" is a better term) life on Mars, it is most likely to be microbial. Not only is it apt to be microscopic, it is certain to be reclusive, hiding from the intense naked tissue-destroying protein-busting ultraviolet rays of the Sun, as well as from the extremes of weather, in subsurface areas of rocks and boulders. Scattered about the Martian landscapes in "strewn fields", the bigger rocks and boulders soak up the solar warmth during the day, and serve as heat reservoirs for a time even after sunset, little microclimates each unto themselves.

Such organisms could avoid the nightly freeze in the Summer if their protoplasm contained enough glycol (as many Antarctic organisms do on Earth), but then would surely freeze through as Fall sets in to stay frozen for most of Mars' year. Their own life and

reproductive cycles would have had to have successfully adapted to such a regimen. There are plenty of examples of organisms on Earth that wait out unexpectedly long periods of cold and/or drought and successfully revive months, years, even centuries later. Even we humans are used to rhythms: the seasons affect how we provide ourselves with food on an uninterrupted basis. And every night we each commonly “shut down” in sleep, only to “revive” the next day. And we repeat these cycles over and over. Life does not need conditions that are constantly favorable, only cyclically so, in a dependable way.

Rock-dwelling microbes on Mars may amount to no more than fiction, but we have found their counterpart on Earth, in Antarctica. If they “once upon a time” evolved on Mars, they might have spread around the planet, from rock to rock in sand storms, much as many terrestrial plants rely on the wind to help propagate themselves.

There may be many species of such microbes, some with merely anecdotal differences, others specially adapted to rocks of differing chemical and mineral composition. If we find them, these micro-Martians will provide a delightful and long-lasting high to exo-biologists, but will quickly bore the Hades out of the rest of us.

### **Implications for Martian Settlement Dreams**

No matter what the scientists find, or fail to find, the hoi polloi being as ill-informed as they are, it'll be a simple matter for a few to rabberouse the public at large into seeing to it that our government(s) make(s) Mars a protected planet, off limits to our bad news species, lest we disturb these little beasties, actual or mythical, and their environment.

Actually, almost nothing we could do is likely to disturb them, uproot them, or supplant them. Earth life, even terrestrial microbes, are ill-adapted to Martian conditions, and are extremely unlikely to survive long enough in the Martian “wild” to threaten the native denizens in any way. And vice versa. Martian bacteria are likely to find the conditions within human habitats intolerable, and die before they could begin to wreck havoc. Alas, the public has read and seen too much scare-fiction. Andromeda Strain and all that. If we find life on Mars, we would be pioneers are dead! Not from Martian germ-life itself, but from our own Halloween fears.

**A prayer:** Dear Lord, let the exo-biologists get their thrills somewhere else, like in Europa's ice-encased global ocean. Let Mars be sterile, or dead. Fossil life, okay. But nothing living, please!

Of course, Mars will be what Mars is! We must look, because we are by essence curious animals. What is to be feared the most is that we will find nothing, but that tabloid-fed rumors to the contrary of a cover up conspiracy will persist. The outcome, a treaty to quarantine Mars, could be the same. The masses need such fodder for their entertainment; Tabloids need it to keep up their circulation. And politicians can't tell the difference. It never gets any better.

The way around such an outcome, of course, is the venerable *fait accompli*. Settlers, defying the proclamations of terrestrial governments, open up Mars anyway – if economic incentives for them to do so can be found. No one now knows what these economic foundations might be. Today, the outcome of tomorrow's efforts remain uncertain.

Humans, and Gaia, will inherit clear title to Mars (and that is what we need if age old science-fiction dreams are ever to become reality!) only if there never has been life on Mars, or if any and every form of it is now forever extinct. If the latter is the case, scientists might still learn something enlightening from lingering fossil traces. Fossil-laden areas would appropriately be set aside in Paleozoic Reserves.

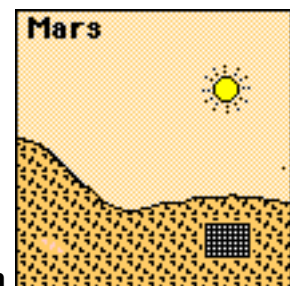
But the stubbornly persistent romantic notion that if we were to find extant native life on Mars, that it would provide the start, at least, of a food chain to support human settlement, and thereby make Mars that much more attractive to the powers that be, the ones in charge of the purse strings – this is notion is unredeemingly sheer nonsense!

Whatever its past, Mars today is a very “raw” world. We can’t just heat it up in some metaphoric microwave. We can’t just recook it. We need to start with a whole new recipe, with new ingredients. Our cuisine will be Gaian, not Areoan.

The future history of humanity and Gaia on Mars, will not be a continuation of some interrupted past chapter. It will necessarily be a fresh beginning. All the same we must be humbly and reverently mindful of what may have gone before.

As space advocates, we have to set an example in letting go of the wistful daydreams of the past and in bravely rerooting ourselves in reality. MMMM

**MMM # 93 MARCH 1996**



**By the light of a smaller, dimmer, cooler Sun**

**LEFT: On Earth**, the Sun shines bright and warm. Our generous oceans act as a thermal sink for that heat, providing an additional mean boost of some 50° F (28° C) over where we’d be without them. Solar collectors do not have to be overly large to tap this energy further.

**RIGHT: On Mars**, the Sun is noticeably smaller, less brilliant. The radiant heat it sheds is not not enough to warm living things, or people. With no ocean heat sink, it is far colder than its greater distance from the Sun would indicate. Solar collectors have to be much larger in size.

## IN FOCUS Mars will require a hardier breed of pioneer

Many people envision with enthusiasm an eventual wholesale settlement and colonization of Mars, and I number myself among them. In doing so, we carry forward what has become a racial dream of our species throughout this century. And we have done so, stubbornly, through revolution after revolution in our perceptions about the Red Planet. Banished to the realm of myth are the Mars of Edgar Rice Burroughs, populated by green men and princesses and thoats, and the Mars of Percival Lowell, crisscrossed with canals feeding green strips of irrigated vegetation, defying the creeping desiccation of the Planet. But gone too is the glimpse of a moonlike Mars that we read into the photos from early Mariner orbiters.

We know now that Mars was once warmer, wet with ocean, rains, and rivers, and lakes, and possibly in early stages of greening. We are all but certain that much of that watery endowment yet remains, locked up in permafrost layers of soil in lower lying basin lands. There may even be liquid subterranean lakes if there are near-surface geothermal pockets still simmering here and there, but we do not know. As to the polar caps, we now know that under a few inches of carbon dioxide frost seasonally chilled out of the atmosphere, there are vast polar ice sheets hundreds of meters thick, at least in the north.

How much water is there? That is, how extensive and patchy are the permafrost deposits? How thick are they? How fresh or brinish? All these questions must be answered to a first approximation accurate to an order of magnitude before any brainstorming schemes of “terraforming” (or, as we would prefer, of “rejuvenaissance” i.e. not making Mars like Earth, but bringing it back to the more encradling Mars-state it once enjoyed) can be much more than an

exercise in “garbage in, garbage out.” Which is why MMM has never gotten into such schemes. It is far too premature an exercise.



What does remain is the promise of a world that is more thoroughly endowed with prerequisites to support human and Earth life than is our own bondsworld, the Moon. Mars would seem to have far more appeal as a homesteading destination for those with enough of the right stuff to be willing to forever forsake the Green Hills of Earth.

But we can indulge in these fantasies, these declarations of willingness to go, only because the need to take a second look has not been thrust upon us by any immanent opportunity to open this frontier. That point of truth is still over the time horizon by an unknown number of years.

When that time does come and those who’ve thought themselves ready to go are faced with the decision to “put up or shut up”, we think that many, even most, will get cold feet.

For despite Mars’ life-supportive endowments, the challenges and obstacles to the establishment of a long-term human population capable of first enduring, then of thrivingly coming into its own, are daunting. And they are daunting from many points of view: engineering, logistical, biospheric, but above all and most critically, personal.

It is this last but ultimately most make-or-break class of challenges that we want to discuss here. POINT: Mars is farther from Earth than the Moon, much farther. And the implications are compounded.

Size: (Earth) Moon Mars	Dist. from Earth (Mn=1)	Dist. from Sun (E=1)	Heat & Power from Sun (E=1)	Launch Window Resupply Frequency	One way transit times
	1	1	1	daily	1-3 days
	150 to 1,060x	1.38min 1.67max	52%max 36%min	every 25 months	6-9 months

Resupply, reinforcement, relief, and rescue are always from 6 months to 25 months away. This will mean a reliance on a strategic “egg yolk” policy, as opposed to maintenance of “umbilical” style logistics. On site repair and fabrication shops as well as hospitals, both as to equipment and personnel expertise will need to be very much more complete. **Triage** in medical emergencies will have to be accepted by all as a potential personal consequence before leaving Earth.

It will mean that the personal commitment to the Mars frontier of each pioneer recruit must be individually that much deeper, more “final”, that much less open to reconsideration down the line. It will be much more expensive to return to Earth, and the delay time before such a repatriation can be affected will be much, much longer. Only the hardest, most self-reliant, and resilient personalities should tempt such odds.

Felt isolation from the mainstream of human civilization will be much deeper. Electronic communication with Earth involve response delays of 6–44 minutes, not the 2 plus seconds Lunans will experience. While, in all but live radio communications, those delays can be edited out, the edited conversations will flow jerkily and clumsily. The new “Martians” will tend to turn inward culturally and socially, and go their own way.

**POINT:** The Sun is not only further, dimmer, and much less warming, it is noticeably so to the naked eye. Not all of that is bad, of course. On Earth, full sunlight is uncomfortably intense. On Mars the softer light will be still plenty bright enough, and welcome, much as the softly sunny November skies in the northern United States and Canada.

But the smaller Sun will be a constant reminder of the reliefless cycle of very cool and bitterly cold seasons. Martian summers are but caricatures of our own temperate zone warm seasons, not even quite on a thermal par with the patchy thaws of our Antarctic summers.

The new Martians will learn to cope and grow to find much pleasure and satisfaction in the accommodations they need to make to acculturate themselves to this new world. But only those with the inner strength and drive to make the enormous adjustments had better set out on such a venture.

It can best be summed up so. Only a tiny fraction of the numbers who say they would go to Mars had they but the chance to do so, would also be as willing to commit to pioneering the relatively far friendlier fringes of our own Antarctica, with its vast fresh water supplies, breathable sweet air, and surrounding oceans teeming with life and food. That has to tell us something. We are all too romantic about Mars!

Yet as long as the moment of truth reality check is yet far off, we can afford to indulge our Martian illusions. And perhaps that is good in the long run. For it carries forth the dream, and with it the ongoing brainstorming exercises that will one day overcome the daunting odds.

PK

Good Reading on Mars

**Astronomy Magazine**, December 1995 issue, pages 36–43 “**The Mars that Never Was**” by Edmund A. Fortier, Paintings by Chesley Bonestel.

### < **MMM’s “Platform for Mars”** >

- >> Economic interdependence of several distinct mutually-trading off-Earth settlement communities is the only plausible path to viability of any of them.
- >> The opening of Mars, its moons, Deimos and Phobos, along with access to near Earth and Main Belt asteroids, is vital to the long-term survival prospects of any pioneer industrial and exporting settlement on the Moon.

**To this end,**

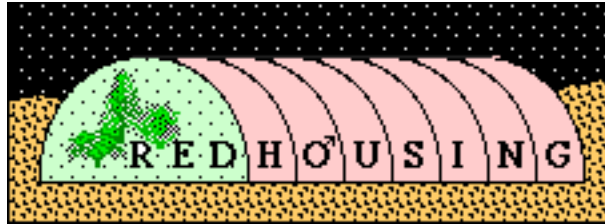
#### **MMM sees the following developments as part of “the critical path”**

- >> **Mars Permafrost Explorer** — The opportunity to pretest such a probe in Earth orbit to improve our knowledge of terrestrial tundra resources, makes this an easy sell.
- >> **Ground Truth Permafrost Tappers** — Orbital surveys will not be much good unless calibrated by well-scattered on site drill cores. Further, only by actual on site taps can we tell either the percentage of water content or its freshness or salinity or how we can best tap the deposit.
- >> **Mars Lava tube Explorer** — The opportunity to pretest such a probe in Earth orbit to improve our knowledge of lava flow terrain, makes this a logical priority. The results could be far less important for geology than for future Mars settlement scenario options. Ancient near-surface Martian limestone caves could also be identified.
- >> **Mars topographic map** with accurate elevations: from which basin and watershed divides can be traced along with their overflow dam points. From this potential primitive and immature drainage patterns can be sketched. This will help avoid siting an outpost in a future flood plain.
- >> **Geochemical orbital mapper** — A refly of the instruments aboard Lunar Prospector.
- >> **Geochemical ground truth probes** — We lack even rudimentary mineralogical analysis of typical Martian soils. Without this, the path of industrial development on Mars remains totally fogbound.
- >> **North & South Polar weather station net**
- >> **Antarctic Mars Training Camp Base** in one of the cold but “Dry Valleys” like **Wright** or **Taylor**. This should be a permanent establishment at which survival gear and methods developed for the Mars frontier can be tested, and prospective expedition members trained.
- >> **“Redhouse”** Wild Flora Experimentation Projects. See the article with this name just below.
- >> Adoption of the Zodiac-based **Mars Calendar** of Dr. Robert Zubrin as published in **Ad Astra** Nov/Dec, 93, “A Calendar for Mars,” with the friendly modifications detailed in **MMM** #73, Mar ‘94, pp. 6–7 Support is sought from: NSS, The Planetary Society, NASA, ESA, IAU

(International Astronomical Union) Russian, Japanese Space agencies, SFWA (Science Fiction Writers of America)

[Note: We have since abandoned Zubrin's Mars Calendar and pushed our own "Mars Pulse" Calendar

[http://www.moonsociety.org/publications/mmm\\_papers/marspulse\\_cal.html](http://www.moonsociety.org/publications/mmm_papers/marspulse_cal.html)



## Breeding "Mars Hardy" Plants in Compressed Mars Air

By Peter Kokh

In the previous "Mars Theme" issue, MMM # 83 MAR '95, on pp. 7-8 "Searching for OLD LIFE on Mars" (P. Kokh), we broke the topic down into two separate questions:

**Question 1:** What kinds of life forms may have had time to evolve on Mars before irreversible climactic decay, and could any fossil traces still endure?

**Question 2:** Could some anemic relic of a once far richer Martian Biosphere still subsist in "oases" here and there?

We concluded with a discussion of the implications for Martian settlement dreams, pointing out that the Romanticists who hope against hope that we will find some primitive (at least!) life forms still extant life on Mars, had better hope that they are wrong. It is incomprehensibly naive to think that should we find life on Mars of any sort, that the political / rabbleocracy powers-that-be would allow humans (us!) to settle there. The Fourth Planet would forthwith be declared a quarantined biological preserve for the rest of time. "Humans and all Earth Life keep out!" We could hardly disagree more with the sentiments expressed by editor Jeff Liss in the recent issue of **Inside NSS**. He had called "disappointing" the recent finding that the Viking "No-Life-On-Mars" experiment results were not flawed after all.

If all we find are fossil relics and perhaps a few incomplete strands of DNA (we should rejoice at finding that much!) Jurassic Park type reconstructions of native life form populations are most unlikely.

If an ecosystem does survive, we could not hope to see any significant further evolution (beyond anecdotal differentational radiation of surviving species into new niches in a restored or rejuvenated more benign climate) within the lifetime of humanity, even if it be a million years - and not even if we succeeded in restoring, permanently, the former more life-accommodating climate with a stabilized all-Martian biosphere and biota. Romantic ideas to the contrary should not be entertained. We would be left with only pre-metazoan life, one-celled plants and animals - nothing we could see with the naked eye! **So rather rejoice that Mars is empty of life!**

**It is not precise to say that Mars is "barren."  
Only that it is "virginal."**

That is not the end of the story. That Mars has no life, and quite possibly never spawned life even in earlier wetter and warmer times does not make the planet "barren". It only makes the planet "virginal". That conditions may have never been special to allow life to rise on its own, does not mean that life, originated elsewhere, and then bioengineered to fit Martian conditions, could not be successfully transplanted to Martian soil, with intelligent guidance, corrections, and compensations. That is a tall challenge, however, but we hope to sketch how it



might be accomplished. Or at least, the first steps one intending to green the planet might take.

The biological side of Greening Mars would have to be brought about “pari passu” i.e. step by step together with the geological rejuvenaissance of the planet. Rather than “terraforming” Mars by making it a copy of Earth, rejuvenaissance looks not at Earth, but the early Mars itself, for its standard of achievement. The planet does need to be warmed, first to the point where a third of the atmosphere no longer freezes out over the poles each winter (twice a Martian year, during northern and southern winters, i.e. paradoxically during southern and northern summers, i.e. atmospheric pressure is at its height only during spring alias fall). Warming it still further will free up additional carbon dioxide bound up at the poles or in permafrost year around. Both temperature and pressure have to be increased to the point that liquid water can exist in the open, even if only as seasonal dews.

But in this article, we want to look at the biological part of the equation. Obviously we want to, have to, use genetic material from sundry terrestrial plants (possibly animals too) and arrive at species hardy enough to survive and breed on a rejuvenated Mars.

What we have to start with is, species after species, a long way from being remotely Mars-hardy. The harshest most demanding habitats on Earth are all much friendlier than the friendliest place on Mars, even possibly on the wetter, warmer Mars of yestereon. Where do we start? How do we proceed?

The most severe habitats on Earth are the deserts, the Andean altiplano of Peru and Bolivia, the tundra of northern Alaska, Canada, Greenland, Scandinavia, and Russia-Siberia, and the Antarctic islands, shores, and “dry valleys.” No trees grow in these areas, not even the stunted, wind-grotesqued caricatures we find at the tree line on mountain slopes and at the tundra limits. Animals fare better, thriving on seafood, other animals and very lowly plants.

Animals, however, need an oxygen-rich atmosphere, which we don't have, have never had, on Mars. Plants, in contrast, thrive on carbon dioxide – it has been shown that most plants can be grown successfully in an artificial atmosphere of reduced pressure (e.g. 1/10th normal) of just carbon dioxide, the major component of Mars air. That is to say, that plants and crops can be grown on Mars in greenhouses pressurized with warmed Martian atmosphere, simply compressed tenfold – nothing else added, besides water, of course. That we could gradually lower temperature and pressure to meet the improving Mars climate halfway with bioengineered species that could be planted outdoors either to be tended and cultivated or left to grow wild is the general idea.

We call this redhousing, rather than greenhousing. We are using the air of the red planet Mars and an improved but still Martian climate – not the air of Earth and an idealized terrestrial climate. This is not to say we shouldn't have traditional greenhouses on Mars. We do have to eat and clothe ourselves and provide for pharmaceuticals and other needs, day in and day out – while we are busy in the redhouses preparing to mate a rejuvenated red planet with a blanket of life bred and engineered to go native there.

Will there someday be forests on Mars, with real trees even if they look unearthly. That's a possibility beyond our vision. Our starting point will likely be the lichen, a moss-like plant that is basically a fungus able to survive thanks to a symbiotic relationship with green algae. That this feat is cooperative is discouraging, that we have to start with a very specialized complex – compound creature. The best place to start in any plan to evolve a radiant family of diverse species is with something very generalized, able to survive in a wide range of habitats. But thankfully, we have many species of lichens in the northern hemisphere and a few in the southern.

But are lichens the only starting point? Not necessarily. Many plants handle annual freezing in stride, but the much longer, much **deeper freezes** of Mars would likely be to much for them. Witness the tree line!

Some antarctic organisms in the animal kingdom, come equipped with an intracellular antifreeze – glycol. But plant cells have protoplasm as well. If the gene responsible for the

ability to produce glycol can be transferred successfully to some plants, that might give us additional breeding stock for Mars. The more starting points, the more diverse the ultimate possibilities, the more niches on Mars that can be greened.

But hard long freezes are not the only challenges Mars poses. Severe **desiccation** is another. Desert plants, like cacti and other “succulents” withstand prolonged very arid stretches well. On Mars the desiccating capacity of the cold parched winds is extremely intense. What the cacti and other desert plants have to offer, will not be enough. But it is a start. Nor is there any reason why the glycol gene cannot be added to the genetic consist of desiccation-hardy plants, and vice versa. Chile’s **Atacama**, California’s **Death Valley**, NW China’s **Takla Maklan** are among the most challenging niches for desert life.

And then there is the untempered **ultraviolet** of the more distant, cooler, Martian “Sun”. Mars tenuous atmosphere without free oxygen (O<sub>2</sub>) or ozone (O<sub>3</sub>) is transparent to this tissue-killing radiation. Here on Earth, the most UV-resistant species are those that live at very high altitudes. The nearer to the equator, the higher up the maintain slopes does life thrive. Plants growing wild in various niches of the Peruvian-Bolivian altiplano (high altitude 13,000–15,000 ft. intermountain basin-plateau between the Western and Eastern Cordillera) may yield genetic contributors to this resistance. — a third ingredient.

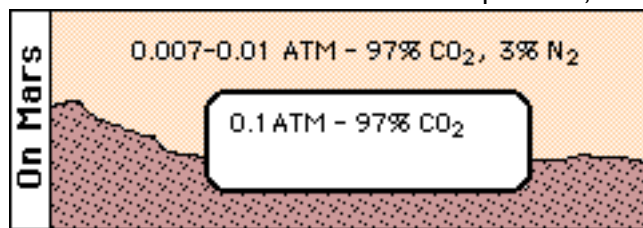
We must add one more characteristic. On Earth many plants are pollinated by insects and birds. Bioengineering animals to breath a carbon dioxide atmosphere seems science-fantastic, not merely science-fictional. So we may want to end up with plants that are **wind-pollinated** or use some other assist than the help of sweet air breathing animal species.

The list of favorable attributes doesn’t end here. We could select also for **abrasion resistance** to wind-borne dust, **low reproductive rates**, **interruptible life cycles**, etc.

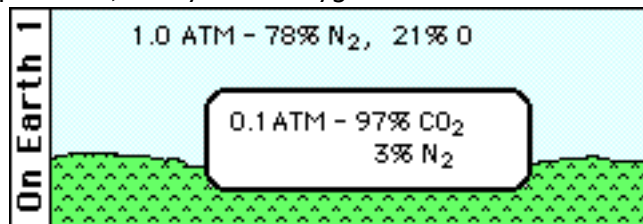
What plant forms will be most receptive to such diverse genetic additions? Your guess is as good as mine. It is not impossible that the best Mars-hardy hybrids will have as ancestors plants that boast none of the assets mentioned, but will have proven receptive to all of them.

Nor do we have to wait until we are on Mars to begin the experimenting. There are so many candidate plants to start with, so many recombinant genetic combinations to be tried. The sooner we begin, and the more the facilities we set up, the sooner are we likely to have our optimism and enthusiasm rewarded – or discouraged.

On Mars, all we will need is a shelter that holds compressed, warmed Martian air.

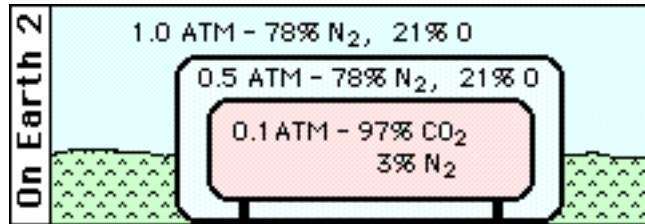


On Earth it will be a little trickier. Unbuffered, the facility would be subject to inexorable leaks from the higher pressure, vastly more oxygen-sweet air of the host planet:

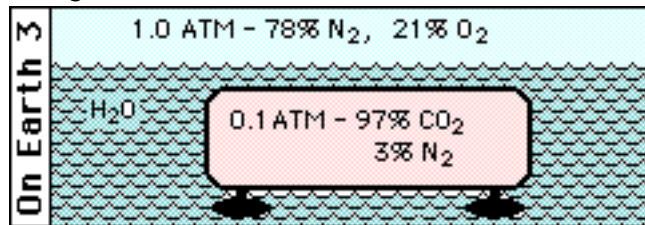


One way we can buffer the facility and prevent hasty degradation of the special atmosphere within, is to use a surround chamber with either Earth air or Mars air at relatively low pressure. Air would tend to leak out of the red house chamber, preserving quality, with makeup quantities from special tanks. If pressure in the surround got to high (too close in value

to that of the inner chamber) the excess could be pump- exhausted to the outside terrestrial atmosphere.



Or the redhouse could be covered and buffered by water in a host lake or pool or tank. This would also tend to prevent atmospheric contamination. A wet porch could not be used for entry, however, as oxygen dissolved in the water would outgas into the carbon dioxide atmosphere within, polluting it.



### An Art of the Possible

The strategy is one of convergence, breeding ever more cold, drought, and UV hardy species for ever more Mars-like conditions in Mars redhouses. Meanwhile, outside the actual Mars climate is improved by human activity and intervention. In fact, the degree to which these experiments are successful, will codetermine the goals set for rejuvenaissance of the planet. Like politics, the greening of Mars will unfold as the art of the possible. As politics should be (but isn't) it will also be the art of "co-promise," not "com-promise"- what can be achieved in improving the climate, temperature, pressure, and wetness of the planet - and what can be achieved by recombinant DNA biological engineering and breeding for Mars-hardiness. We can only speculate at the results.

### The Role of Intervention

On Earth, and most likely on all life-bearing planets, evolution has not been smoothed. Each outburst of new species origination slows into a self-stabilizing rut, impeding further progress. It is the periodic decimation of existing species by comet and asteroid impacts that has cleared the way for new evolutionary growth. The future of redhousing will include man-made catastrophes to severely purge prematurely stabilizing indoor ecosystems and clear the way for new rounds of the game of survival of the most (man-determined) fittest.

### Redhousing and the Plan for Mars

As progress allows us to preview the eventual results, we will know better what areas of Mars to set aside as future areozoic parks and preserves. Low-elevation basins and canyons will have the highest atmospheric pressure, the warmest temperatures (latitude for latitude) and be the first to experience dews and eventually free standing and/or flowing open water. The Mars Orbital Laser Altimeter aboard the Mars Global Surveyor (November '96 launch, September '97 arrival) will give us a good idea of where these oases-to-be are located. We will then even be able to speculate about setting aside right-of-ways for future parkways.

### Redhousing in the Grand Design of Things

To return to the point we made at the outset, if Mars is devoid of life, that makes it a virgin world, not a barren one. The cosmic vocation of humanity, unsuspected by all the world's pretentious scriptural traditions, may indeed be to bring life to places where it can survive, but never originate on its own. Only an intelligent species can serve this function. Humanity then

becomes “the” reproductive organ of Gaia (meant as the name of Earth–Life in aggregate, not as some mythic meta–individual).

Further, through interstellar flight, even if it only be of ships bearing nothing more than seeds, spores, and fertilized eggs, this particular human vocation takes on a more general Cosmic significance, in the Solar neighborhood (probe–reachable limits to be determined!) beyond this nursery womb–world nano–turf we call Earth. DMM

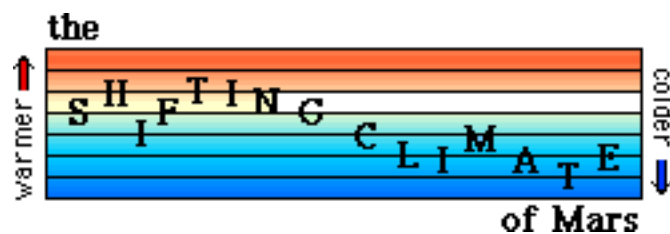
### Make a Mars “Redhouse”

- with controls, entry safeguards etc.,
  - as a chapter project
    - or school science project
    - for public display, including at ISDCs

Be a Doer, not a Watcher.

The watcher is likely to be disappointed.

The doer has the comfort of knowing  
that he has tried, and perhaps laid foundations,  
for others who follow, and may reach the goal.



### And the challenges for those needing data points for their terraforming schemes

By Peter Kokh

Those brave optimists who attempt to put together various schemes to bring about major climactic and environmental changes on Mars in order to render the planet much more appealing a destination for would be Earth–forsaking homesteaders, can at present do little more than B.O.E. (“back of envelope”) calculations of the material and energy inputs and relocations needed to bring about such changes.

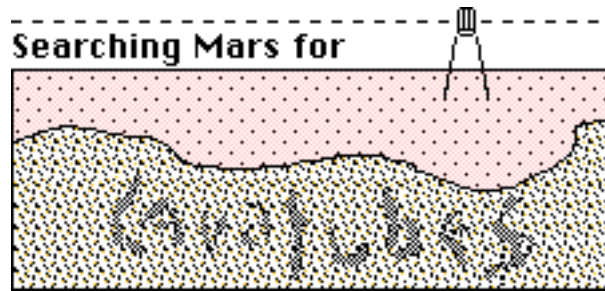
Whether the goal is “**terraforming**” (making Mars another “Earth”) or “**Lowellification**” (making the planet at least as friendly as we thought it was fifty years ago), or “**rejuvenaissance**” (“restoring” Mars to its wettest and warmest former state of about three billion years ago), the equations are hard to work without good data about the present.

In point of fact, despite all the revelations of the Mariner and Viking missions, we know much less about the Mars of today, than most writers will admit.

- (1) We don’t know within two or even three orders of magnitude how much water remains on Mars, locked up in the polar caps, in subterranean aquifers and lakes, or chemically bound up in hydrates, or frozen in the interstices of soil particles as permafrost. Nor is such vital information the target of instruments aboard presently budgeted missions to Mars.
- (2) We don’t know how much carbon dioxide is locked up in clathrate frosts at the poles, nor how much may be chemically bound up in sedimentary carbonate rocks or limestone layers.
- (3) We have only a very crude idea of the relative altitudes of Martian surface features, and thus only a very imperfect idea of potential drainage basins and watersheds. Fortunately, this ignorance is being addressed by the **Mars Global Surveyor** ready for launch later this year.
- (4) Hubble has shown that what we thought we “knew” of Martian temperature ranges, was pegged to a transitory condition.

Apparently, mean temperatures on Mars have dropped an astonishing 20° in the two decades since Vikings I and 2 established weather stations on the planet. By comparison, a mere 2° rise in terrestrial temperatures worldwide, would cause environmentalists and meteorologists and climatologists to reach for the panic button.

At the moment, we have no idea how long-lasting this cooling will be, nor even if the downward swing has bottomed out, nor on what timeframe such meta-seasonal changes take place. Given that, brainstorming pathways to a friendly future are interesting fantasies and no more. As they say, “garbage in, garbage out.” Yet carefully designed future missions could tackle each of these points of our ignorance quite well. **MMM**



SEARCHING MARS FOR LAVATUBES

## **Mars' vast shield volcanoes & lava sheets are prime territory for lurking lavatubes & prime real estate for the New Martians**

By Peter Kokh

Whatever geological and scenic attractions may beckon siren-like to the first manned Mars expeditions, the “California” of future waves of Martian homesteaders is more likely to be the expectedly lavatube riddled shield volcano flanks of Olympus, Arsia, Pavonis, Ascraeus, and Elysium – and likely similarly endowed vast lava sheets of the attendant Tharsis uplift region.

The pre-excavated radiation shelter and the thermally buffered retreat of the tubes will make any settlement establishment much easier, giving it a considerable head start, as well as an enduring advantage. Mineralogical assets will also count, of course. And happily, the Tharsis region impinges on the head of the great Valles Marineris canyonland complex where many strata of rock will lay revealed for prospecting ease. **Pavonis Mons**, a great shield volcano already cited as possibly the most strategic mountain massif in the entire Solar System, its western flank the ideal site for a launch track complex, neighbors this canyonland head region on its eastern flank. [Cf. MMM # 18 SEP '87, pp. 6-7 – MMM Classics #2]

But all this is little more than reasoned speculation. We do know what kind of terrain sports lavatubes on Earth and we do see analogous terrain on Mars. But that's it. On the Moon we have the added advantage of seeing actual examples of partially and wholly collapsed lavatubes (e.g. Hyginus and Hadley Rilles, respectively). Surveying such features on the ground will take generations. If we can search for them with orbiting instruments, our pre-settlement “treasure” maps of Mars will be enormously more helpful and propitious.

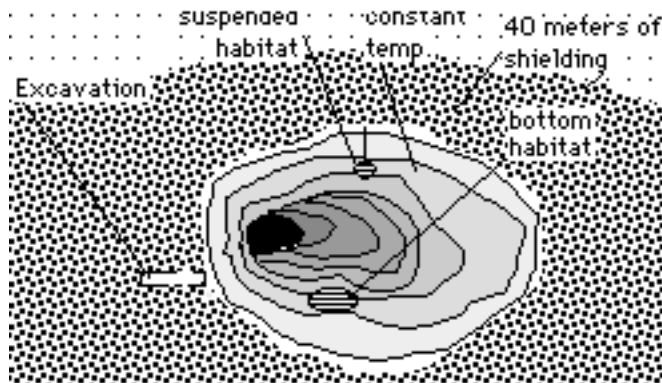
While many, if not most tubes may lie within lava sheet layers that have been subsequently buried by later flows and thus be well below the surface, those in the uppermost flows should lie near enough to the surface to be detectable by appropriately tuned radar.

Cf. MMM # 44 APR '91, p. 6, in which we report on the suggestion of Tom Billings of Oregon Moonbase (and published in Oregon L5's **Starseed**) that since airborne radar had been used successfully to find lavatubes on the Big Island of Hawaii [i.e. the Mauna Loa / Mauna Kea shield volcano complex], given the dryness of the lunar [and Martian?] surface, it should be possible to map near surface tubes with orbiting radar. To penetrate deeply enough we would need a wavelength of 5-20 meters, meaning an antenna 20-80 meters across.

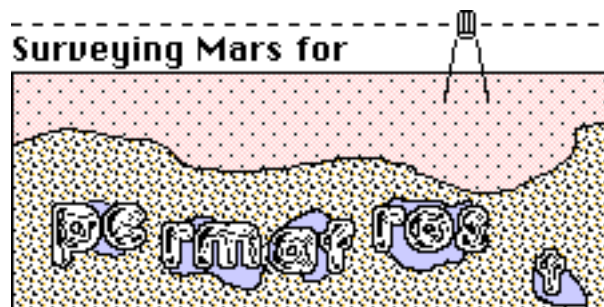
Given our experience with the quixotic results of some of the Viking lander experiments, it only makes sense to fly such instruments first in low Earth orbit. We can then compare the findings with known “ground truth” and check the verisimilitude of the readings and better correct the calibration. Finding unsuspected tubes in various regions on Earth may be reward enough to merit such a precursor mission.

This being done, a second such orbiter mission could do its tricks in orbit above the Moon, adding enormously to the practical knowledge necessary for intelligent planning of lunar development scenarios. The third tubefinder mission would head for Mars polar orbit. Lessons learned at Earth and at the Moon would allow mission planners to fly the leanest and lightest and least expensive probe to Mars capable of doing the job usefully well.

Would permafrost deposits interfere with the readings and conclusions. Not likely, as the radar wavelengths for the former are LONGER – SHORTER by a factor of X. However the radar instrumentation needed for the two global searches would seem to make made-in-heaven bus mates — a “tundra and tube” mapper. If we did find permafrost and tubes in the same region,. and we may not, that would mark the location as especially attractive for settlement development.



**LAVATUBES AND THEIR USES:** On Earth, these features are typically a few tens of meters wide and high and hundreds to a few thousands of meters long. On the much less gravid Moon, and with the scale of Hadley Rille as evidence, we expect to find lavatubes hundreds of meters wide, and many tens of kilometers long. On Mars, with its in between 3/8ths normal gravity, we might expect such features to be in between in size, say 50–100 meters wide and a few kilometers long. On both Moon and Mars, “tubing” will be a major outdoor hobby, akin to limestone cave spelunking on Earth. **TTTTT**

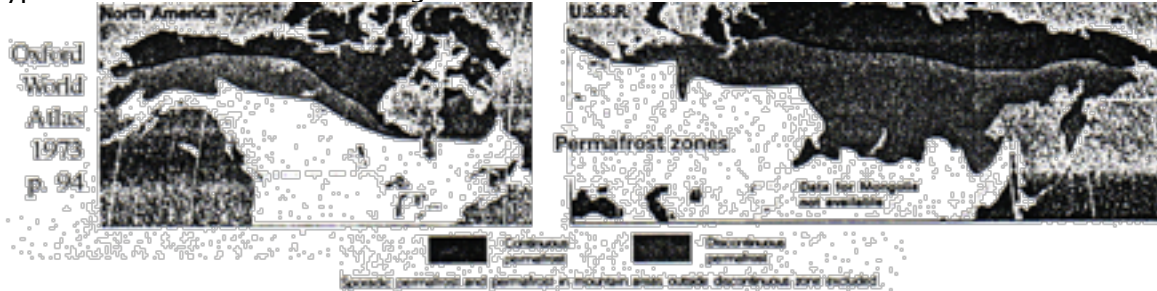


By Peter Kokh

**PER•ma•frost:** [from perma(nent) + frost] perennially frozen subsoil. Also called pergelisol.

### Where do we find permafrost (on Earth)?

We find permafrost mostly in circum arctic lands of Alaska, Canada (Northwest Territories, northern Quebec, northern Labrador), Greenland, Iceland, Scandinavia (Norway, especially), and Russia–Siberia. Permafrost is the soil condition that manifests itself in “tundra” type no-root or shallow-root vegetation.



[loc. cit.: Permafrost can be differentiated into 3 main zones: (a) continuous permafrost, where very little land is unfrozen and where permafrost may reach depths over 600 meters or 2,000 feet; (b) discontinuous permafrost, where patches of unfrozen ground occur; and (c) sporadic permafrost, where patches of permafrost occur in a generally unfrozen area. Overlying the permafrost is an ‘active’ layer of rock or soil which thaws in summer and freezes in winter.]

### How does permafrost form?

Permafrost forms in ground water areas through gradual transition to ever more severe winters and ever shorter and cooler summers. The deeper the ground water penetrates, and the greater the water content per volume of soil, the thicker and richer the permafrost layer.

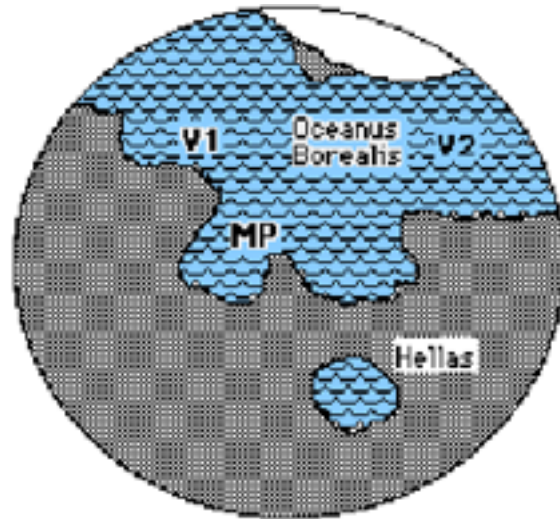
### Why there may be extensive permafrost deposits on Mars?

There is abundant evidence from high resolution Viking photos of landforms for which the only plausible explanation is that they were formed by water: tear drop shaped islands in the middle of large valleys, relic beaches and ancient shorelines, wave-sculpted dry lake and sea shore bottoms, deltas and estuaries, flood-carved channels. From such evidence, it has become clear that Mars even sported a respectable northern hemisphere ocean that once covered more than a third of the planet to respectable depths. Not all of this water could have evaporated or sublimated into space. Archaic water-saturated lake and sea bottoms should have retained their water content as the climate got colder and the ground froze to deeper and deeper levels.

### Where on Mars is permafrost most likely to be found?

The likeliest areas of significant permafrost deposits are the ancient northern ocean bottomlands, deep major impact basin bottoms like Hellas and Argyre, and canyon bottoms (especially the outflow areas like the Ares Valley landing site for the **Mars Pathfinder** lander. Unfortunately, this lander is not providentially equipped to test for permafrost underfoot. It is typical that the kind of knowledge most needed to assess settlement feasibilities is low on the priority list of planetary scientists interested primarily in scratching the itches of their own narrow scientific curiosities. Both Vikings likewise landed in areas in which we might expect to find substantial permafrost deposits, a condition that went untested.)

Permafrost could have formed in adjacent areas not covered by standing water through the lateral spread of ground water, and in still other areas if subject to seasonal rainfall.

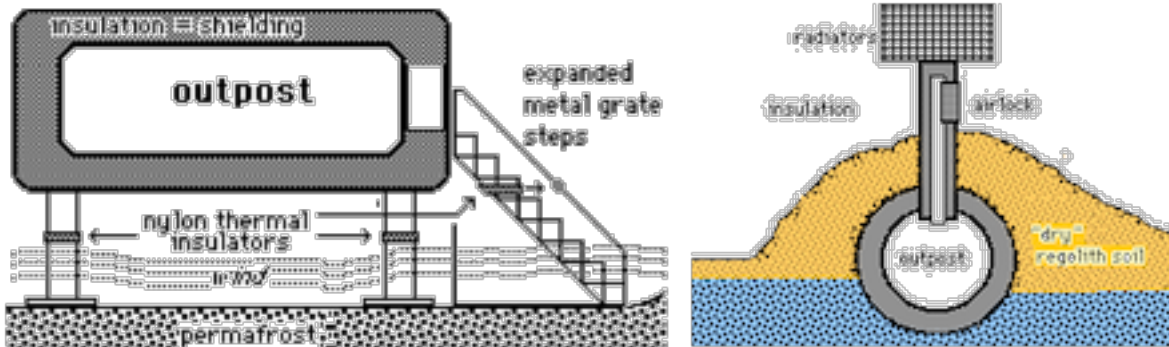


**What, if any, would be the significance of permafrost on Mars for future settlement / development?**

**On Earth,** (a) permafrost renders the land agriculturally unproductive, although tundra lichens and other vegetation is sufficient to maintain a large wildlife population of caribou, rabbits, and other hardy arctic fauna. (b) Buildings must be set on bedrock or thermally isolated from the ground, commonly by use of stilts made of materials with low heat conductivity, along with effective use of insulation to prevent heat radiating from the bottom of the building to frozen soil below. Stilts raise the underside of the building high enough above the ground to allow free air/wind circulation. (c) Road building creates special problems: special measures had to be taken during the construction of the Alaska Pipeline.

**On Mars,** seasonal thaws may not be a problem at first, but may become more extensive as activities, planned and unplanned, lead to a significant warming of the climate.

- (a) For this reason, outposts in permafrost areas will be especially challenging to build and maintain. Settlement may be limited to areas of patchy permafrost, with construction held to frigid but not ice-saturated soil and rock areas.
- (b) Only those areas where the 'topsoil' is 'active', i.e. thawing seasonally, will be colonizable by bioengineered Mars-hardy plant varieties developed in an aggressive redhousing program.



**Left:** Mars outpost on stilts-insulated ----- **Right:** Mars subsurface outpost-insulated





Above: Mars subsurface outpost in “patchy” area

### How can we tap permafrost water assets?

- (1) We could strip mine the permafrost layers and then run them through melting ovens on conveyors, redepositing the dried soil back in place, all in one operation. This could be more mechanically difficult than it sounds, with lots of equipment breakdowns, given the hardness of the soil/ice aggregate.
- (2) We could heat the deposits in situ (in place) and then pumping out the freed and liquefied water if excess waste heat at a high enough temperature is available. This requires drilling holes for heat conducting rods or superheated steam pipes. Such waste heat would be available if the outpost had a small nuclear plant both for heat, power and for extraction of various atmospheric gasses.
- (3) We can cover the frozen ground with an “infrared-black” plastic tarp and apply concentrated solar heating.

Which ever method we use to extract the ice-melt, it may be necessary, if the water proves to be saline, to distill the melt to purify it of salts (and possibly heavy metals). A few “ground truth” cores taken by rover drilling probes would soon establish just how fresh or how brackish the permafrost ice is, and whether it varies in quality from place to place.

Excess water produced by an outpost’s local permafrost tap may then be trucked, or airlifted, or eventually pipe-lined to other less advantaged settlements and outposts. Thus, water could well be the first real intra-Mars trade commodity. (A futures market, anyone?)

### What alternative sources of water are there?

Other most options for providing water needed for drinking and hygiene, agriculture and life support, processing and manufacturing do exist:


(1) Nuclear powered atmospheric hydro-extraction plants are certainly feasible. In 10,000 tons of Mars air, there are 3 tons of water vapor, i.e. 0.03%, plus 7 tons of oxygen and 270 tons of nitrogen, both of which would also be extracted as byproducts. Each outpost or settlement is likely to have such a plant anyway, to produce carbon monoxide and methane fuels as well as fresh oxygen and nitrogen. The question is, will such a plant produce enough water in the process to meet demands, or will this “air-water” need to be supplemented?

(2) A much bolder and higher cost option would be to mine ice from the edge of the north polar cap (the southern cap may be mostly carbon dioxide frost). Melted, this glacial melt could then be trucked (requiring roads or ground effect vehicles) or (especially later as population on Mars and demand grows) a network of aqueducts would follow the paths imagined by Schiaparelli and Lowell from the north polar cap southwards. (cf. MMM #62 FEB ‘93, pp. 6-7 “CANALS on Mars” [republished in MMM Classics #7] and MMM #73 MAR ‘94, p. 5 “Canal Names” – Read in MMM Classics #8) One or both of these options can serve “ice-dry” areas of Mars.

### Putting together a Mars Permafrost Map – Now

Because extensive permafrost zones are found here on Earth (some continuous, some discontinuous, some patchy), we have an ideal opportunity to fly the needed radar instrument package in polar Earth orbit to both test how well it can detect permafrost and to properly calibrate the instruments by checking their readings with actual data on the ground, so we will have greater confidence in interpreting the readings we get in flying an identical instrument

package around Mars. We need to determine how well depth of the layer below the surface, ice content percentage, and thickness of the deposits are indicated in the readings, and whether differences in salinity or other factors affect the data points we get.

If flown alone (not with lavatube radar) as a US – Russian mission, **Bering** (Russian-born explorer of Alaska, Vitus Bering) might be a good name for the probe. **Mars Permafrost Mapper** would be an alternate choice. 

## A Space Frontier Tech Demo Program

IDEAS for Lo-budget feasible demonstrations of technology items needed or useful on the Mars Frontier

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\* The following suggestions by no means exhaust the possibilities and readers are encouraged to think of, pre-brainstorm, and report to MMM of other neat doable projects that will help bring home to all of us, veteran space enthusiasts and general public alike, the concrete doability of space pioneering on the Moon, Mars and elsewhere in the Inner Solar System.

### The “Mars Engine”

The goal is to produce a motor vehicle engine for use on Mars that will burn fuel and oxidizer derived from Mars’ atmosphere and whose combustion products will return to the atmospheric gasses from which they were derived. Two fuel combinations are possible: “**Carmonox**” engines will burn carbon monoxide ( $2\text{ CO} + \text{O}_2$ ); “**Methanox**” or “**Oochie™**” engines will burn methane ( $\text{O}_2 + \text{CH}_4$ ). Methane is the more powerful fuel and will be the fuel of choice if reasonably salt-free water can easily be produced from permafrost taps.

The GOAL of this tech demo is not a vehicle chassis suitable for Martian terrain, but an engine that can be used in any such vehicle: car, truck, coach, caterpillar, etc.

START: There are now any number of experimental methane burning vehicles already on the road. REPLACE the carburetor with bottled oxygen and combine with the methane in an INTERNAL COMBUSTION cycle, not a rocket motor.

### A Mars Airplane

The density of Martian air at average surface levels is equivalent to the atmospheric pressure on Earth at 125,000 ft., an altitude that can be reached by a balloon-mounted platform. DESIGN, BUILD, and FLY an unpiloted airplane to and from such a platform – at or during ISDC ‘98 Milwaukee.

Paul Swift of the Ontario Space Society (ISDC ‘94 Toronto) has expressed an interest in taking up this challenge.

### Mars Meteorburst Experiment

Meteorburst communications in which messages bounce off the electronic debris trails of incoming meteors high in the atmosphere have been used successfully for over-the-horizon communications by long distance trucking companies. The devices never having to wait more than a second or two before finding a suitable placed meteorburst.

Because these events occur high up, this system also should work well on Mars, as a reliable backup to a more expensive to deploy and maintain satellite communications system. DESIGN, BUILD, and FLY such a system, again aboard a balloon-hung platform at an altitude of 125,000 feet.

### Igloo shielding sebatier reactor

Can shielding be manufactured by a sebatier reactor from atmospheric components on Mars? If so, a small nuclear thermal power plant could enshield a telerobotically landed Mars

habitat module or complex without disturbing the boulder strewn and possibly permafrost hardened soil all around the campsite to be.

One possibility, in theory, is DiNitrogen Pentoxide, N<sub>2</sub>O<sub>5</sub>, which is a white powder throughout the whole range of Martian ambient temperatures. It is dangerously chemically unstable, however. A much safer product would be simple carbon (graphite) dust, powder, or crystals.

DESIGN, BUILD, and DEBUG a sebatier reactor device to start with a Mars-like atmospheric mix and end up with such an inert thermal shielding powder. Make note of any potentially useful atmospheric byproducts produced in the process.

### **Mars Hovercraft or Skimmer**

Traversing Mars boulder-cluttered strewn-fields will be slow going and impede easy, frequent, and timely travel between outpost sites on Mars by wheeled vehicles or legged walkers. A hovercraft which could skim over such routine obstacles at speed would open up the planet like nothing else could. Mars' low atmospheric density, however, makes a traditionally designed hovercraft infeasible. If the weight of such a vehicle, with cargo and fuel, could be partially (say 90%?) compensated by hydrogen aerodynamically styled buoyancy bags, perhaps such vehicles could work. Hydrogen is safe to handle on Mars where there is no free oxygen to speak of.

DESIGN, BUILD, TEST, and DEBUG a scale model Mars Skimmer.

### **A Mars "Redhouse"**

Unlike a "greenhouse" which maintains terrestrial plants under Earth-normal ideal growing conditions in less than ideal climates, a "redhouse" would be pressurized with relatively pure Carbon Dioxide, CO<sub>2</sub>. BEGIN with the hardiest plants known on Earth, lichens and other tundra plants; plants that thrive in the high altiplano of the Andes, and at the tree line of other high altitude areas; plants that thrive in desert conditions; plants which survive intense cold.

The eventual goal of "redhousing" will be to breed ever hardier and hardier hybrids which someday may take hold and survive outdoors on a Mars where human intervention has succeeded in meeting them halfway by raising the carbon dioxide atmospheric pressure and ambient temperatures.

#### **HOW TO PROCEED: The game plan:**

- Gather a team with the right mix of expertise, • Brainstorm a design
- Price the materials and tools that you will need • Make a presentation to potential corporate sponsors

## **Mail Box**



### **Is Mars more impact-prone than Moon?**

It would seem to me, that settlers on Mars could be more exposed to meteorite bombardment than pioneers on the Moon. Mars weighs in some 5 times heavier than the Moon, giving it more gravity [3/8ths vs. 1/6th Earth-standard] and hence a bigger/wider/deeper gravity well. This means it will "catch" more asteroidal and cometary debris, and impose on it higher velocities of acceleration prior to impact.

Mars tenuous atmosphere will burn up the micrometeorite stuff, so that Mars' surface is not subject to the steady 'rain' that the lunar surface undergoes. It would follow that the dust

on Mars is from weathering, rather than impact “gardening.” But the larger stuff will not be stopped and much will get through that incinerates in Earth’s much thicker atmosphere.

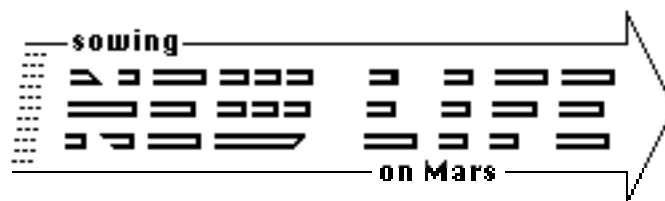
Further, Mars is much closer to the main asteroid belt and probably is exposed to a thicker concentration of debris than the Earth–Moon system.

We should not be misled by visual and photographic comparisons of the Martian and Lunar surfaces at various resolutions. Unlike the Moon, Mars experiences real weather (wind, and scattered freeze–thaw cycles) and formerly underwent major episodes of volcanic activity. This gives its surface a deceptively younger, less impact–scarred look.

Not to scare anyone away. The heavy lunar bombardment we see happened mostly more than 3 eons [3 billion years] ago, and danger to pioneers will be less than us terrestrials face in volcanic eruptions, earthquakes, hurricanes, tornadoes, lightning, avalanches, landslides and other catastrophes from Earth’s active geology and weather systems. The same should be true on Mars.

Thomas Heidel, Milwaukee, Wisconsin

EDITOR: Thanks Tom. You have summed up the situation accurately.



A book review of the second in the epic trilogy of Martian Exploration and Settlement

## GREEN MARS

Kim Stanley Robinson

Bantam Books, New York 1994 ISBN 0–553–09640–0 (HC)

Reviewed by David Dunlop, LUNAX Corp.

I enjoyed **Red Mars** immensely. **Green Mars** was a continuation of the pleasure. Many of the same characters appear in the narrative and the Marsscape and supporting technology picture is essentially the same. **Green Mars** is a continuation of the saga of Mars–a–forming and paints a picture more focused on the psychological struggles and political and sociological tensions of the development of a three world economy.

Kim Stanley Robinson favors the dark side of the human and political character in developing his scenario of the Martian future. His portrait of unrelenting corporate greed and manipulation of the political and financial investments in the development of Mars provide the backdrop for the emerging Martian identity and struggle for a self sufficient independence.

In **Red Mars** a gigantic orbiting tether is built from asteroidal resources to provide an elevator to orbit from the Martian Surface. This is destroyed by Martian settlers focused on independence. In **Green Mars** they build another one.

One missing component of this Saga is sufficient background on the context of Earth politics which are assumed to be driven by disintegrating economic and environmental circumstances. If there is any potential weakness in Robinson's formulation it may be that an Earth not in pursuit of its own advantage could not be rationally foreseen to continue to make enormous investments in Mars. From historical grounds one cannot question that Robinson's picture of human motivations in initiating a colony or attempting to continue to control the colony and protect the investment in the colony is unrealistic. However the sustaining economic and political commitments that settling and terraforming Mars will require will also require a political and economic structure than provides a continuing flow of benefits to those on Earth. It is difficult to imagine a sustaining commitment to Mars that would not be more

benign in terms of the polarization that massive destruction and war create. It is also clear that great economic growth in the aftermath of war occurs as a result of technology developments made for the waging of war.

The Moon as a staging area for Martian settlement and the base of an Earth/Moon economy are not clearly visible as structural precedents of the Martian development. One could just as well have argued for a saga that followed more of an Antarctic base buildup than the explosive expansion pictured in Red Mars and **Green Mars** would be more likely. The nanotechnologist would of course dismiss all of this as a quaint picture of pre-nanotechnology scenarios.

The more benign scenarios I have suggested would of course deprive Mr. Robinson of the dramatic backdrops of violence. Where (in the solar system) would the poor novelist be without sex and violence? Out of the popular market I'm afraid.

There is little in **Green Mars** to dissuade me from looking forward to the next in the Trilogy **Blue Mars**. After all if you are stuck in the house during a spell of 30 below weather would you rather spend an afternoon in the tub reading about the dramatic adventures of the nanobots? DD

### **Serious Non-Fiction on the Topic**

Schemes for long term terraforming of Mars abound.

The following book has a proposal for a quicker fix.

### **The Greening of Mars**

Michael Allaby & James Lovelock, 1984

The authors propose that the world stockpile of CFCs be payload for the world's stockpile of ICBMs, all retargeted for Mars, where the CFCs would contribute a maximum "greenhouse effect", putting the temperature of Mars over the threshold where the carbon dioxide trapped in the polar caps would permanently melt, thickening the atmosphere to the point that liquid water would be stable on the surface and the "greening" of Mars with hardy genetically reengineered plants from Earth could begin.

They see no place for animals in this scheme. The thickened atmosphere would be fine for plants but unbreathable to humans, so the latter would continue to live in pressurized habitats or underground cities [with their pets, and urban wildlife, the author's indifference to animals not withstanding!]

James Lovelock had previously co-authored the more widely read book "**The Gaia Hypothesis**" with noted biologist Lynn Margulis. <MMM>

**MMM # 103 - MARCH 1997**



## The Moon “and/or” Mars

The Space Advocacy Movement has been so conditioned to the politico-economic reality of fixed and shrinking budgetary pies that taking sides, Moon or Mars, seems the only logical framework for action.

It has always been the posture of MMM that we “have to” find a way to do both, or we will end up doing the “winner” badly. This month’s editorial and the articles in this issue address this critically patient “choice for both”

### Outlining a Comprehensive Mars Fossil Discovery & Mapping Program

One or two robotic missions to Mars targeted on the basis of long range site assessment will only yield a “garbage in, garbage out” picture of early life on Mars.

**“If it’s worth doing, it’s worth doing right!”**

By Peter Kokh

### Relevant Reading from past Issues of MMM

MMM #83 MAR ‘95, p. 7: “Searching for Old Life on Mars” [republished in MMMC #9]

MMM #93 MAR ‘96, p. 3: “MMM’s Platform for Mars” [republished in MMMC #10]

### “Course Prerequisite” Missions

In college, you cannot take calculus without first having taken algebra, geometry, and trigonometry – these are course “prerequisites” and without a reasonable familiarity with them a student cannot be expected to grasp the essentials of the new course. So it will be, “going to school on Mars” in search of an understanding of its presumably extinct life-forms whose traces may be found here and there by “lucky strikes” in the geological record. We need to prepare ourselves for this study and search by prerequisite work in contextually relevant areas.

Admittedly, we are still discovering ever more and more about the geological context of paleontology research on Earth. But our present picture of Mars is not advanced enough to earn the rating of “sketchy–” Any “Report on Fossil Evidence of Early Mars Life” would be of “C– high school caliber” if basic geological and topographic precursor missions have not been undertaken, and their data analyzed beforehand. Such precursor missions will be even more important for the success of any proposed human fossil-hunting expeditions to Mars, lest we waste exceedingly expensive “manhours” on a world it has cost us so dearly to reach.

The following missions would give robotic and human fossil hunters both a better idea of where to look, and a better understanding of what they are seeing, when and if and wherever they find some apparent life-trace:

- **Mars Permafrost Explorer & Ground Truth Permafrost Tappers** — Where the water is now, will give a more complete picture of where it was in a wetter past. We now have only Viking Orbiter photos of riverine and beach landforms to go on.
- **Mars Topographic Mapper** – With accurate elevations from which primitive basins, watershed divides, and drainage patterns can be sketched. This knowledge will help illuminate how life may have spread across Mars.
- **Geochemical orbital mapper** — A re-fly of the instruments aboard Lunar Prospector might reveal many mineralogical clues to understanding whatever life traces we find.

- **Creation of a an “Age Map” of Martian Surface Features** — showing the relative ages of various Martian landforms and strata (argued from morphology, cratering and splash out sequences.)

Geochemical ground truth probes, needed to qualify and calibrate readings from orbit could double as fossil-hunting probes. The same goes for permafrost ground truth probes. But in both cases, we will now have orbital information and on site readings that shed light upon what we see with whatever fossil-detecting instruments we have on board.

### **Fossil & Ecosystem Discovery Missions**

Presumably, our consensus international goal in this effort is not just to find incontrovertible on site confirmation of ancient microbial life on Mars. We will want to develop a[n always tentative] picture of its levels of attainment and evolution, of its diversity, even of its ecosystems. And we will want to ferret out which nucleic acids it was based upon, and what systemic genetic similarities and differences there are between presumably native aboriginal Mars life, and presumably native aboriginal Terrestrial life. In so expensive and long-term an effort, we should aim high. For indeed, only the most shallow will find their curiosity sated by an affirmative answer to the first question.

If we agree on this, we must agree that a simple probe or two, however capably instrumented, will hardly do the job. This is a long term, open-ended project of great depth and scope and will require a supportive commitment on Earth with a “cathedral-building” dedication and mentality.

We will begin this effort with robotic probes. But we must realize now, that any thorough investigation will not only require humans-on-the-ground, but humans at the end of sustainably and repeatably short logistics lines. That is to say, this project can only be done justice as part of a continuing scientific investigation of their new “home planet” by humans who will have settled Mars. Not only can we not do it by proxy probes, we cannot do it (well enough) by proxy human scouting expeditions.

But we must start somewhere. Keep in mind that we will not be looking for “bones”. It is most extremely unlikely that native vertebrate type creatures could have evolved in what is at best a billion year long window for evolution on Mars. We will be looking instead for traces of inorganic body parts like shells and glassy cases (as in our diatoms) or spicules (as in our sponges). We will also be on the lookout for correlative evidence like crawl and wiggle tracks preserved in petrified mud.

Here is a trial balloon proposal for an introductory [pre-settlement] endeavor:

**(1A) ORBITAL** detection of likely sedimentary deposits followed by

**(1B) SURFACE** rover drill-core sampling for limestone deposits (fossil calcareous shell) siliceous ooze deposits (glass cases, spicules) carbon-rich decay products (slate, coal, oil) patterns that may be fossilized tracks noted by an on board Expert Program as needing further analysis – the rover could collect such samples and when its storage bin was full, deposit them on a tagged site with an activa-table beeper, for future collection by human expeditions.

**(2) SURFACE** rovers perusing ancient beaches for stromolite beds (fossil algae mats)

### **On Location and Terrestrial Laboratory Analyses**

As we have suggested, Robotic Rover (drill-core) sample Retrievers should have Expert Analysis Programs on their on board computers, and deposit their hoards in tagged, beeper-activatable piles along their route for future collection by on-the-surface human crews. Only a very few samples could be rocketed back to Earth, yielding a very expensive and totally inadequate hit-and-miss result. The cost-benefit ratio of such a plan deserves rejection. We must, if we truly want to “know”, commit to the open-ended incorporation of Mars into the Greater Human World as a human settled frontier.

- There is no way to adequately explore what remains of the presumably extinct Martian Biosphere, except by a permanent, onsite, largely self-supplied human population.

## The Real Prize

The prospects for recovery of even partially intact DNA-type remains are small. Coming across a Martian equivalent of sample trapping amber is all but inconceivable. But we will not know anything really significant about Mars Life until we know if the nucleotide bases on which its DNA equivalent is based are the same four upon which all terrestrial life is based [A – adenine, T – thymine, C – cytosine, and G – guanine] or upon a partially [25%, 50%, or 75% commonality] or wholly different set. Stereo mirror versions of one or more are also possible. The implications of the answer, should we be able to uncover it, will be enormous.

- IF the nucleotide base set is wholly the same, the implications will be either that this is the only workable possibility, or that both Mars and Earth have been seeded from the same pre-biotic source and are fraternally related or that one is an offspring of the other.
- IF Mars' nucleotide base set is even partially different, the implications for the cosmos-wide diversity of life beyond "life-as-we-know-it" are profound. In that eventuality, we would be even more driven to discover everything possible about this "different Genus of Life" on ancient Mars.

## Putting Together the Big Picture

Whatever the truth be about genetic meta-type commonality and difference between Martian and Terrestrial Life, we will want to know how far along Martian life got before geological forces prematurely closed this epic chapter.

- **In terms of diversity** of and within phyla, families, genera, etc.
- **In terms of complexity.** We have evidence of bacteria type creatures. Did true cellular organisms evolve? Colonial organisms?
- Outline of the sundry "**next logical evolutionary steps**" for which evidence is not in hand but needs seeking for a hard positive or negative finding.
- **Geographic ecosystem differences and biome mapping**
- Comparison of **Martian and Terrestrial start up conditions** (atmosphere gasses, pressures, temperatures, hydrospheres, cycles, seasons, tides etc)

This is a partial sketch of work that will consume and absorb all the energies of university Mars-biology departments into the indefinite future.

## Establishing Provisional Paleontological Preserves



So we begin our search for answers by robot probes. What should we do to protect sites in which they make positive finds? Those sites that by their geological nature promise to yield much more sample "evidence", we may want to designate and protect as "temporary" "Do Not Disturb!" set-aside zones, at least until reasonably thorough on site "human expert" perusal has been undertaken. If temporary paleontological preserves were established only on the basis of sound evidence, very little of Mars 55 million square miles ([as much as all the dry land on Earth!]) would be excluded from the first round of frontier development. As these sites became more thoroughly explored by paleontologists, and the picture of local Mars life becomes more complete, this protection might be removed. Thus a "sunset" provision with renewal procedures could be part of the initial legal proclamation.

This Section of a future Mars Frontier Treaty could be agreed upon separately, well in advance of consensus or compromise on other more politically and economically controversial sections.

There is work to be done, work that in the end will absorb many people over generations. If we do not commit to doing it, it will be to our eternal shame as a sapient species.

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# Feasible Goals of Assistance in the “Opening” of Mars for an early profit-seeking Lunar Industrial Settlement

By Peter Kokh

## Relevant Reading from past Issues of MMM

MMM # 18 SEP '88, “A Strategy for Following Up Lunar Soil-Processing With Industrial M.U.S./c.l.e; the importance of the Lunar M.U.S./c.l.e plan for the opening of Mars” [republished in MMMC #2]

MMM # 62 FEB '93, “The Triangle of Trade: Economics behind Lunar Settlement and the Opening of Mars”[republished in MMMC #7]

Suppose [humor me!] the “powers that be”, and/or any free enterprise forces that may choose to ignore them, do decide to begin resource-using lunar settlement before any serious effort to open Mars as a frontier (whatever the timetable for an initial human exploration sortie). Of what assistance could [an] established industrial lunar settlement[s] be to the eventual pioneers of Mars?

(1) **The Moon is a place where most of the systems and equipment needed to make a Mars outpost work successfully, can be field-tested** — under real sustained live-use conditions — and debugged within easy range of resupply, repair, and rescue from Earth.

This includes:

- Recycling life support systems
- Power plants
- Regolith moving equipment
- Shielding systems
- Mining and processing equipment
- Construction equipment and methods
- Surface transport systems
- Pocket factories
- Pocket hospitals — and more

To risk first sustained use of such systems on Mars where resupply, repair, and rescue if needed are as much as two and a half years away would be reckless bravado of a kind deserving no applause, should the gamble pay off. At stake are human lives.

(2) **Early lunar industries** will concentrate on the manufacture of more Massive, Unitary (items needed in considerable quantity), and Simple components to complement and/or be mated to more Complex, Lightweight, or Electronic components manufactured on Earth – the so-called “**M.U.S.-c.l.e. strategy**” for getting the greatest cost reduction in the import burden from the smallest import investment of capital equipment – the fast road to off planet industrialization. The punch line is that anything lunar pioneers can make from such starter industries will be available for export at a competitive advantage over admittedly more sophisticated terrestrial manufactures, to all space locations: LEO, GEO, L5, the asteroids — and the Mars system. If Martians choose and order the equipment they need designed, manufactured, and sourced by the Lunan “M.U.S./c.l.e. system, they will save money. And for early Martian pioneers, with few if any ready-to-sell exports, saving money will be make-or-break important. The same buck will buy them more and take them further, with Lunan pioneers to order from. “**Frontier-made, tougher, simpler, less breakdown-prone, easier to repair, cheaper.**” That’s quite a sell.

**Such exports might include:**

- Shells for early Mars habitats, the more sophisticated lighter weight innards to have been manufactured on Earth, for outfitting completion en route to Mars (keep ‘em busy).
- Ready-made portable shelters and sheds
- Aerobrake shields
- Initial furniture and furnishings until a local manufacturing capacity is established.

- Tanks for tank farms (volatiles)
- Simpler, heavier components for processing and manufacturing equipment, assembled en route
- Greenhouse components, etc. etc.

**(3) The availability of Lunan industrial knowhow** and field-proven methods will prove invaluable. This kind of intellectual property export could include:

- Multiple design, manufacturing, & assembly techniques
- Lunan experience in creating variety & diversity for small markets.
- of building materials and construction and assembly techniques
- Fiberglass/glass matrix composites
- Fiberglass reinforced local concrete
- Alloy ingredient substitutions
- Regolith derivatives
- Cast basalt
- Site-appropriate ceramics
- Fiberglass/sulfur composites

All of this expertise will already have been field-tested in a setting that permits intervention, and rescue and resupply and expert staff relief.

**(4) The availability of Lunan field-experienced experts for assistance in set up, problem-solving, maintenance and a host of many other “experience helpful” positions.**

Would-be Martian Frontier pioneers, if they have the benefit of standing on the shoulders of Lunan pioneers who have preceded them, will have an incalculable advantage over those who would attempt to open Mars “inventing the wheel from scratch” in a setting where the slightest setback – equipment or systems failure – could well prove fatal to all. XXXX

## **Tempering Enthusiasm for the Red Planet as “The Next Human Frontier” with Personal Honesty**

As the time for enlisting gets ever closer and closer and the window for “changing one’s mind” shrinks towards “the point of no return,” an outbreak of widespread “Cold Feet Syndrome” is sure to occur.

By Peter Kokh

### **I. Being Honest About the Cold**

A cherished dream dies hard. We have known for a couple of decades now, that the real Mars is a much colder, drier, thinner-aired world than the one we used to dream of colonizing, than the Mars of Lowell and Clarke and Heinlein and Bradburry, the Barsoom of Burroughs.

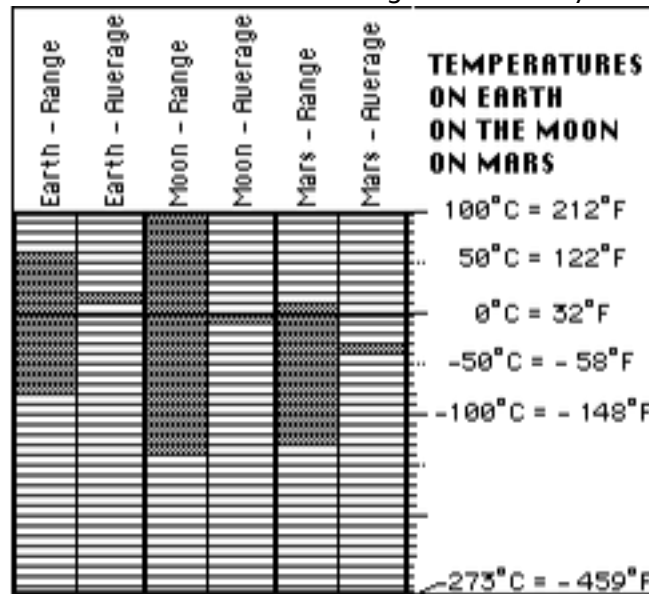
We had ourselves prepared for thinner air, say that of Earth’s high mountain plains 20,000 feet up. Alas, Mars’ air is more comparable in pressure to Earth’s at 125,000 feet, more than four times the height of Everest. We had ourselves braced for cool Martian summer days in the 60°s (F) and winter nights perhaps the same number of degrees below zero (F). But Viking meteorological stations showed a year in, year out pattern much much more bone-chillingly cold than that. Mars has no Florida.

We still don’t quite believe it. For the cold is “invisible” – there is no surface ice or snow – away from the polar regions – to give us a clue. We look at the Arizonesque scenery and we expect Arizonesque temperatures. Mars looks seductively tolerable. But how many of us are really hardy enough to handle even the Martian summers, let alone the winters. Doubly long by Earth standards, and doubly cold, will they not wear us down, rob us of our hope of a spring. When it’ll be merely quite cold, not bitter? Even us hearty northern snowbelters can tolerate our own winters, just, because we know they only last a few months. In Alaska, the longer winters translate to a higher than (national) average suicide rate. Imagine what that statistic will be on Mars, and the price it will exact on any settlement. Summer will at last come, and it won’t be much to enjoy, even by mid-Siberian norms (and I’ve experienced those first hand). Yes, we have people in Antarctica who have withstood comparable temperature cycles. But none of

them has been sentenced, or has sentenced himself to experience none better the rest of his life.

Ah, but there will be compensations! The chance to start fresh, where all the ladder rungs are open, where all the rules can be rethought, where traditions will be what we make them from scratch! On a world too distant to suffer meddling interference or haughty paternalism from bureaucrats and politicians on Earth. Yes, yes, yes — but! The chance to pioneer freely on Mars will be there in full.

But the interference-foiling distance is a sword that cuts two ways. For it makes rescue and bail out quite impractical as well. Our Martian wanna-be's are going to have to swim or sink – quite entirely on their own. This defining aspect of the “Martian Condition” will see the making of many episodes of real heroism, heroism perhaps of epic proportions. But these glories will be perhaps a bit too-well-salted with tragedies hewn by the same sword.



KEY: Absolute Zero at bottom.

**Why the Moon has a colder average temperature than Earth**

While both Earth and the Moon lie the same distance from the Sun, Earth's atmosphere and oceans moderate the temperature daily and seasonal differences whereas on the Moon superficial (surface only) extremes are found.

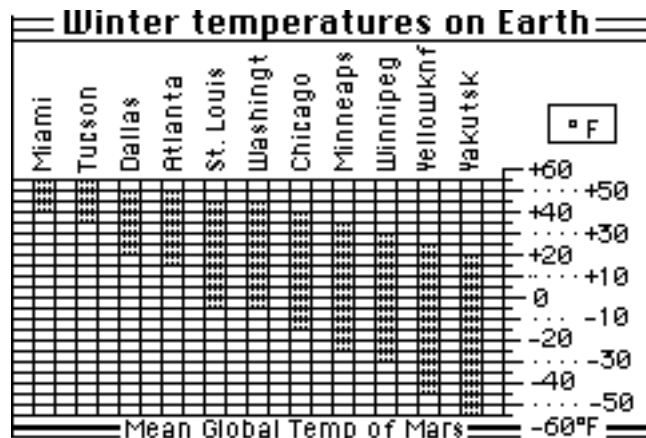
For practical purposes the real temperature of the Moon, a couple of meters/yards down is a steady cool -4° F = -20° C. **This is 62° F = 34° C cooler than the Earth** whose oceans act as an enormous heat sink/thermal flywheel to keep Earth significantly warmer.

**Mars' thermal flywheel is non-existent, and the average subsurface soil temperature is 50° to 60° F colder than on the Moon, more than 100° F colder than on Earth.**

NOTE: **the highest equatorial mid summer mid-afternoon temperatures on Mars are below the mean global temperature on Earth (58° F = 14.4° C)**

**Both habitats and suited individuals on Mars will need insulation and reliable heating.** Heat failure in either case will pose a life-threatening emergency.

(On the Moon, the poor conductivity of the soil allows body heat and human activity heat to carry the load quite well.)



Even the hardest of us will find Mars "too cold"

Martians, like Lunans, will be pioneering from scratch, forging their own building materials, making their own fertile topsoils. Nothing on the shelf, nothing in the stores – unless it be imported from Earth or Moon. Much as Lunans will perhaps already have experienced, smoothing the overly many rough edges of this naked-born frontier will take ever so long. But it will get done.

How many of us declaredly ready to pack our bags are being honest with ourselves? How many of us have already made life style choices and changes in favor of less hardy, less rough, warmer and smoother and friendlier conditions and settings? That's not a good sign.

Mars IS a place for humanity to pioneer, to "frontier", to start afresh, to redefine itself anew. But when the time comes for irrevocable decisions, for signatures on the dotted line, for beginning a journey across the void from which for most there will be no return, all that real opportunity will lose its appeal for most who now "would go" — now, while the saying of it is cheap since there is little chance of our bluff being called, not even by ourselves.

Nothing will endanger our collective hopes of opening the Martian frontier, more than a collective outbreak of "cold feet." We are setting ourselves up for this by continuing to look at Mars with rose-tint glasses, "seeing Arizona in the merely Arizonesque." Without honesty, we can hardly prepare ourselves or others to take up the dream. Let's be honest!

Mars is a world whose air is too thin to screen out the micrometeorite rain, too thin to shield from the Sun's burning, tissue-destroying naked ultra violet rays. Mars is a place where one cannot turn his back to the Sun to feel the warmth. It is a place of deceptive skies and dangerously invisible cold. A world in some ways more forgiving than the Moon, in other ways less so, if only because its appearances and meager resource pluses may prove disarming.

#### Past less than popular frontiers

Not every frontier on Earth has been a clear success story. Many a frontier has proven less than popular, more challenging than its would-be pioneers were ready for, too unattractive to lure more than a scattering of pioneers, most of whom may have had no real idea of what they were getting themselves into. Consider these examples.

- **Siberia's** 6 million square miles of Taiga and Tundra are easily the most populated of these frontier regions, but this has been achieved by very high incentives and considerable forced relocation. The region has 30 million people at the outside. It is much warmer, wetter, more fertile, verdant, full of wildlife, ready building materials (wood), and more resource-rich than Mars. So if it has taken a century to build its population to this point, at the end of a relatively short and easy journey from the friendlier more civilized and sophisticated western regions of historic Russia proper, what grounds does that give for a belief that we could see 50 million pioneers on Mars within a century of its opening?

- **Yukon & Northwest Territories:** Similar to much of Siberia, is Canada's great Far North, with a combined size half that of the continental U.S.. Again resource and life-rich, within 2 hours reach by air of Canada's major cities, but after a century plus home to less than 50,000 hardy

people. Major Canadian Arctic islands, like Baffin and Ellesmere, veritable Floridian oases by Martian standards, are populated mainly by prehardened Eskimos.

**The Falkland Islands:** This haven of the South Atlantic, perennially disputed by Argentina and Britain (incumbent landlord) are treeless and wind-swept but have other vegetation and wildlife, and are surrounded by food-rich waters, and are much more “balmy” than Mars. After centuries, they are home to less than 5,000 souls.

**South Georgia:** 800 miles SE of the Falklands, this thousand square mile isolated refuge from civilization is home to few humans, many rats.

**Greenland:** apparently this greatest of Islands had green-clad shores fringing its glacial interior at the time of its discovery by vikings a millennium ago. True, 80% of this nominally Danish autonomous country is covered by a thick ice sheet. But the Montana-sized ice-free coastal areas boast only 60,000 heavily import-dependent citizens.

**Spitzbergen:** in the no man’s sea between the North Atlantic and the Arctic Oceans, well to the north of the top of Norway who owns them, these islands the size of West Virginia are home to the most poleward (78°N) of real human settlements (i.e. excluding the family-free caricatures we see in the Antarctic), namely Longyearbyen with its “suburb” Barentsburg, counting together some 2,000 coal-mining pioneers, mostly from Russia. When’s the last (or first) time you saw a blurb appeal to help open the Spitzbergen frontier? Beat the rush! Compared to Mars, Spitzbergen is a paradise!

**Antarctica’s shores and fringes:** By all salient characteristics and measures, only the night-day pattern is friendlier on Mars than in Antarctica. The temperature ranges and seasons are similar, except in length. Antarctica’s air is oxygen sweet, ready to breath through a warming filter. It’s winds pack more windmill-turning punch. It’s dry valleys sport lakes with algae life. Birds abound. Its shore-washing waters are more abundantly teeming with food-fish and sea mammals than any on Earth. It has oil and coal and iron ore.

However remote by description and lore from the familiar rest of Earth, Antarctica is not that far away anymore. Base personnel are on the Internet and FAX lines, and the two dozen some outposts of several nationalities are all reachable within a couple of days through most of the year.

But there are no real settlers, no pioneer families. Treaty forbids this you say! Give me a break! If people wanted to go, they would. Since when have treaties not been made to be broken? — People don’t want to go — in droves, in an eloquent unanimity by default — not to this god-blessed, spectacularly beautiful world-apart within our world, a place which viewed through equally untinted glasses is far richer and friendlier and more beckoning than Mars.

**The difference is this and this only. When it comes to Antarctica, we are being honest, when it come to Mars, we are still prisoners of romantic myths.**

This sampling of not-so-popular frontiers gives little comfort or credence to those who expect hundreds, thousands, or millions to flock, Oklahoma style, to Mars once the planet is pronounced “open”. Yes, some will volunteer, and actually go through with it, and work the Martian Frontier as if there were no return — for there may well be none. But those recruits who do not get cold feet at the last minute will be “the few, the proud, the Martians”. They’ll come mostly from already hardy subarctic and cold desert populations. Will they be enough to provide Mars with a critical mass? Maybe not.

The time to be personally honest is now.

## **II. Being Honest about the “Outdoors”**

Few people other than agoraphobes do not love the **outdoors** on a fair, sun-glorious day. But some of us have a soul-need to spend significant quality time outdoors, walking, driving, playing sports, or just relaxing on the front porch or rear deck. The rise of Television and the Internet has not quenched that thirst in all of us, only in some of the already dead.

Then there is that fraction of the population who plunge into outdoor hobbies necessary for their sustained mental balance. Some of these we will be able to transplant to Mars, up to a point: motoring, hiking, rock collecting, even flying. Others, we can forget — at least until we can build cities or recreational parks within huge macro-structures that create modest

“middoor” environments: sailing, bird watching, hunting, fishing, etc. Most of these outlets for the soul will be unavailable to the early pioneer. As they are the ones who must come first, who must indeed “pioneer” and set up shop for the dreamt of Martian civilization to come, the question for Mars enthusiasts returns. “Am I being honest with myself? Would enlisting mean sacrifices that over time I would find so unbearable as to unbalance me? Each must answer that question for himself.

The time to be personally honest is now.

### **III. Being Honest about the “Boondocks”**

The outdoors isn’t all pioneers will be called upon to give up. Mars is a world physically large, its surface comparable to all Earth’s continents together. But sociologically and economically and opportunistically it will be a very, very small “world”. One or more really small towns where everyone knows everyone else, from which there is at first no change of human scenery. Are you a city guy or gal, or a country one? Or like me, someone who needs to spend time in both? could you handle being stuck in a small ultra rural hamlet the rest of your life with no more than time-delayed electronic access to the greater world of man? Even the most content farm boy likes to sample the big city lights once and a while.

Those of us who revel in the diversity of our World, “big W” (not only the cities, towns, cultures, nations, etc. but the plant and animal wildlife, ec.), may find “the little w” unbearable. Earth will no longer be, as on the Moon, a TV or radio set on-off switch away and available for a two week vacation for the price of a little exercise in the gym followed by a couple of days’ travel each way. The new Martians will have only imported videos to remind them that there is/ was more to the universe they have chosen to leave behind. On Mars, returning “home” could be as much as a two and a half year undertaking – one way.

We are used to a world where everyone does not know everyone else, where it takes more than a minute to read the days news, with an inexhaustible supply of strangers to meet, diverse rags to read, and of stores to shop. Mars will be, at first, “the ultimate small town, all alone on a big super remote island.”

The time to be personally honest is now.

### **IV. Earth need not be the only source of Volunteers for Mars**

In contrast, for established or native-born Lunans, Mars may have all the siren appeal of an Oasis. Lunans will already have weeded themselves out, have become accustomed to not being able to go outdoors without a space suit, used to spending their lives entirely in air-managed micro-environments, accustomed to the recreational tradeoffs they have had to make, accustomed to the “boondocks”. Here on the Moon, where such weeding out is a much less expensive proposition, a population will emerge that is well adjusted, creative of its own diversity, recreational and artistic opportunities, of its own diversions and “get-away” escapes, able to work the frontier free of paralyzing depression.

Some longtime and native-born Lunans will find themselves ready for a new challenge. To them, Mars will appeal as a veritable Mecca. The cold, the isolation, the restrictive living – all this will be either nothing new, or scarcely intimidating. There will be tradeoffs they have to face and accept in making the move. Mars is physically and logistically and interactively two magnitudes (a hundred times) more remote from Earth. Balance this against the consequences and perks of a thin atmosphere, a little more gravity, freedom from the tyranny of a gray toned palette, a lot more carbon, nitrogen, hydrogen, and water, a more Earthlike pace of sunrise and sunset, a somewhat more relaxed lifestyle.

Unlike people who have never been off Earth before, Lunans will come to Mars ready for the job, experienced with the rough edges of the frontier, full of depression-resistant optimism and enthusiasm. No Earth-born Earth-bound population offers to be as fertile a source of Martian pioneers.

Again, it is the pre-hardened Lunan pioneer, ready for fresh challenges, who will be able to handle such deprivations – he or she has already made them (or never experienced such

activities) and survived in good psychological health. Pioneers of this future national background (dare we say it) stand to be the born-leaders on the Martian frontier.

**If in impatient urgency, we attempt to open Mars before there are Lunans to help, we risk setting up history's most expensive ghost town.**

That is we tempt failure, tempt it big time. "Pride goeth before the fall." Not to forget one of the most primary cosmic laws as it applies to the affairs of mortals: "Impatience always backfires"

This consideration is in itself, a weighty reason for beginning lunar settlement first, whatever the timing for a first "flags and footprints" exploratory bravado mission to Mars, likely to be as much a false start as Apollo, half a century earlier.

The time to be personally honest, and to be honest as a space advocacy community, is now. For the National Space Society and its Board of Directors, It is time to return the pendulum to the center. Yes, we must open the Martian Frontier! – In sequence!

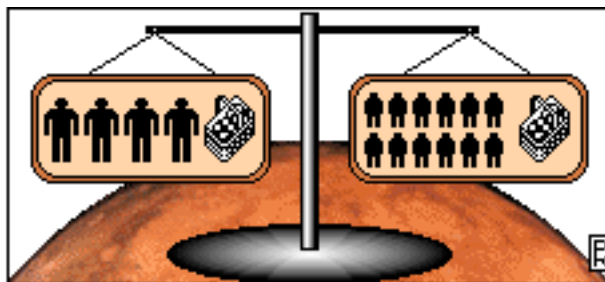
Granted, government[s] probably can do one or the other and not both. Let the government[s] concern themselves with Mars, after it[they] have set up a politico-economic regime and amply-incentivized rules of the game that will entice free market enterprise to open the Moon. Ultimately, only profits can open the frontier, and they are far, far likelier to come from the Moon.

#### **Relevant Reading from past Issues of MMM**

MMM #92 FEB '96, p. 7: "Who Will Pioneer"

MMM # 93 MAR '96, p. 1 "IN FOCUS: Mars will require a hardier breed of pioneer"  
[republished in MMMC #10]

**MMM # 113 – MARCH 1998**



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

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

#### **IN FOCUS In a word: Marsandback, No! – Marstostay, Yes!**

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

It is now more than 25 years since the last human set foot on the Moon. But what did we expect? The Apollo program was explicitly aimed at putting a human crew on the Moon and bringing them back safely. Period. Moonandback. One word. Period. Those of us who knew

there should be more, kept fooling ourselves into thinking that there would be more. Right building. Wrong foundation.

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

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

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

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

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

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

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

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

So let's cut this talk of human exploration of Mars! Let's start pushing the "settlement of the Martian frontier," and picking means that lead to this end. Logically, it is a simple thing to do. Not to use the right means to the end, is to play into the hands of those who will be only to



happy to see our efforts come to naught. We have to stop being our own worst enemy through our carefully organized and compulsively pursued klutzery.

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

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

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

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

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

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

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

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

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

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

**Marstay does not segue from Marsandback.**

**Marstay must be pursued instead of Marsandback.**

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

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

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

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

We close with this paraphrase of a modern proverb:

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

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

<PK>

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

By Peter Kokh

### **✓ On Robotic Mars Exploration**

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

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

### **✓ A program of field exploration**

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

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

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

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

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

### **✓ A humans-to-Mars program**

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

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

An old horseblinder cliché. Opening space depends on much more than mechanical engineering and physics. Its success depends far more on chemical engineering, green engineering, and human factors engineering and students should be guided accordingly. “Space

curricula” designed to steer students towards hardware engineering and physics is woefully inadequate. <MMM>

## MMM Mars Policy Statement

### Precursor Missions and R&D for a successful “Mars-To-Stay” Campaign

By Peter Kokh

Programs and missions that work towards a Working **Economic Geography of Mars:**

RESOURCES: Permafrost, Ores, Lavatubes, Geothermal hot spots

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

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

- **Yolk Sac Logistics** – prior in situ manufacture of needed volatiles, including oxygen, methane, ammonia, and water reserves as well as building material stocks for a multi-Mars year reserve. Prior landing of a thorough and generous spare parts supply. To attempt to open Mars with an Umbilical Cord Strategy relying on resupply and rescue windows more than 25 months apart would invite disaster and tragedy.
- Development of **cheaper, faster, safer transit to Mars**, drastically reducing immigration costs.
- Toad-style **amphibious landers** that will provide ready surface motor coaches and hovercraft trucks
- **Bioengineered Mars-hardy plant varieties** for surface “redhousing” – food and fiber production
- A Mars **Industrial and Agricultural Diversification Strategy** to accelerate attainment of self-sufficiency goals
- Continued work on a **Rationale for a Positive Trade Balance** with Earth and with off-Earth outposts on the Moon and elsewhere: “The Economic Case for Mars” has yet to be made!
- Development of a **pocket “General Hospital”**
- Founding the **University of Mars in Cyberspace**
- A **Charter for Staged Autonomy, home rule, and eventual independence**, and relations with Earth and with other off-Earth settlements
- A **Federal Frontier Constitution** trial document to set relationships between multiple settlements, and establish a regime for scenic and geological preserves and easements. <MMM>

## **Yolk Sac Logistics**

### A Strategy Tailored for Mars

By Peter Kokh

#### Foreword

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

Any opening on Mars must be supported from an amply supplied forward station, preferably one deployed in advance of first personnel arrivals. Such a forward base could be set up on one of the Martian moonlets, Phobos or Deimos. But it would be more securely placed on

the surface at the intended focus of operations. Humans bound for Mars would then depart from Earth secure in the knowledge that all the supplies necessary for their long term survival on Mars were already in place at the landing site.

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

### **A Radical Game Plan is a Must**

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

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

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

### **Yolk Sac Basics**

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

The nuclear thermal plant needed to power the fuel and volatiles production from the atmosphere should be gang-able so that other units landed subsequently can be used in tandem to provide a scalable energy production plant. Excess power can be stored as chemical energy e.g. used to electrolyze water reserves that can later be combined in fuel cells to recover that energy as needed.

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

### **Amphibious Crew Cabins**

The cabins of all landing vehicles could be designed with minor weight penalty, in amphibious fashion, fitted with wheeled chases so that they can serve as surface vehicles. There will never be enough of these, and every crew cabin that returns to Earth will be felt on the

frontier as a mortal wound. This concept was first developed in our 1991 paper on Lunar Hostels<sup>1</sup>, delivered in San Antonio.

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

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

### **Stowaway Imports**

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

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

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

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

### **High Morale is Quintessential**

Morale in a community obviously expanding, flourishing with ever newer, bigger opportunities, with ever more consumer goods in greater variety and of improved quality, with ever more social horizons, with ever more occupational choice, etc. – morale here will be high. By contrast, in a NASA outpost where every added cubic foot of space and every increase in crew size will be argued about for years by a succession of political committees of spurious

jurisdiction, morale must soon sink beyond recovery except for those who will have come with no expectations other than the journey itself. If we go to Mars with a commitment only to explore, and that only in a short timeframe, there will be no reason to expect political forces to turn this timid tentative opening into a bold unstoppable one. We must not go to Mars, not at all, unless we “go to stay” from the outset.

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

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

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

#### **“Just-in-case” vs. “Just-in-time”**

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

#### **Isolationism as a consequence**

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

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

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

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



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

Peter Kokh

### **Relevant Reading from past issues of MMM**

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

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

That would be common prudence. But! ...

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

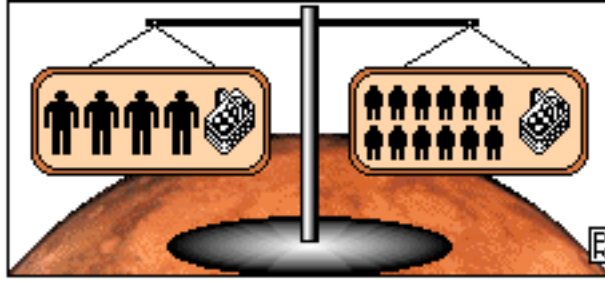
All these items can either be designed for reuse on Mars in the same or some other application. Or they can be made of materials otherwise hard to come by for the infant Martian industrial economy.

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

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

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

<MMM>



## “More to Mars”

### Sending 12 men to Mars for the price of 4, or 24 for the price of 8 A Radical First Exploration Mission Plan that Should Not be So Lightly Dismissed


By Peter Kokh

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

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

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

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

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

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

Second, while the mass and volume of needed spaceship systems and work stations would remain unchanged, the size, volume, and associated mass of both private and common quarters and walk space could be proportionately reduced. Keebler and Tshieq contend that for otherwise identical missions, one crewed by Little People and designed to be so, would have a fueled launch weight 40% less than one planned for full-size crew members.

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



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

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

AFD News Service

### **In fact, we were dead serious about this proposal.**

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

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

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

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

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

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

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

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

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

I am not suggesting here that Mars be settled exclusively with diminutive individuals, only that making our initial exploration crew selection from their ranks could be the smartest thing we can do.

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

### ***Yes, this would be a bold tack in casting the 1st Mars Crew***

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

### **Could prejudice ruin our one best chance?**

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

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

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

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

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

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

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

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

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

Does it not seem poetically fitting that a "race" of little scouts turn the trick once again – this time on Mars? <PK>

## Dwarfs & Pygmies

*Just the facts, please!*

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

**Pygmies** are members of two "races," the

- 150,000 Negrillos of central Africa, and approximately
- 35,000 Negritos of Southeast Asia and Oceania. (These figures are some years old.)

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

**The Upshot for a "More to Mars" Mission with a Dwarf and/or Pygmy Crew**

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

Its a win-win-win situation!

MMM

MMM # 123 - MARCH 1999

## In Focus First Step toward Mapping Martian Permafrost



There is widespread agreement that the many of the features of the Martian surface show that Mars once had abundant water: rivers, seas, even an ocean. Yet the only trace of water now visible is in the polar ice caps. Did it all evaporate into space? Surely some did, but just as surely, ground water and water saturated soils froze in place. We are likely to find an extensive permafrost layer, continuous in some areas, not so in others, thicker here, thinner there. The actual water content may vary considerably. Some deposits may be fairly fresh, others rather salty. So we guess. We need to know!

Unless we are going to melt polar ice at the fringes of the ice caps and pipe it to lower latitude outposts in aqueducts reminiscent of Lowell's canals, we may need to site our bases in areas where we can tap local permafrost reserves. Several permafrost tap operations are in service here and there on Earth, so this is not an altogether novel idea.

Two Deep Space 2 microprobes are en route to Mars aboard the Mars Polar Lander launched this January. They will crash at about 200 mps (400 mph) burying themselves beneath the surface. They will then sample the soil, looking for signs of water ice.

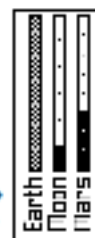
The target site is within the edge of the layered terrain near Mars's south pole. Finding (or not finding) subsurface ice in this location, within a meter of the surface, will neither prove or disprove the existence of globally extensive permafrost. It's a neat and adventurous science experiment. But it won't give us an iota of the knowledge we need. It'd be foolish to await positive results before brainstorming what we have to next.

We have extensive permafrost regions here on Earth in Alaska, Canada, and Siberia. This gives us the opportunity to brainstorm and test remote sensing instruments to detect permafrost and at least partially quantify it by flying a precursor mission in Earth polar orbit. The results would give us great confidence in interpreting any data gathered by a twin probe, subsequently put into Mars polar orbit. We need this data!

The Ground-Penetrating Radar Experiment conducted this past summer on Canada's Devon I. (p. 9) is a major first step. The goal was to map ground-ice and other subsurface discontinuities in a variety of locations. Distribution and structure of ground-ice was studied. GPR imaging of the subsurface was 'ground-truthed', where possible, with direct drilling. Devon's breccia may be a close physical analog to regolith at high Martian latitudes. This GPR test may hint what a similar effort might reveal on Mars. - PK

# Mars <sup>3/8</sup> the Gravity

## Enroute to♂ Mars



By Peter Kokh

At million\$ per man hour on Mars, does it make sense to guarantee that the first few months will be unproductive due to the need to recuperate from 6–9 months of zero–G when this could be avoided? Maybe, if it saved anything, the trip home could be done in zero–G, jettisoning whatever equipment mass was necessary to provide rotation. But certainly not on the way out.

It is not a question of physiological health. Perhaps we can keep people healthy in zero–G. That is totally irrelevant. It is a question of preparedness.

Nor is the other extreme appropriate: sending out our scouts on a ship designed to offer full Earth normal (1G) gravity. Not only would that environment fail to acclimatize them to Mars, it would require 8/3rds or 167% greater boom or tether length and mass – at the same rpm rotational speed.

On the way home, Mars gravity would suffice, shortening the period of rehabilitation to full Earth normal gravity. The crew would not need to be fit to hit the ground running, so to speak. They will be on extended debriefing vacation anyway.

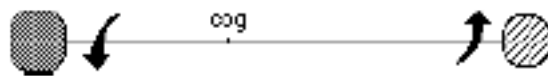
Why do many Mars Mission architects not want to bother? Providing for artificial gravity adds some constraint on Mars ship design, adds weight, and adds a modicum of vulnerability. So what? If we don't do it, the quality of the return on the mission investment will, with absolute certainty, be compromised. The savings from not providing artificial gravity does not pass the cost/benefit ratio test!

Further, NASA has wasted decades with lip service experimentation with tethers, and no more than paper study experiments with artificial gravity. The agency simply is not ready. It has no reason to feel confident it can pull off an artificial gravity mission. NASA seems to have a cultural mental block against the subject. If that is indeed the case, then, if we are to have the best Mars Mission we can for the money, some other agency may have to be put in charge, even if we have to create one.

We are more likely to go back on sequel expeditions of exploration and go on to establish an outpost at which we can experiment with living on Mars on its own terms, preparing for day we can open of Mars as a Frontier for settlement – more likely that is, if we do the very first mission right, and as well as we can. If the rubric of the first mission is simply Marsandback, one word, then doing it right, doing it as an overture to the future – that won't matter. Quite predictably, we will get as minimalist a Mars mission (in the singular) as possible instead. If you think its been a long wait after Apollo for our yet unscheduled Return–to–the–Moon–to–Stay, try staying alive after such a first Mars mission long enough to see the next!

#### **BASIC ARTIFICIAL GRAVITY SCHEME**

Many people are familiar with the giant wheel station of Wernher von Braun, well illustrated in the 1968 classic Arthur C. Clarke/Stanley Kubrik film: 2001: A Space Odyssey. Many have also seen artist sketches of Gerard O'Neill's classic space settlement designs: Bernal Sphere (Island I), Stanford Torus (Island II), Sunflower (Island III). The concept is also key to two TV Series: Babylon V and Deep Space 9. But nothing so grandiose, complex, or vast is needed to effect an artificial gravity environment. All we need is a pair of masses, not necessarily equal, joined by a tether or boom, and set into a spin about the common center of gravity ["cog"] – like a barbell.



**The pertinent questions are:**

- How slow/fast should the spin rate be?
- How long/short should the tether or boom be?
- Which is more advantageous, tether or boom?
- How do we deploy to the separated configuration?
- How do we spin up/despun the assembly?
- How do we rejoin the assembly components?
- How can we abort from tether or boom failure?

- What items should go into the Consist of each end?

There seems to be widespread agreement that a spin rate of 1 rpm is tolerable by most people, and that a spin rate of 2 rpm may be tolerated by enough people to find a crew. Coriolis effects, which cause dizziness when you turn your head, is the problem to be minimized here.

At 2 rpm, the habitat part of the assembly would have to be 581 ft (162 m) from the center of gravity. At 1 rpm, this distance would be 1062 ft (324 m). The distance from the center of gravity ["cog"] of the Counterweight "Consist" (assembly) would depend on its mass relative to that of the Habitat or Crew Consist. The less it weighs, the longer the distance to the cog, just as the less your friend weighs, the further he or she has to sit from the fulcrum of the teeter-totter to balance the load. By the same token, the less the mass of the counterweight, the greater the total length and mass of the tether. But as the tether or boom should be considerably lighter than either of the two counterbalanced portions, the mass fraction of the counterweight is not a critical concern.

Tethers will be much lighter than booms, and generally easier to deploy (via a simple winch and storage reel). Tests seem to show that a rigid boom is not appreciably more stable than a tether, weighs considerably more, and may indeed have more failure modes. The concern is to avoid twisting at the end of the tether. If a boom is used, the forces that would build up to induce twist could eventually weaken or even fracture the connection. So it is much better to reduce the tendency to twist, than to try to control it with fragile rigidity. This can be done with a pair of gyros counter-rotating in the plane of overall spin, one inside each assembly. [We have never seen this suggestion made – why not? It need not add much additional mass to either consist, in comparison to all we save by using a tether instead of a boom.]

The two assemblies can be separated with a mechanical shove, the tether being allowed to pay out freely to the set length. Two small rockets, one at each end, vectored slightly outward to counter the bounce-back when the tether limits are reached, fire in opposite directions in the selected plane of spin, just as the tether was reaching full pay out.

When the cruise portion of the journey is over, and preparations must be made to go into orbit about Mars (or Earth), an opposing pair of retro rockets fires in the spinward direction to slow the angular momentum to zero, as the winch reels in the tether.

The tether should not break or snap, the rotational forces being well within its design limits. But the question arises, what if tether should be severed by errant debris or some meteorite? This question has been addressed\* but it would seem that the probabilities of this happening, while finite, are astronomically small, and that is the right word.

"A Manned Mars Artificial Gravity Vehicle", David N. Schultz et alii, pp. 325–352, specifically

\* p.339–343, in *The Case for Mars III: Strategies for Exploration*, Editor: Carol Stoker, Vol. 74, Science and Technology Series, American Astronautical Soc.  
Order from: Univelt Inc., P.O. Box 28130, San Diego, CA 92128

#### **WHAT ITEMS SHOULD BE AT EITHER END?**

This is a question that has no hard and fast answer. There are pros & cons of safety vs. convenience in putting all the habitat crew space at one end, or splitting it up. Most would keep all personnel together, and we agree. The next consideration is which items must be accessible during cruise mode, and which will not be needed until journey's end. If this preliminary sort leaves the non-crew assembly mass being too "light," we could add the expended trans-Mars-injection booster, or we might consider keeping some liquid consumables at that end, accessed as needed through double tubing built into the tether, shifted mass replaced by liquid wastes.

Our next consideration is what type mission are we talking about. A first "Marsandback" mission will need to carry along a landing shuttle and an Earth return vehicle (if not one and the same) if one (or both) had not previously been sent ahead to be awaiting the crew in Mars orbit

and/or on the surface. All published Mission Plans that we have seen that work artificial gravity in the design are of this type. In MMM, we have a habit of looking beyond beginnings.

A vehicle carrying pioneers in an era when most stay and relatively few return to Earth, can be designed as a “frog” – amphibious. The crew quarters would be designed to pass through Mars atmosphere, land, and be recycled as badly needed surface vehicle, or extra habitat or lab space: “one way to Mars”. The Mars-bound assemblies need not include anything needed for crew return. The part of the transit chassis that remains in Mars orbit, could be tugged or barged back to Earth to be reoutfitted with new passenger modules to bring more pioneers.

All the designs I have seen are apparently for chemical fuels. The barbell design is especially right for Nuclear Ships. The large separation between the units will afford added radiation protection for the crew and passengers, the nuclear plant being housed at the opposite end of the boom or tether. The “cycling” Mars ships proposed by Aldrin and others could be quite large, with permanent artificial gravity designs, plying the Earth–Mars run continually for decades.

**Design options are many.**

Craft bringing Lunans to Mars might start the trip at 1/6th G and gradually work up to 3/8ths G on the first half of the journey, leaving time for Moon-acclimatized people to get used to the heavier load. Another special case has native-born or naturalized Martians traveling to Earth. Again, the journey could start at 3/8ths G and build up gradually to full 1G.

We need to bite the artificial gravity bullet, not just on the drawing boards, but in low Earth-orbit testbed facilities where we can afford trial and error. This minority view must prevail.

NOTE: artificial gravity is NOT a feature of the Mars Direct mission architecture in so far as it incorporates the ARES shuttle-derived vehicle. But that vehicle is not essential to Mars Direct. From this point of view, the Mars Direct mission architecture needs to be reviewed. Getting there fast and cheap is no good if you get there physically incapable of performing on Mars itself!

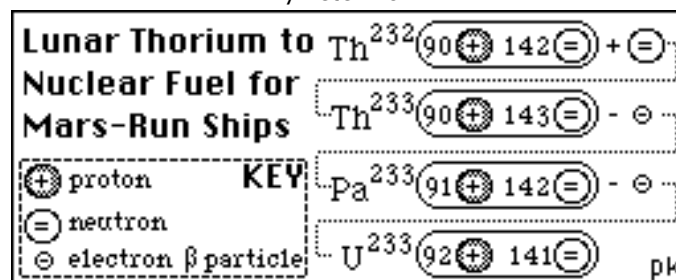
We think that a redesign is possible that would provide Mars level gravity for the trip to Mars. As the return to Earth will be in a different vehicle, that poses a separate question, but one less critical for mission success.

Any “Humans to Mars” Mission Plan that fails to provide artificial gravity enroute, is not quite ready to be taken seriously. – <MMM>

# Lunar THORIUM

## Key to Opening Up Mars

By Peter Kokh



## **THE TIME BARRIER TO THE OPENING OF MARS**

Most Mars Mission scenarios are based on the best available current technology: chemical rockets burning liquid oxygen and liquid hydrogen. It is feasible to send a scouting expedition to Mars in this manner, even though they will need to sign waivers and releases because they will be in space “too long,” absorbing more than the recommended maximum dosage of harmful cosmic rays. The added danger of solar flares can be minimized by scheduling the flights in Quiet Sun periods which occur every eleven years. “Humans to Mars” is something most of us want very much to see, so it is tempting to be brave and cavalier\* about the nontrivial radiation risks.

\*Dr. Zubrin shows little concerned about radiation hazards during prolonged time in space (beyond Earth’s protective Van Allen Belts), or during total time spent on Mars’ surface, poorly protected by the thin atmosphere. But it serves no point to lower mission costs by dismissing the need for shielding the outpost with soil or water reserves.

Once the glory of reaching turf formerly out of human reach wears thin, fewer and fewer people will be willing to take such risks, or to spend so large a fraction of their working lifetimes doing so (3 years, say 6%). Chemical rockets are unsuitable as workhorses to open the Martian Frontier to droves of Earth-forsaking settlers and developers. Their power limitations exact a price in the coinage of time.

- Time is precious (life is too short)
- Time is expensive, adding time-indexed costs
- Time for overexposure to radiation
- Excess time discourages tourists, settlers, developers, and traders
- Excess time exaggerates difficulty of rescue, repair, replacement, resupply
- Time idle promotes boredom\*

Travelers can fill the months on board with university courses in fields where expertise will be useful on Mars, or back on home if/when they return. They can also keep busy assembling items needed on Mars that had to leave Earth in compact kits. But not everyone will find sufficient relief for boredom and cabin fever cooped up in a sardine can for six to nine months. This is not the 16th century. People of today will not care that their ancestors once spent comparable time crossing the Atlantic!

## **NUCLEAR SHIPS ALONE CAN “OPEN UP” MARS**

Nuclear ships won’t be essential for an initial to land human “Kilroy Crews” on Mars, just for the political rah-rah sake of saying we did so, planting a flag, and coming home with some neat pictures and souvenir samples. But that hardly constitutes Step One toward “Opening” Mars “as a human settlement frontier”, any more than Apollo succeeded in opening up the Moon as Earth’s Eight Continent.

But unlike chemical propellants which are too quickly exhausted, nuclear fission fuels (U233, U235, and Pu239) offer the power needed for sustained high thrust, resulting in a much higher velocities. Nuclear ships can shorten transit times, extend windows, and telescope round trips, and just as importantly, cut all time-indexed costs. Nukes could cut transit time to Mars down to eighty days or so, per Stan Borowski and make Mars a nearby, viable human frontier.

## **AN ENVIRO-POLITICAL MONKEY WRENCH**

Would trans-atmospheric shipment of fissionable U-233 evoke as much enviro-political concern as that of the Plutonium-239 that fuels NASA’s deep space missions Galileo, Cassini (and hopefully, the Pluto-Kuiper Express? The assumption behind this article is that, given the guaranteed irrationality of rabbleocratic political process, no distinction may be made. If not, then the dream of opening up Mars, asteroidal resources, and the Outer Solar System could die – unless! Unless we can ship unfueled nuclear engines and reactors through the atmosphere, and refine the fuel they need on the Moon.

Unless the supply of nuclear fuel throughout the Solar System is assured, there is little point in developing the engines that would use it, nor the spacecraft that would use such

engines. Research on nuclear propulsion continues, primarily at NASA–Lewis, on the presumption that fuel is a non–issue.

### THE MOON CAN RESCUE THE MARTIAN FRONTIER

Lunar Prospector has been gathering data for a global geo–chemical map of the Moon and thorium is one of the elements on which it has been zeroing in. There seems to be economically minable amounts in some accessible areas.

{**thohr'**–**ee**–**uhm**} This element is a soft, very ductile metal, silvery in color. It is in group IIIB of the periodic table, a member of the actinide series. It was found radioactive in 1898 by Marie Curie. It had been discovered in 1829 by Swedish chemist J. J. Berzelius, who named it for the Norse god Thor.

#### **Thorium reserves contain more available energy than all uranium and fossil fuel reserves combined**

See also MMM #116 JUL '98, pp. 7–8, “URANIUM & THORIUM on the Moon”, P. Kokh

Thorium–232 can be used in a breeder reactor to produce a fissionable uranium–233 through neutron absorption, in the same manner Plutonium–239 is bred from Uranium–238. The reaction sequence is shown in the page 1 graphic. (Beta decay is the "transformation" of a neutron into a proton, with the emission of an electron for charge conservation, and an antineutrino for energy and momentum conservation.)

U–233's physical and chemical properties make it much less difficult and dangerous to handle than extremely toxic Plutonium. Further, the thorium=> uranium cycle is vastly less dirty than Plutonium production. An energy amplifier reactor fueled by thorium has significant advantages:

- **the reactor is essentially sub–critical**
- **much less transuranic actinide waste is generated**
- **much less radiotoxicity especially if the bred 233U and additional U isotopes are recycled**
- **thorium can be rendered proliferation resistant** through mixing with the isotopic denaturant U–238

On the Moon there is neither air nor ground water to pollute or infiltrate. Storage of wastes in a lavatube would be cheap, easy, and absolutely safe.

A lunar thorium–based nuclear fuel production operation could be highly automated. A manned station will be needed to tele–operate mining equipment, make repairs, and ship the packaged product.

Moon–based shuttles, and later, a mass driver (once the volume of demand warrants) would ship the U–233 fuel to (a) Fueling Depot(s) in one (or both) of the stable Lagrange points (L4 and/or L5, 60° {or 5 days} ahead of/behind the Moon in its orbit around Earth), conveniently outside the lunar gravity well, yet easy to reach from Earth and Moon alike.

Assuming five–day margins, nuclear rockets could offer affordable windows to Mars from 3 weeks a month from these twin “Marsgates” – for at least the major portion of the 25 month long synodic period between optimum Earth–Mars lineups. Not only will the length of trips to and from Mars be cut appreciably, but the constrictive timing of the narrow and infrequent windows would cease to choke traffic.

On its first year mission, Lunar Prospector identified the Fra Mauro region, south of Mare Imbrium and the great crater Copernicus, as notably rich in Thorium. This is the area visited in January, 1971 by Apollo 14 (the Antares with Alan Shepard, Edgar Mitchell). It is just south of the lunar equator, making a mass driver shipping operation practical.

Lunar Prospector is now in an extended mission in a low surface–skimming orbit, affording closer scans at higher resolution. By mid year (1999) we may know if its gamma–ray spectrometer has better localized the thorium rich deposits in the Imbrium splashout area. We may soon have a short list of ideal sites for our nuclear fuel production operation.



## **A REASON FOR MARS LOVERS TO LOVE THE MOON**

It would seem that those driven by the vision, not just of a human scouting science-picnic outing to Mars, but of going beyond that to open the Red Planet as a Frontier for settlement, and as an eventual second human home world, would put thorium mining and U-233 production on the Moon near the top of their “must-do-first” list, right after development of nuclear rocket engines themselves. Yet outspoken proponents of “Mars First” seem preoccupied with doping the discussion with a list of impatient bogus reasons to “avoid” a lunar “detour”.

**Lunar Thorium** may be the number one utility of the Moon to the Mars Frontier constituency.

But there are other benefits that shouldn't be dismissed:

- **Handier dry run equipment & procedure test-outs**
- **Cryogenic rocket refueling**
- **Manufacturing heavy components needed on Mars**
- **Source of willing, tried and seasoned pioneers**

Just as the “Earth Problems First” crowd overlooks the possibility that the solution to some of Earth's most intractable energy and environmental problems may just lie in space, so do some “Mars First” people overlook the possibility that any of the sine qua non prerequisites for “opening” Mars as a Frontier may involve a lunar operation. Emotions that have become almost “partisan” are getting in the way.

We are not saying that Lunar thorium will be needed to fuel nuclear power plants on the Martian surface. Mars Global Surveyor may identify similar deposits on Mars. Pioneers on Mars will duplicate the Lunar facility. Having a workable debugged operation on the Moon will make design and construction of a similar industry on Mars itself that much easier.

## **REASONS FOR MOON LOVERS TO LOVE THORIUM**

A thorium-based lunar nuclear fuel industry will have benefits for lunar industrial diversification. Among many uses for thorium and thorium compounds these three promise to be especially welcome on the early Lunar Frontier.

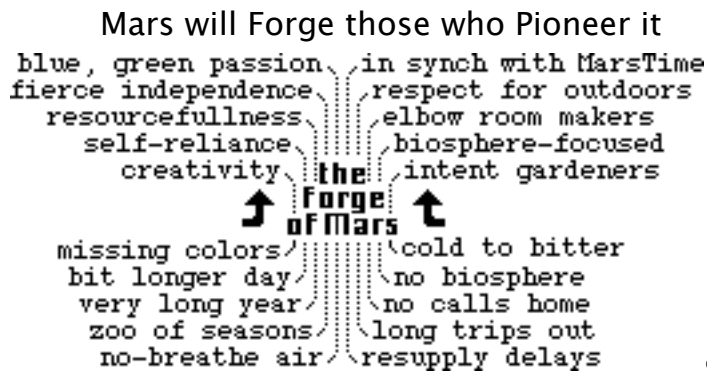
- Temperatures
- Thorium oxide is used for high-temperature laboratory crucibles
- Glasses containing thorium oxide have a high refractive index / low dispersion – used for high quality camera lenses and scientific instruments

## **MARS RUN LUNAR THORIUM FUEL ECONOMICS**

Nuclear power plant architects and engineers familiar with thorium, and chemical engineers who can figure out how to most economically extract it from lunar soils, will need to work together to come up with a set of overall designs and operation plans for such an industry before we can begin to estimate the price. It won't be high in relation to the payoffs.

Those who would open up the Mars Frontier would have to pay much of the bill for creating such a thorium-based nuclear fuels industry on the Moon. Lunar developers will want nuclear power plants. So they will chip in their share. So will those who need nuclear rockets to access asteroidal resources.

Those determined to open Mars, may find no politically realistic alternative if they want to make Mars-run nuclear ships a reality. Choose not to pay the price and it may cost the dream. **MMM**



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

## In Focus Making Mars More Valuable

Commentary by Peter Kokh

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

That is our point. In last month’s IN FOCUS essay, we outlined how entrepreneurs could make a tidy bundle here and now by developing technologies needed on the space frontier that also would have a real market on Earth. Poor Ore Mining Technologies, for one. Not only could one make money selling such technologies to “resource poor” nations on Earth, not only would you end up putting “on the shelf” technologies needed on the frontier, but even more important, just by doing so, you would make that land on the Moon or Mars much more valuable. For the R&D being done, the resources on these worlds will become more than “theoretical” – they will become real. They will become something we know how to work with. Then, only then, is any talk of land grants and land purchases something more than wild-eyed pie-in-the-sky.

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

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

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

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

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

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

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

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

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

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

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

## **Seeds & Wellsprings of Mars Frontier Culture**

By Peter Kokh

### **Forward**

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

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

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

# The One-Sided Mars Palette

## The Given

On July 20th, 1976, two weeks after the 200th anniversary of American Independence, many of us were glued to our TV sets awaiting transmission of the first color pictures from the surface of Mars! At last the first frame came in, one line at a time, and the oohs and “ah”s were audible as we saw that beautiful blue sky above those beautiful ochre sands! Yes. Blue! But it was a teasing miscalibration. Once the computers corrected to match the color chart on the leg of the Viking I lander, the blue sky was gone, gone forever, to be replaced with the true salmon.

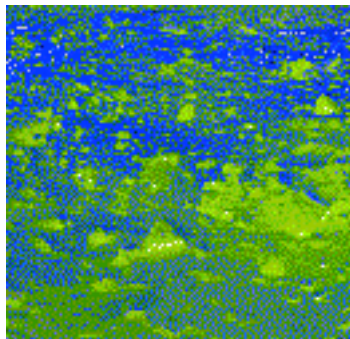
That Mars’ skies might not be blue was an idea that had escaped most writers and visionary painters, including the great Chesley Bonestel who had inspired us all for the past quarter century. Oh well, we were used to being disappointed by Mars.

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

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

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

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



## The Mars Missing Colors Project

**Above:** a simple color inversion of a Martian landscape

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

Blues and Greens will be our primary “antidotes” to sensory deprivation from the unrelieved consistency of the Mars-tone palette with which all of Mars apart from the icecaps is colored – as much rusty land as in all of the continents of Earth put together. There is no

escape from the one-sided palette unless we provide it ourselves. Finding ways to “restore the rainbow” and especially the missing blues and greens will “terraform” Mars virtually.

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

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

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

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

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

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

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

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

## **Mars Time**

### **Mars Time – the “slightly longer” day**

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

Mars day is about 40 minutes longer than our own, and ever since this was discovered, writers have treated this as a very happy coincidence. We've never heard or seen anyone suggest that this slight difference will pose any kind of problem. In fact, explorers and pioneers on Mars may be plagued by a mild jet lag effect that never goes away, ever. For those forty

extra minutes will be like traveling west at a rate of two time zones every three days – for the rest of your life. The body, adjusted by evolution to a 24 hour pace, will want to go to bed 40 minutes earlier every night, and get up 40 minutes earlier every morning. This may pose different problems for “morning people” like myself, and for “night people.”

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

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

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

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

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

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

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

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

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

immediately begs to be followed by the 1st, that is the sequence immediately resets itself in the mind.

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

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

### **Mars Time – the much longer year**

Mars orbits the Sun in 687 Earth days, or 668.60 “padans”. That translates to 22 months. It is a long “year”. Most Mars calendar makers do not try to find any way of making the marsyear seem less never ending. Most proposed Mars calendars have 20, 22, or 24 “months”. Zubrin’s very innovative calendar has 12 months, a familiar number, but they vary from 46 to 66 days in length to keep pace with Mars’ seasons whose lengths vary considerably, three apiece.

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

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

### **Mars Time – the diverse season lengths**

Another familiar feature that Earth and Mars have in common is a very similar axial tilt: 23.5° for Earth, and 24° for Mars. Thus Mars has a similar set of seasons: Winter, Spring, Summer, Fall. Of course, with this big difference – they are all cold! Now some Mars calendarsmiths seize on this fact to ignore them. Doing so allows one to come up with a calendar maximized for rationality: 24 months, 4 seven day weeks each – you would need only one calendar page a each month would start on the first day of the week and end on the last. There would have to be some adjustment at the end of the year because 668.60 padans is 3.4 days shy of  $24 \times 3 = 96$  weeks. Out of every five years, in two years there would have to be one week with only four days, and three years with one week with just three days. How can you call it a week? Okay, a short week – call it a “wek”.

While that makes a perfect calendar for a textbook world with 668.6 pairs of sunsets and sunrises. It is not a perfect calendar for Mars. For in fact the seasons will be just as intrusive, if not more so, in the daily life of Martian pioneers, as our own seasons are in our lives. How so?

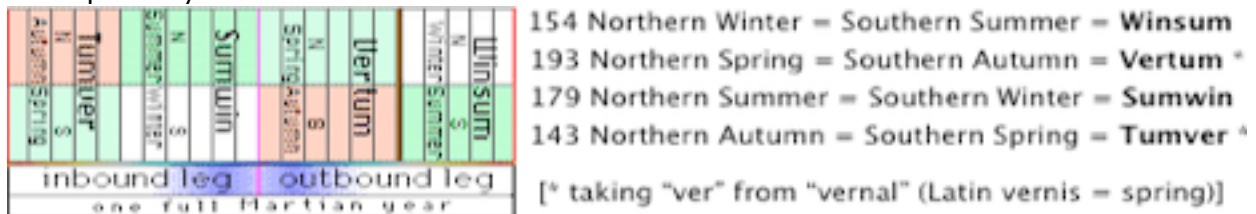
To address the first “put down,” that Mars’ seasons differ only in the degree of coldness, that is so superficial a remark as to be undeserving of any one calling him/herself a Mars enthusiast. Consider that slight differences in the temperature could have very critical effects.

On Earth, for example, liquid propane gels at minus 54° F, a very salient fact in the central northern areas of my native Wisconsin. Happily, the thermometer rarely plunges that low. We remember that in last year's rescue attempt of a doctor stationed at the Antarctic South Pole was dependent on the temperature affecting the rescue plane hydraulic systems =. On Mars, such seasonal temperature differences will be extremely crucial for outdoor activities.

Further, whenever it is winter in one hemisphere or the other on Mars, about 30% of the carbon dioxide in the atmosphere freezes out over the winter pole. And carbon dioxide makes up 97% of Mars' air! Thus air pressure on Mars is at its lowest in Winter/Summer and at its highest in Spring/Autumn.

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

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



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

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

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

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

These very different season lengths are quite inconvenient for calendar makers to reflect. It is much easier to ignore them when laying out the calendar and be content to simply note the days on which the solstices and equinoxes occur. Most Mars calendar makers in the group follow this route, as does James Graham, inventor and publisher of the well-illustrated



and widely published Mars Millennium Calendar with its totally out-of-the-clear-blue-sky choice of month names without any natural significance for Mars. (Pretty, but “thumbs down”).

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

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

Since then, however, Richard Weidner has found another way to tie the months to the seasons. <http://cicero.jpl.nasa.gov/~richard/Calendar/index.html>

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

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

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

[http://www.moonsociety.org/publications/mmm\\_papers/marspulse\\_cal.html](http://www.moonsociety.org/publications/mmm_papers/marspulse_cal.html)

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

## Outdoor Mars

By Peter Kokh

### **Mars' Thin Unbreathable Atmosphere**

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

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

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

### **Mars: from cold to cold beyond bitter**

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

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

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

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

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

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

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

It is not the "cold" that will be the "issue" so much as always having to wear a pressurized suit and helmet – never being able to feel the air and wind on one's face and breath

in its freshness and enjoy the breezes. It is not so much the cold, but the thinness of the air, and its unbreathable mix, that will shape the Martian character.

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

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

### **Mars Outdoors – no open water**

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

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

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

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

### **No Biosphere Awaits Us**

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

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

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

### **The Remoteness of Mars – Beyond Conversational Reach**

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

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

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

### **The Long Trip out to Mars**

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

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

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

### **The Long Wait Between Launch Windows**

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

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

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

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

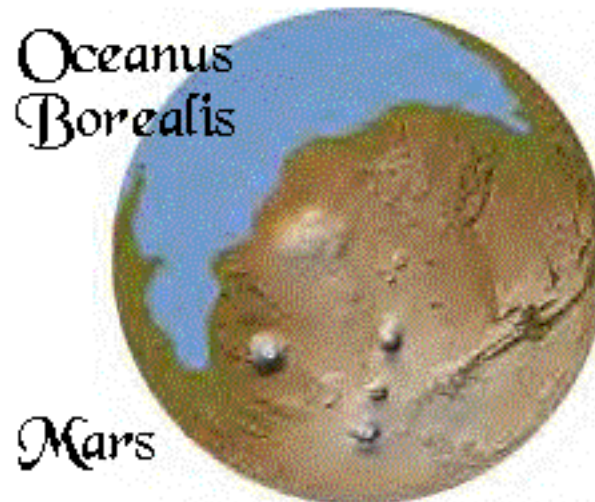
**MMM # 143 – MARCH 2001**



**Manned Deimos Outpost is the Key to Timely Opening of Mars**

Sometimes an apparent “detour” is the key to reaching the finish line first (fable of The Tortoise and the Hare!) An as soon-as-possible manned outpost on Mars little outermost moon, Deimos could:

- **Deploy various probes as soon as ready, not every 26 months**
- **Teleoperate probes on Mars in “real time”**
- **Be a Quarantine Lab for a whole series of Mars Sample Returns**
- **Provide up front backup support for manned landing missions.**



### **Evidence Found of Ancient Mars Ocean**

[http://www.brown.edu/Administration/News\\_Bureau/1999-00/99-060.html](http://www.brown.edu/Administration/News_Bureau/1999-00/99-060.html)

The great Volcanoes and Valles Marineris are clearly visible to the south of the ocean. Providence, RI, 12/10/99 – James Head, Brown Univ. planetary geologist, is the lead investigator on a team of scientists that has found evidence supporting the presence of an ancient ocean on Mars.

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

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

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

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

The **Space Advocacy Movement** has been so conditioned to the politico-economic reality of **fixed and shrinking budgetary pies** that taking sides, **“Moon or Mars”** seems the only logical framework for action.

**There is a reason that Moon Enthusiasts should be interested in Mars!  
In fact there are many reasons!**

**There is a reason that Mars Enthusiasts should be interested in the Moon  
In fact there are many reasons!**

**That is why opening the Mars Frontier is the 2<sup>nd</sup> focus for MMM!**

It has always been the posture of MMM that we “have to” find a way to do both, or we will end up doing the “winner” badly.

In the following articles and discussions focused on Mars, **we revisit many themes** touched on above and we delve into a number of new topics. One of them is **how Mars itself will forge the characters and culture of its settlers**, looking at one salient feature of Mars after another: geology, climate, coloration, the length of its days, seasons, and year. The isolation in time lag, distance and launch windows, the need to be extremely self-reliant. Most fans are overly romantic about Mars. Few would settle Antarctica, a much friendlier place by every possible measure.

**The significant asset of a forward exploration base on Phobos and/or Deimos** is treated further. Ignoring these assets for fear of getting bogged down there, is a strategic mistake.

One seemingly bizarre proposal that has gotten zero feedback, perhaps because most people automatically think that it is a joke, is that by using “little people” like dwarfs, or perhaps pygmies, we could double or triple the number of brains and operators on an early Mars expedition for no increase in life support, weight, or other consumables. Brains and hands count, torsos less so.

The dire need to work on an **“Economic Case for Mars”** is repeated often. Is anyone listening?

**MMM #153 - MAR 2002**

### **In Focus** **Mars and NASA's new "Nuclear Systems Initiative"**

Editorial Essay by Peter Kokh

A central feature of NASA's new budget is its “Nuclear Systems Initiative.” NASA explored several nuclear propulsion ideas back in the early seventies, but this effort, perhaps premature, fell victim to Nixon's cost cutting ax. So we have been hobbling around the solar system relying almost exclusively on chemical rockets. Even pushed to their theoretical performance limits, chemical engines are severely limited in what they can do. They permit us to crawl to Mars, the asteroids, and the outer planets with barely enough instrumentation to make these efforts worthwhile. While what we have learned from the Voyagers, Galileo and various Mars missions along with what we hope to learn from the Cassini- Huygens mission to Saturn and Titan is most amazing. We have, however, only scratched the surface.

Galileo's multiple orbits of Jupiter through the realm occupied by its four great moons has revealed four worlds each deserving of its own dedicated fully instrumented orbiter and a fleet of landers. Europa, especially, deserves as much attention as we have been giving to Mars. It is most likely, moreover, that Cassini will reveal Saturn's moons to be equally deserving of intensive, dedicated further study.

Yet up to now, only two more outer system missions have been under consideration: the Pluto-Kuiper flyby, and a first Europa orbiter. Both have been so constrained by unrealistic budgets, that the amount of science either would be able to deliver, while very welcome and surely enlightening, succeed mainly in intensifying our curiosity even further. Both these targets are worth major missions, not lightweight token efforts. But given chemical rockets and the distances to be covered, we are limited in our achievements.

We have always been strongly supportive of near term missions to both Pluto and Europa. But perhaps it is time to take a longer, more patient view. Do we want to learn the little we can in the next 10-15 years, with slim chance of follow up missions to answer the many major questions both these limited teaser probes would raise? Or is it worth putting both these exciting chemical rocket missions on hold while we develop significantly superior nuclear electric propulsion engines that in the long run, promise to offer us much more science in a decade or two than we can hope to gather with another century of reliance on chemical rockets?

What is under consideration, is development of a uranium-fueled nuclear fission reactor with an advanced electric propulsion system that energizes a set of ion engines.

**Safety will be paramount:**

- The nuclear reactor would stay intact in the event of a launch failure.
- The nuclear hardware is to be launched in a "cold," nonoperating state.
- The reactor (of any future spacecraft mission) would be activated at nearly 1,555 miles (2,500 kilometers) distance from Earth. This high, non-decaying orbit altitude was chosen to be compliant with the NASA Orbital Debris Guidelines in case the system failed to start.

Sean O'Keefe, NASA's new administrator, is making a gamble that many are unhappy with. Two most scientifically important missions are being put on hold for the development of a propulsion system which may take longer than expected to perfect. Even many of those who applaud NASA's Nuclear Systems Initiative for its unquestioned promise, feel that this new emphasis does not justify scrapping two conventional missions already well into their planning stages. Indeed, given the way the Bush administration is spending billions futilely strengthening only some of many weak links in our defenses, it is disturbing to see worthwhile initiatives cut to pay the price. We'd very much like to be around when the first Europa orbiter peeks below that moon's ice crust to confirm and map the ocean below. But we'd be even happier if we knew that we had developed the technology to open the outer solar system to routine science missions that would enable much more thorough exploration.

Nuclear electric propulsion for unmanned probes is just the beginning. If humans in the flesh are ever to go beyond Mars (or to go beyond exploration of Mars to opening it up as a new frontier) we will need a faster, and safer, means of propulsion. Safer? Yes, because shorter trip times mean less total exposure to the radiation hazards of space.

Nuclear thermal rockets could cut trip time to the Moon to 24 hours (instead of three days), one way to Mars down from 6-9 months to perhaps three. At the same time, the faster propulsion would work to lengthen launch windows significantly. Humans to Mars by chemical rockets is possible, just! Longer missions to the asteroids and beyond would stretch this old revered technology to the point of suicidal absurdity. If we want an open ended future for humans in the solar system, we have no choice but to get beyond the infancy of our "Space Age."

Patience is a difficult virtue to practice. It does not mean sitting around waiting. It means aggressively working for better options. We owe this to ourselves, to our dreams.

Go NASA, go! - PK

# To Mars by way of La Paz No, not Mexico, Bolivia!

By Peter Kokh

## The Search for Mars Analog Locations

We've all heard of other "Terrestrial Roads" to Mars:

- to Mars via the Dry Valleys of Antarctica
- to Mars via Canada's Devon Island (FMARS)
- to Mars via Hanksville, Utah (MDRS)

All these places have their analogies to Mars. The Antarctic dry valleys are very cold and ultra dry, as close a climatic match as is to be found on Earth. But the logistics between here and there leave much to be desired.

Devon Island is remote, but in comparison to the Dry Valleys, practically in our back yard. Here the analogy is not so much the climate but the terrain, and paucity of vegetation.

South Central Utah is red rock country and also has vegetation-free areas. Plus it is in easy reach of Salt Lake City, Las Vegas, Albuquerque, and Denver.

## Why add La Paz, Bolivia to this list?

Because on Mars, the air is thin -- as thin as it is between 100,000 and 125,000 feet up here on Earth. That's something it's fair to say that most of us will never directly experience. Sure there's Mount Everest and our own Mount McKinley, and closer to home to most readers, Pike's Peak in Utah at 14,002 ft. (I've been there myself.) But these are all uninhabited places.

La Paz, Bolivia, is the world's highest capital city at 12,000 ft., nestled in the Altiplano valley between parallel ranges of the mighty Andes. And now suddenly well over a million in population, it is also the world's highest major city, significantly higher than Cuzco, Quito, Nairobi, Bogota, and Mexico City, in descending order. [For nit-pickers, much smaller Lhasa in Tibet is a 100 meters higher.]

La Paz' J. F. Kennedy Airport, at 13,800 feet is even higher. But that's a lot lower than 100,000 ft. let alone 125,000 ft. But for the current bunch of major human settlements, La Paz is as close as this planet has to offer.

Curiously, one of the nearby scenic musts is Vale de Luna, Valley of the Moon. With its Mars-hued rocks, perhaps it is misnamed! For a glimpse of this scenic treasure, go to:

<http://www.cogs.susx.ac.uk/users/fabricer/trips/bolipix/profond.gif>

To Mars by way of La Paz? The point of course is that if you think that 12,000 feet up is too high, then maybe you had better think twice about going to Mars.

But if you are looking for a vacation trip out of the ordinary and that will put you in a Mars mood, why not here? One thing is for sure. You can have much more fun in La Paz than in Antarctica, Devon Island, or the middle of nowhere in Utah! Just thought you'd want to know. :)  
<MMM>

## Mars Aviation Task Force





### **Aviation on Mars – A Task Force & A Plan**

Above, NASA's solar-powered unmanned Helios Prototype on its way to a record altitude of 96,863 feet on August 13th, 2001. Its 247 ft wingspan carried a payload of 100 lbs. to an altitude where Earth's atmosphere is as thin as Mars'. A new breed of planes will open the planet's vast roadless reaches to daring human pioneers.

### **A Mars Society project for exploring the design issues, the relevant framework, and the operational characteristics of an airborne transportation system on Mars.**

By Paul Swift ([pswift@shaw.ca](mailto:pswift@shaw.ca)) and Peter Kokh ([kokhmmm@aol.com](mailto:kokhmmm@aol.com))

The highest major airport on Earth with regular scheduled jet service is La Paz, Bolivia's J. F. Kennedy International airport at 13,800 ft. It was a milestone of aviation history when the first Boeing 727 arrived. Now if that was such a feat, how can we be serious about flying on Mars where the air is as thin as it is at 100–125 thousand feet up on Earth?



Despite the tremendous challenge and many hurdles, there is quite a bit of excitement, and confidence, that we can learn to do just that! NASA has several unmanned Mars drone plane probe designs in the works, including the KittyHawk, which would be on its way next year for a maiden flight over the immense Valles Marineris canyon on December 3, 2003 as part of a celebration of the 100th anniversary of the Wright Brothers famous first flight -- had it not been for the Mars Polar Lander fiasco.

On August 13th, last year, NASA's solar-powered unmanned Helios prototype reached a record altitude of 96,863 feet, where the air is about as thin as it is on Mars.

But aviation designers are looking beyond lightweight unpiloted exploration craft. For more than fifteen years they have been brainstorming just how we can achieve piloted flight on the Red Planet.

#### **What's at stake**

On Mars the role of special airplanes will not only be to assist truly global exploration of this intriguing world, but to be the workhorse of expansion of a human frontier on Mars to territory as vast as Earth's seven continents combined. The trackless surface is a veritable minefield of boulders, and creation of a global road network would be slow and expensive.

Large aircraft that could take off and land vertically carrying runway-building equipment would open the planet by building runways that could then be used by conventional aircraft of various types.

Unlike the situation facing Lunan pioneers, an "umbilical cord" to Earth is not feasible. The governing paradigm will be that of the "egg and yolk sac." Because of the long 25+ month wait between launch windows, plus additional wait for return windows, reliance on Earth-based rescue, repair, and relief would be a recipe for certain disaster and failure. The first expeditions will have to bring with them whatever resources they may need to fall back upon in order to recover from mishaps and disasters.

Once we commit to the establishment of an open-ended frontier community, it will make much more sense to develop a broad diversity of local resources. If you need copper, for instance, and there is none in the local soils, you will want to be able to access such a resource elsewhere on Mars. In other words, an interdependent plurality of settlements scattered over the Martian globe will be much more viable and self-reliant than any possible single site.

Roads can and will be built in and around the various settlements. But we will need to “leapfrog” hundreds and thousands of miles/kilometers of intervening trackless, rugged terrain to forge scattered settlements into one diversified Martian economy.

For this task, Mars aircraft will be essential. We will need planes for prospectors and geologists seeking to verify and pinpoint strategic resources: metals, alloy ingredients, water, thorium and uranium, etc. We’ll need VTOL search & rescue craft. And cargo planes to ship specialty manufactures from one area to another. Passenger airliners too. Without planes, to reach and explore a remote site, one would have to return to Earth and launch again to a new site – sheer folly!. Yes, flying on Mars will pose great risks.

The fearful can stay behind. It is absurd to think of opening a frontier without risk.

If we want to open Mars, it is essential that we soon fly drone scout aircraft on Mars, and then quickly begin developing human-piloted craft. Our goal should be to have such a craft included in the first Mars Landing mission. Aim high, hit the mark!

#### **Readings:**

**Dirigible Airships for Martian Surface Exploration** by W. Mitchell Clapp. AAS 84-176. Case for Mars II, Ed. Christopher P. McKay, 1985, American Astronautical Society ISBN 0-877030220-3, pp 489-96.

**Nuclear Thermal Ascent Vehicle Using Indigenous Fuels for Multiple Takeoffs and Landings (NIMF)** by

Robert M. Zubrin, pp. 17-28, Proceedings of ISDC '89, Ed. Jeffrey G. Liss, Univelt, ISBN 0-912183-09-8

Mars Airplane Design Studies, Kenneth R. Silver and Michael F. Lembeck, pp. 204-15, ISDC'89 op. cit.

**A presentation by Paul Swift**, Mars Convention 2000 The Mars Aviation Task Force – Paul Swift

This is a formal announcement that the Mars Society will be hosting a unique discussion group on the topic of traveling through the 'air' on Mars. Specifically, this discussion group will consider all aspects of crewed airborne transport on Mars.

The Martian environment will require a multi faceted approach to enable humans to move about the surface of the planet. It is acknowledged that aground transportation segment will be a vital and necessary subsystem of this Mars Transportation System, but is not a part of this discussion.

The time is now here to start to formulate the types of missions that will be undertaken by the first comers to Mars, as well as the groups to subsequently come doing their extended work.

#### **Discussions are expected to focus on some of these following issues:**

- The Martian aerial environment
- Base camp and 'fly' camp placement and servicing
- Crew and passenger selection and functions
- Mission definitions
- Range and capacity of aerial vehicles
- Speed and payload capability
- Landing, takeoff limitations and requirements
- Fuel system management
- Propulsion and structural requirements
- Crew safety procedures
- Search and rescue etc.

The reason for putting this list into action now is simple. We will soon be overtaken by events unless we are very proactive in this area. The time to define the Airborne segment of the Mars Transportation System is now. We have the capability of specifying what is needed, building and testing it here on Earth, while learning perhaps some new skills and putting our theoretical approach into practice.

- Hardware proposals include wing supported airplanes, rocket supported aerodynamic vehicles as well as nonaerodynamic vehicles.
- Propulsion varies from propeller driven to rocket or steam jet, or an engine that may use certain elements from the Martian soil or atmosphere.
- Fuel categories include chemical, solar, nuclear. Listed here are some of the missions that will help determine how we think as designers of aircraft:
  - Long range recon – eyeball & camera plus sensors
  - Mapping • Cinema–photography
  - Landform examination (outcrops / anomalies)
  - Outpost servicing • Search & Rescue
  - Point to point delivery/pickup of people/supplies
- Fuel depot management • Atmosphere research And probably more. These require characteristics in the flight vehicle vastly different from one another, including speed. Some of these missions will require flying as fast as possible, while for others it will be hard to fly slow enough. Some flights will carry only a tiny payload, while others must have massive cargo capacity. I foresee several aircraft types, one for each type of mission. The low level Mark I Eyeball terrain recon mission at low speed and highly maneuverable (my pet project.) Medium range search & rescue high speed vehicle for point to point operations. Heavy lifter for outpost construction and resupply.

The area of field maintenance is extremely critical. But it all boils down to the design. Is it built to be manufactured cheaply, or built for easy field access to all components? You can squeeze by on Earth, but flying over Mars, mechanical problems must be field-solvable. A staffed and well-equipped hanger may be half the globe away. [As a preliminary reference document, the content of a presentation by Paul Swift to the Mars Society membership at the 3rd Annual Mars Convention in Toronto in 2000 is on this site for consideration.]

### **Where to find us**

We may or may not have the Mars Aviation Task Force website and email discussion group up and running by the time this issue of MMM arrives in your mailbox. Our target date is mid-late April. And here are the addresses we have reserved:

<http://MarsHome.org/MarsAviationMarsAviation-Subscribe@lists.MarsSociety.org>

Nontechnical assistance needed -- Peter Kokh. If you think that flying on Mars is a great idea but are not an aviation engineer, we can still use your help. Two early priorities for the Mars Aviation Task Force do not require technical proficiency:

1. Compile an exhaustive bibliography that will be accessible online covering
  - a. Papers on Aviation on Mars
  - b. Papers on Aviation on Earth at very high "Marslike" altitudes
2. Compile an image library accessible online of appropriate artwork to include serious sketches of Mars Aircraft design ideas but also historical and fictional art in the "inspirational" category (Bonestel's depiction of Von Braun's great winged Mars Landing Craft, for example.) Outreach & Recruiting Opportunities Galore The immediate spark behind this effort is an opportunity in Milwaukee. Aviation Career Day is an annual event held at Mitchell Field International Airport every year on the last Thursday evening / Friday morning each April. At last year's event, we reserved a table for the Wisconsin Mars Society chapter & LRS with the theme "You can fly on Mars!" Aviation and Experimental Aviation enthusiasts are an enormous untapped resource. In every part of the country and abroad there are annual Air Show events at which, following our model, chapters of the Mars Society and National Space Society can get the message across: "We CanFly on Mars!" <MMM>

## **Mining Mars' Atmosphere as if our survival depended on it!**

By Peter Kokh

Mars' atmosphere is 97% carbon dioxide, the rest mostly nitrogen, with some argon and traces of water vapor. Thin as it is, this "air" is thick enough for aerobrake assistance in landing from orbit, or on direct trajectories from Earth -- saving fuel. We are also confident that it is just thick enough to support flight. And from this atmosphere we can derive both oxygen and nitrogen to provide breathable air in our pressurized outpost and settlement structures. These are three critical pluses for the exploration of Mars.

But the usefulness of this thin envelope does not end here. Its chemical feedstock potential will help pioneers make do without the fossil fuel bounty to which we have become addicted on Earth. Robert Zubrin's ISRU [in situ resource utilization] experiments, repeated successfully by others, show that we can use Mars' air to produce useful fuel combinations: carbon monoxide + oxygen; and the more potent methane (CH<sub>4</sub>) + oxygen. These bottled or liquefied fuels will run generators for electric power, operate machinery, and provide fuel for Earth return craft, surface transports, and even aircraft.

Power for generators and fuel for vehicles are extremely important. We will need both right away, and having to bring along from Earth only the capitol equipment needed to produce these fuels rather than fuels themselves, will not only make early missions that much more doable, but lay the groundwork for successor missions and outpost expansion.

### **Chemical industry feedstocks**

On Earth, we rely on petrochemicals not only for fuels, but also for feedstocks for our diversified chemical industries, even for pharmaceuticals. If a frontier is to be established on Mars, we will need some way to kick start the local equivalent of a petrochemicals industry so as to minimize very expensive imports from Earth.

Assuming that Mars does not possess non-biogenic oil, coal, and gas resources, how far can we go towards building up a chemicals industry on feedstocks synthesized from the ingredients of the Mars air soup? While there is a small minority group that maintains that the Earth's oil and gas reserves are not biogenic, i.e. not fossil-derived, this is a view that has a long way to go to earn respect. The mainstream view is that our petroleum, coal, shale, and much of our gas reserves are the bounty of abundant terrestrial vegetation in eons past.

If we were to find such resources on Mars, it would be quite astounding and radically revolutionize much of our geological, and even cosmological assumptions. It is a romantic notion much more unlikely than finding alien artifacts on Mars.

What is at stake? If we can even start down this road, leaving to future Martian pioneers how to advance further, we will have helped kick open the door to Mars that much wider.

But there are challenges that we must recognize. On the one hand, we have a good supply of elemental ingredients. On the other hand, "starting from scratch" i.e. with elemental ingredients, is not the route of chemical synthesis we are familiar with. Like many a modern Kitchen Queen or King, we are used to using "starter" pre-prepared ingredients like gravy mixes, canned soups, canned spaghetti sauce, etc. Our petrochemicals industry supplies many advanced "building block" molecules isolated from petroleum and/or coal in the refining process.

## **Chemical Engineering Young Turks to the Rescue**

Essentially, what we must undertake on Mars is one of those "paths not taken" in the course of industrial development on Earth. Not taken, because we did not have to go that route. While some research along these lines may exist, it is a safe bet that a lot of it has not been pursued. To prepare the way, we need qualified people to find the chemical pathways and to "engineer" ways to follow them

on an industrial scale (not as laboratory curiosities.) Indeed, we may want to set up a Mars Atmospheric Feedstocks Task Force

**“Sabatier Products Unlimited”**

**Mars Atmospheric Feedstocks Task Force  
“Sabatier Products Unlimited”**

By that, or some other name, to pursue previously unexplored avenues.

### **Starting with the easy stuff first – Ammonia**

In addition to fuels, one of our earliest and most essential needs will be nitrate fertilizers. It is a common misconception that on Earth, plants get all the nitrogen they need directly from the air. In fact, only certain microorganisms, and some legumes (bean family) in whose roots some of these micro-organisms live in a symbiotic relationship, are able to “fix nitrogen” directly from the air. In our greenhouses on Mars, we will have to inoculate our soils with these special microbes and also cultivate legumes. But we can also use Mars Air to produce ammonia (NH<sub>3</sub>) via the Haber Process and from this we can make nitrate fertilizers. Ammonia can also serve as a refrigerant. Other logical feedstock products are NH<sub>4</sub>OH /ammonium hydroxide, and reacted with sulfur and chlorine, ammonium sulfate and ammonium chloride.

### **More Nitrogen products**

N<sub>2</sub>O Laughing gas is used as a mild anesthetic but can also be combusted with carbon to revert back to pure Mars Air (CO<sub>2</sub> + N<sub>2</sub>) providing another fuel combination option for specialized uses. NO Nitric Oxide can be used to make HNO<sub>3</sub> nitric acid for the manufacture of explosives, celluloid, dyes, nitrates and fertilizers, and as an handy laboratory reagent. Nitrogen compounds are a logical place to start.

### **N<sub>2</sub>O<sub>5</sub> Dinitrogen Pentoxide: An inconvenient attribute**

According to Jeffrey Landis, a respected NASA researcher and writer, N<sub>2</sub>O<sub>5</sub> is sufficiently unstable as to be classified as an explosive. But if it could be stabilized somehow, (it may be naive on our part to suggest that it can) it would be very useful.

You see it is stable as a white powder throughout the entire temperature range found on Mars. If it could be handled safely, it could be used as air-derived shielding for Mars habitats and outposts.

The advantage? We wouldn't have to disturb the soil around the outpost to get shielding, Given all the boulders we see on Mars, and the possibility of permafrost hardening of the soil, that could be quite an advantage. A catch is that the traditional way of preparing dinitrogen pentoxide is to react phosphorous pentoxide with nitric acid. If we could not find a direct route, then we would have to synthesize P<sub>2</sub>O<sub>5</sub> first.

### **Hydrocarbon chemistry**

Now it gets harder. Hydrocarbons are the most important of all chemical feedstocks. We refine these from petroleum or coal. How far can we get synthesizing basic hydrocarbon feedstocks directly from the carbon, oxygen, and hydrogen in Mars' atmosphere? Methane CH<sub>4</sub> is the first in a series followed by Ethane C<sub>2</sub>H<sub>6</sub> and Propane C<sub>3</sub>H<sub>8</sub>. If we could synthesize ethane and propane, we'd have additional fuels as well as the building blocks of ethylene C<sub>2</sub>H<sub>4</sub> (> polyethylene) & propylene C<sub>3</sub>H<sub>6</sub> (> polypropylene -- trade names: Olefin, Herculon, etc.)

The Alcohol family begins with Methyl Alcohol CH<sub>3</sub>OH derived from Methane and Ethyl Alcohol C<sub>2</sub>H<sub>5</sub>OH derived from Ethane. These two avenues can give us a head start by allowing pioneers to manufacture many useful products. But from here on it may get harder. Starting on this foundation, future Martians will be able to go much farther as their population increases and as their industries continue to diversify.

### **Growing Chemical Feedstocks on the Farm**

It will be practical common sense to use biological assistance in our efforts to build a chemical industry on Mars Air resources. We will be bringing both animals (ourselves, at least) and plants to Mars and we would deserve to fail if we overlooked all the chemical byproducts these living creatures synthesize directly or indirectly.

### **Some instances:**

- Urea, NH<sub>2</sub>CONH<sub>2</sub>, from human urine

- Organic dyes
- Organic oils and lubricants from Oiliferous (oil-bearing) plants
- Organic solvents
- Organic adhesives

The list of useful plant / animal byproducts that can be used as chemical feedstocks is already lengthy and continually growing. The partnership of farm and chemical industry is a two way one. Mining Mars Air can jump start a diversified industrial underpinning for settlement. <MMM>

## Drilling for Water on Mars

### Water “on location” for drinking, bathing, growing food, and for industrial purposes

By Peter Kokh

Until Mars Odyssey arrived in Mars orbit, schemes for supplying water to an outpost/ settlement have fallen into 3 general categories:

1. Squeeze water vapor out of the thin atmosphere. While Mars atmosphere is less than a hundredth the thickness of Earth’s (at the surface) and its capacity to hold water is vastly less, there is still some water vapor in the air. In the Sabatier reactor ISRU process of air-mining for oxygen and fuels (carbon monoxide, methane) it should be feasible to produce a steady trickle of condensed water vapor as a byproduct.
2. Fetch ice from one of the caps, if the outpost is near one of them. Water Ice, known for some time to be the major constituent of the North Polar Cap, could be transported equatorward by truck, pipeline, or by enclosed, pressurized, heated neo-Lowellian canals. Not a minor undertaking, any such scheme might be part of an advanced phase. See MMM #62 February, 1993 page 6 “ The Canals of Mars: From Self-Deception to Reality.” P. Kokh
3. Taping permafrost and/or ground water

Still in the early part of its mission, the Mars Odyssey Orbiter has been detecting the tell tale signature of hydrogen. The implication is that water or water ice, not only at both poles and throughout the circumpolar areas, but just about everywhere.

The probe’s gamma ray spectrometer is similar to that flown on Lunar Prospector. Its resolution is similarly coarse, about 100 km or 60 miles. This is good enough to give us a general idea, but if we want to validate a short list of premium Mars outpost locations, we will want to fly another mission with a much more powerful instrument, so that we “can land on the dime.”

But the presence of frozen water or permafrost in the soils of a proposed site is still far from adequate information. What is the percentage of water content in the soil? How deep does these layers extend? How saline is it and what salts are involved?

We have become accustomed to thinking of ice and permafrost on Mars. But if this frozen resource is more than a surface phenomenon, if these deposits go down and down and ... then at some point we will encounter liquid water aquifers. Why? Because Mars has a hot iron core, smaller and less hot than Earth’s but bigger and hotter than the Moon’s. However cold the surface may be, at some point as one probes deeper and deeper, the temperature will start to rise, steadily. Eventually, a point will be reached where liquid water would replace ice. Can we drill to that depth? Or do such aquifers run too deep? The rate at which settlement operations, including farming and industry, can expand, hangs in the balance.

#### **Location, Location, Location**

We’ll want to site our outpost, or certainly our first settlement, handy to an aquifer if possible, but not on soil so saturated that it could become unstable if we succeeded someday in warming Mars.

#### **Water from Permafrost**

There may be permafrost mining at various places on Earth, in Alaska, Canada, or Siberia. But given the abundance of streams of liquid water in most subarctic areas, it could be that no one has tried to engineer such a system. If so, that can be fixed. We can experiment with permafrost mining here on Earth. The idea would be to come up with two or more workable systems and send an unmanned probe to a verified permafrost area to conduct field tests on location. When we send people, it would be insane to equip them with systems that have not been tested on location.

**If the ice is salty**

Another reason for unmanned permafrost testing on location is to determine its quality and purity. If the water ice is saline then:

1. Crews will need distilling equipment to produce drinkable water
2. Crews will need storage facilities to store the salts isolated in the distilling process as these will become an important resource, a treasure for both industry and agriculture

Given that the era of flowing liquid water ( an ocean, rivers, lakes) has been much shorter on Mars than on Earth, there may be salt, but much less of it, i.e. in lesser concentrations. Nonetheless, salt mining could be an important pillar for diversifying Martian industries, hastening the day of manufacturing self-reliance.

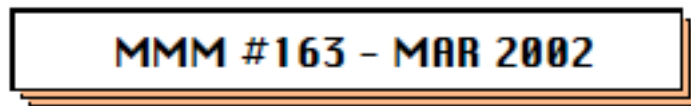
Below is a chart of the major sea salts found in Earth’s global ocean. If we can mine them from salt on Mars, this will add greatly to the resources we can tap in the atmosphere:

| <b>Main Salts in Earth Seawater</b> |       |                   |       |
|-------------------------------------|-------|-------------------|-------|
| Cations                             | g/kg  | Anions            | g/kg  |
| <b>Sodium</b>                       | 10.76 | <b>Chloride</b>   | 19.35 |
| <b>Magnesium</b>                    | 1.30  | <b>Sulfate</b>    | 2.71  |
| Calcium                             | 0.41  | <b>Carbonate</b>  | 0.14  |
| Potassium                           | 0.40  | <b>Bromide</b>    | 0.07  |
| Strontium                           | 0.01  | <b>Boric acid</b> | 0.03  |

Those in bold face would be especially useful -- the others should be easily found in the soil itself.

**The Upshot**

It is not enough to get excited about Mars Odyssey findings. We have to follow them up with a series of segue probes before we can intelligently plan a manned commitment to Mars.  
<MMM>



**There is Daylight on Mars!**

By Peter Kokh

That may seem to be a strange declaration. In fact, Mars is likely to be the only world in our Solar System where people will walk and live in “daylight.” For, despite the Sun shining constantly on the Moon for nearly 15 days at a stretch (the “dayspan”), there is no true “daylight” on our neighbor world to be experienced and enjoyed.

The Moon’s “skies” are black, not bright blue (or any color). There is direct sunlight but no ambient daylight, light scattered from all directions, such as we experience here on Earth.

Indeed, the Moon has “heavens” but not a “sky.” Mars, on the other hand, has a real sky. Yes, it is not blue. Yes, it is only half as bright as our sky. But a sunny day on Mars is significantly brighter than a cloudy day on Earth. This is one aspect of the Mars Frontier that will make it more attractive than the Moon to many.

We wrote about “The Black Sky Blues” (on the Moon) in MMM # 138, SEP 2000. For future Lunans, relief will come in ample “middoor” spaces with brightly cove-lit vault ceilings, possibly sky blue in color, and possibly similar ceilings in private residence structures, hallways, etc.

Indeed, since most Lunans will live the bulk of their everyday lives within enclosed settlements, not out on the surface, one might be tempted to say, “what’s the big deal? The sky is black! So?” Actually, Lunans will have the better nightspan star gazing experiences. Not so during dayspan.

The Apollo astronauts, all of them on the Moon only during midmorning lighting conditions, found that the glare of the sun makes the stars invisible in the black sky. But when Lunans travel between settlements and other remote locations, they will never experience daylight.

The lunar terrain may be brightly sunlit, but the sky will be black, and almost all the available light will come from one direction, from the sun. There will be some trivial reflected off of sunlit surfaces. Hearty Lunans will learn to adapt. On Mars, the pioneers will also have to adapt -- but not to a black sky, to a salmon colored one much easier on the eye. They will enjoy full daylight when traveling or working out on the surface.

This difference between the Moon and Mars may seem trivial, but should result in some distinctive cultural differences between the two frontiers. As content as future Martians may be with their color-shifted daylight, future Lunans will be the better able to adapt to similar black sky situations on most other moons and asteroids in the solar system. Besides Mars, only Titan offers a bright sky, also reddish, but much dimmer (1/50th the light levels!) Alas, I’d still miss the blue skies of Earth, and the Arizonesque Marsscapes will seem wrong without them. For a while, anyway! <MMM>

## **Keeping the Mars Frontier in the Pink Solar Sail Cargo “ Pipelines”**

**Can greatly reduce the cost and risks of “opening up” Mars as a frontier**

By Peter Kokh

The long-awaited Cosmos-1 solar sail mission may provide a big boost for dreams of opening Mars to human settlement. The reasoning is simple. By being able to tack in the solar winds, solar sail cargo vessels can slowly make their way to any destination in the inner solar system without waiting for ideal launch windows, in the case of Earth <—> Mars flights, some 25+ months apart.

The cargo or payload capacity of a solar sail depends on the size (area) of its sail. Cosmos I is a modest 30 meters (99 ft.) in diameter, but much larger sails could conceivably be built, all of gossamer light materials, using such devices as inflatable tubes and/or rotation to keep the sail taut in its unfurled state. It can “tack” inward and outward against the solar wind much as sail ships on the oceans can tack towards and away from the wind.

Sails made on Earth need to be coated with polymers to be sturdy enough to launch. Selecting polymers that degrade and evaporate in sunlight would help reduce the weight and increase the efficiency. Someday, more efficient sails may be manufactured in space.

### **About the Cosmos I Solar Sail Mission**

<http://www.planetary.org/solarsail/>

The spacecraft is being built by the Babakin Space Center in Russia, under contract to The Planetary Society. It will have a 30-meter (100 ft.) diameter sail,



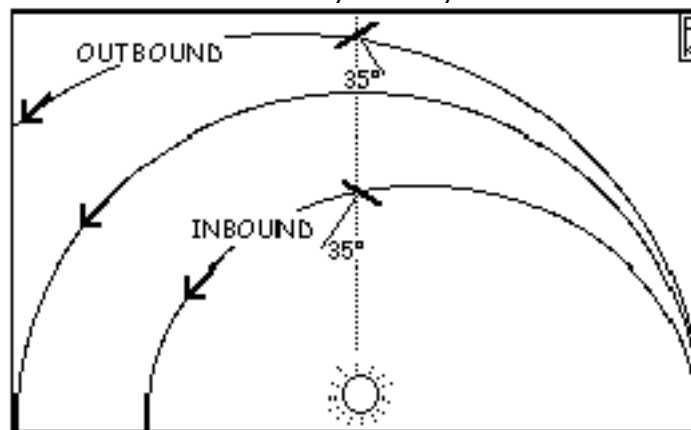
configured in 8 triangular blades and deployed by inflatable tubes from a central spacecraft at the hub. The 100-kilogram spacecraft will be launched by Volna, a submarine-launched converted ICBM, into a 800-kilometer (c. 500 mi.) circular, near-polar orbit of Earth.

Microwaves beamed from the 70-m Goldstone radio dish in the Mojave desert will then push it through space. The submarine launch planned for mid 2003, will be from the Barents Sea north of Murmansk. The spacecraft will be operated from the Babakin Space Center near Moscow. Telemetry data will be received in Russia and in the United States.

Inflatable tubes keep the sail rigid. The solar sail use the pressure of sunlight to increase its orbital energy and raise its orbital altitude. The sail is controlled by pitching the blades, thus turning the direction of the solar force. The purpose of the Cosmos I mission is to conduct the first solar sail flight and demonstrate the technique for traveling between planets.

#### **Tacking outbound, tacking inbound**

Aligning the sail so that sunlight falls on it straight on (perpendicular) is not efficient in orbital mechanics. If we tilt the sail so that the angle between the sun and the perpendicular to the sail is about 35 degrees, we maximize the component of thrust parallel to the direction of travel. This allows the craft to be pushed along the direction of travel, climbing up the gravity well, yet slowing down. By aligning the angle the other way to oppose orbital velocity, sunlight pushes against the direction of travel, dropping the sail down the gravity well and causing it to speed up. Solar sail can travel sunward as easily as away from the sun.



While the original idea was to use the energy of sunlight, quite strong everywhere in the inner solar system, scientists are now considering additional “beamed energy” sources such as microwave beams and lasers. These energy boosters would work to increase cargo capacity and/or shorten trip times. Beamed Energy Propulsion (BEP) is gathering much attention these days, witness the First International Symposium on Beamed-Energy Propulsion held 5-7 November at the Univ. of Alabama in Huntsville. Using sunlight or beamed energy instead of tons and tons of rocket fuel and fuel tanks and the engines themselves, makes this form of transporting cargo relatively cheap.

#### **Solar Sail Cargo Shipments as Infrastructure**

Solar or beamed energy cargo sailing vessels, given their ability to take a variety of complex trajectories to their destination, can create a virtual “pipeline” if they are dispatched in sufficient numbers to form a “steady stream” of cargo is always arriving at the destination -- say Mars. While this transportation system would not address any emergency needs of the Martian pioneers, it would be ideal to provide a steady stream of fresh supplies needed on a regular, routine basis for maintenance of the base and staff, and for planned expansion of habitat space, the agricultural areas, power systems, etc. Examples include foodstuffs not yet grown on location, components needed for outpost expansion, agricultural soil amendments

and nutrients, fuels which cannot yet be produced locally, clothing items, tools, seeds, replacement parts, etc.

## **The Great Solar Sale Race of 1992**

[Excerpted from] <http://caliban.physics.utoronto.ca/neufeld/sailing.txt>

### **The outlook in 1990**

The first President George Bush charged a committee with planning events to commemorate the five hundredth anniversary of Christopher Columbus' departure from Europe for the Americas. Among the ideas chosen to be implemented was the Columbus 500 Space Sail Cup. Spacecraft were to launch on conventional chemical rockets around Columbus day of 1992 and have to go to Mars using only light pressure. Among the serious competitors were the Canadian Solar Sail Project, an initiative of the Canadian Space Society, the Aeritalia Team from Italy, Cambridge Consultants from Britain, and the World Space Foundation from the United States... also teams from Japan, Israel, and the Soviet Union ... Among the criteria for winning, was shortest transit to Mars orbit and the closest approach to the planet. To be recognized as a winner the sail must have received no government funding, but could have received money from the Columbus Commission. One team from each of the Americas, Europe, and Asia, was to receive whatever money became available. The World Space Foundation sail was the official Americas sail, and was receive some of the money ...

**In retrospect:** The race did not take place. Commercial funding was not available for private launches, and the US government decided not to pay for launch costs for the three entrants.

### **How long it will take a Cargo Solar Sailer to get to Mars?**

Cargo sailers may take much longer to reach their destination than would chemical rockets. The time will depend on the sail and payload mass relative to the area of the sail, and to the relative positions of Earth and Mars at launch time. But for "routine cargo shipments, all that will matter is that there be a fairly continuous supply at the destination. Time spent "in the pipeline" is immaterial.

### **How a Cargo Sail Pipeline will Help Open Mars**

The advantage to Martian pioneers will not only be in the much greater frequency of shipment arrivals, but also in a significantly lower bill for "shipping & handling."

Solar sailing is attractive as a means of travel between the planets, when time spent in space is not important. The propellant is sunshine, there is no fuel, and the thrust is continuous. In contrast to chemical rockets, solar sail freighters do not have to be 95% fuel by mass.

As the pioneers will be hard put to produce exportable products that will be marketable on Earth, it will be vital for their bottom line to minimize the cost of imports for which they must find some way to make payment. Solar Sail Cargo shipments will thus greatly reduce the bill for maintaining, sustaining, and growing the human outpost(s) on Mars.

Cargo sailers are not one-use-throwaway craft. With proper trajectories, payloads can be dropped off, and picked up, as the sailer flies by Mars. This is vital, because goods exported to Earth will help settlers pay the reduced bill for imports. Using solar sail freighters to ship items back to Earth will minimize shipping costs, making Martian exports more attractive on Earth. Thus solar sail pipelines between the Earth-Moon and Mars-Deimos-Phobos systems will help on both ends of the Import-Export Equation.

The attractive economics are not the only advantage, however. A solar sail cargo "pipeline" will also provide some insurance against missed launch window opportunities for chemical rocket payloads, whatever the cause of their being missed (technical, weather, political mischief.)

How payloads will be delivered to the surface of Mars is important too, but another question. Aerobraking cargo shuttles, self-landing payloads using parachutes and inflatable pods, are among options to be considered.

### **What cargos will go by the solar sail pipeline?**

The pioneers will be doing all they can with the tools and equipment provided to rely on building materials they can produce locally on Mars, and on other local resources. But as they expand their settlement they will need many components and items that they cannot yet manufacture or supply locally. Along with imports of more and more capital equipment to allow local manufacture of more items on the strategic must-make-locally list, they will need ever more vehicles, appliances, electrical wiring components, plumbing items, water and air recycling systems, vehicles, power generators – the list is quite long.

### **The alternative: the “yolk sac” strategy**

There Mars pioneers will need a continued influx of many common commodities such as fuel, food stuffs not yet produced in outpost farms in sufficient quantity or variety, pharmaceuticals, clothing, etc. But without a solar sail cargo “pipeline” to deliver such items on a “just-in-time” basis, the outpost will need a substantial nest egg (a “yolk sac”) of supplies in quantities large enough to provide prudent margins should consumption or accident use up or waste needed items faster than expected. If a dire need develops before the next rocket shipment from Earth (on 25+ month intervals) they would simply be out of luck. Mars is simply too distant for an umbilical cord type of nourishment. [see MMM # 113 MAR ‘98, p. 6, “Yolk Sac Logistics”]

Yet a solar sail freighter pipeline will provide no relief at all for unexpected emergencies. To maintain & repair critical systems (power, life support, medical, etc. a “Yolk Sac” cache must be “on hand,” not “in the pipeline.

That fact has consequences that those who insist that a prior lunar outpost would not help open up Mars in a timely fashion must consider. It would be the height of presumption to send undebugged, unproved, critical systems to Mars without proper field trials. Some of these systems can indeed be tested in low Earth orbit. But those that rely on gravity to function properly, can be tested with more reliable results, and greater confidence, on the Moon where rescue, resupply, and repairs are only a few days flight away. We don’t ask the government to open the Moon first, or at all, but if a commercial Moonbase is in place before decisions about critical equipment to be included in a first Mars outpost, that would take some of the pressure off the need for a burdensomely large cache of replacement parts.

### **Point of Departure in the Earth–Moon System**

For routinely needed parts and goods that can be made on the Moon, sails departing from near the Moon will provide quicker service to Mars than sails departing from low Earth orbit. The climb out of Earth’s deep gravity well on sunshine alone, will take months. The Moon rests on the shoulder of that gravity well. Sails leaving from the Earth–Moon L1 Gateway will make the trip that much faster. Thus

any early lunar industries making items for use in the lunar outposts and settlements that can also be of use on Mars will help sustain efforts to open the rusty frontier.

### **If Cosmos I succeeds, what’s next?**

The Cosmos I mission hopes to test several things: in-space deployment of the sail itself; tacking in sunlight; rates of acceleration etc. We know from bitter experience with NASA tether missions, how disappointing such test flights can be. Failure can come from an unrelated system with the result that nothing at all is learned. NASA’s reaction has been to not try again. Cosmos I is the baby of a determined party, however. The Planetary Society understands the crucial value of solar sails to the opening of Mars, a goal to which TPS is committed. Congress, unfortunately, has not allowed NASA to be so committed.

If the flight goes less well than hoped, it'll be back to the drawing boards, with a retest a couple of years down the road. If all goes well, we'll want to do several things:

- Testing improved, more efficient sail materials
- Testing improved deployment systems
- Trial flights to Mars over several windows
- Recovery of the sail after Mars flyby
- Payload delivery to Mars surface, on target and intact
- Test navigation precision
- Scaling up the sail to carry helpful payloads

The years ahead promise to be exciting ones for solar sailing. It's been a very long wait,  
<MMM>

#### **Read More -- SOLAR SAIL LINKS**

<http://www.kp.dlr.de/solarsail/>

[http://www.spacetransportation.com/ast/abstracts/3C\\_Frisb.html](http://www.spacetransportation.com/ast/abstracts/3C_Frisb.html)

[http://www.spacetransportation.com/ast/abstracts/3E\\_Horod.html](http://www.spacetransportation.com/ast/abstracts/3E_Horod.html)

<http://caliban.physics.utoronto.ca/neufeld/sailing.txt>

<http://web.mit.edu/newsoffice/tt/1990/sep19/23638.html>

<http://members.aol.com/dsfportree/AT13.htm>

## **The Ideal Mars Suit**

If we ever would be something more than "Strangers in a Strange Land," we'll need lightweight, Mars-hardy, and intelligent "outerwear" to let us enjoy "the big red outdoors" as if we truly belonged there.

By Peter Kokh

### **Attitude is Everything**

On Earth, those of us who live in winter country, know how to dress to keep warm no matter how cold, how blustery, no matter what the wind chill. It's all a matter of layering. For most of us rugged winter-hardy folk, it's a matter of just keeping warm enough to go about our business of getting from here to there without getting a chill.

That said, many of us would have to admit that while winter is "not a problem," we still do not feel quite "at home" outdoors in that kind of weather. But there are those who have transcended to that point of comfort, thanks to lightweight winter "sportswear" flexible enough to allow full free movement of arms and legs. It is the winter sports people, and their outfitters, who have found a way for people to feel quite at home outdoors in weather that our less hardy sunbelt countrymen would find nothing short of Antarctic.

NASA did an excellent job of designing the Apollo Moonwalker suits, again relying on layering to provide micrometeorite, radiation and thermal protection, along with pressurization and life support. The suits were big and bulky, but they allowed us to get around, clumsily, and get the assigned tasks done. The Apollo suits provided a personal micro-environment that allowed us to explore an alien environment that would have been instantly fatal without the protections they afforded.

Compare those suits to the first early diving suits, or (why not?) to the aquarium "suits" that fish must "wear" Stranger in a Strange Land" – SISL. SISL suits are good enough for exploration perhaps, but not for pioneers that want to be able to go here and there in their adopted homeland "as if they belonged," in a way that protects but yet allows full freedom of movement without fatigue. Lunar "Out-Vac Sportswear" will appear when there is a market. Pioneers who volunteer to settle the Moon, but who are unwilling to check their love of outdoor sports at the door of the launch pad on Earth will create that market. In time light, flexible, yet still fully protective suits will be available that will let future lunans fill truly at home engaging in a wide variety of out-vac sport activities.

The SISL mentality will likewise produce suits for Mars Explorers that will be adequate for all the tasks that mission control assigns. But again, in time the market for something much better will appear.

### **Anticipations of Martian Surface Sportswear**

One place people are already working to design a “better Mars suit” is in Australia. We first reported on Mars Society Australia’s “Marsskin” Project in MMM #150 NOV. 2001, p 15. Mars Society Australia Projects. See: <http://www.marssociety.org.au/marsskin.shtml>

The Apollo suits, and all space suits used to date by both astronauts and cosmonauts are of the gas–pressurization type. They work, and have been amply tested in the field. But they have stiff joints which fight the wearer’s efforts to bend them. And they are bulky. Moreover, by containing an atmospheric shield that envelops the whole body of the wearer, they greatly increase the chances that a puncture of any part of the suit will be fatal.

In 1967, Webb and Annis published the concept and early experiments of a Mechanical Counter Pressure Suit (MCP), and in 1971 described the first demonstration of the many advantages to the MCP approach which exerts pressure on the body using formfitting elastic garments.

MCP garments offer dramatic improvements to gas pressurized suits in reach, dexterity and tactility due to the replacement of stiff joints and bearings with light, flexible elastics, lower suit costs and vastly reduced weight and volume. And, they are safer: a tear or hole would remain a local defect rather than cause a catastrophic puncture. MIT flexibility tests in the mid 1980’s found MCP gloves to be notably superior to gas–pressurized ones. Since then there have been major advances in textile technology for fibers, yarns, and automated knitting machines.

Mars Society Australia’s Project MarsSkin aims to design, produce and test analog mechanical counter pressure (MCP) space suits to be used in Mars analog research projects undertaken in Australia and internationally. They will behave in a near identical fashion to the real MCP suits which may one day be worn on Mars. Meanwhile, NASA–supported research into MCP suits has become another victim of the budgeteer’s ax.

The U.S. Army’s new “warwear” – (as shown on ABC’s “Good Morning America,” 2/26/03) includes a handsfree drinking tube (reminiscent of Fremen Stillsuits for all you Dune fans) and a handsfree radio that uses your skull bones as an amplifier, and a walkie–talkie GPS combo.

Military needs are akin to the needs of the sportsminded, in that performance is paramount. The wearer must not be encumbered in any way. To the contrary it is important to give the wearer every possible tool to be able to comprehend, analyze, and negotiate his/her “alien” environment to advantage. A proper Mars Suit (or Moon Suit) just as a battle suit, needs to be a smart one.

What “smart suit” features will help us on Mars? One can conceive of a “dust storm visor shield” that would automatically slide over the helmet visor when a certain threshold of airborne dust was reached, paired with a shield–activated visor heads–up screen on the visor that would use radar (and infrared and/or whatever can penetrate the dust?) to create a useful live picture of one’s surroundings good enough to navigate by. Such a dust shield and enhanced view screen will be a miniaturization of what will be needed on Mars vehicle “windshields.”

Infrared heat sensing vision will be important in search and rescue, in finding cave entrances (shelter) and even in prospecting (highlighting minerals that either retain heat longer or lose it faster than the background, minerals that heat up faster/slower than the background.)

In dusty or overcast sky situations where the direction of the sun is not apparent, and where the terrain seem monotonously the same in all directions, it will be easy to lose one’s bearings. As Mars lacks a magnetic field, a compass will be useless. A satellite network GPS system will help determine position. But not necessarily direction, until one moves enough in some direction to make a noticeable change in position. Or can the GPS be configured to reveal direction as well?

We wrote about “Engaging the Surface with Moon Suits instead of Spacesuits” in MMM # 151 DEC 2001. In that article, we discussed a number of useful smart suit features such as monitors that would keep the wearer informed of straight-line distance from base or vehicle and minutes of life-support remaining before safe return to base or vehicle became marginal.

But while the first explorers will definitely benefit from any improvements offered by the improved space suits of the time, for the pioneers themselves, those intending to spend the rest of their lives on Mars, the difference between a suit that will make them feel “at home” out in the open and one that will merely keep them safe, is critical -- critical to the overall morale and mood of the settlement population. Feeling safe, but still “a fish out of water” will do little to reinforce their decision to stay and make a new life in a new niche for mankind.

NASA and other government agencies involved in the effort to explore Mars are likely to prioritize “some” space suit improvements. But the budget ax will fall on other worthy improvements. Nonetheless, the explorers will make do and “succeed” in their explorations.

Yet we in NSS, the Mars Society, the Planetary Society, and even the Moon Society seek to go beyond exploration, beyond another series of science picnics and temporary encampments. Our vision is not that of the explorer or scout. It is that of the settler, the colonist, the forsaker of an Old World, of one committed to a fresh start in a virgin land, willing to learn the ways of that land, determined to “become a native” to the extent that such a seeming contradiction in terms is possible.

It is our efforts, spearheaded by MS Australia, and eventually championed by commercial outfitters of frontier sportsmen, that will make it possible. <MMM>

## Need for More, Diverse M.A.R.S. Hab Designs

By Peter Kokh

The Mars Analog Research Station designs in use on Canada’s Devon Island in the Arctic and in the south central Utah desert are based on Robert Zubrin’s “twin tuna can” Mars Habitat designs featured in his “Mars Direct” mission proposals. Both are two story structures supported on legs used for landing the habitats on site. The new EuroHab version is the first one to tweak the original design somewhat. Making it “a tad taller” gives just enough room to squeeze in three floors (with reduced ceiling height) and therefore 50% more floor space. One of the positive things to come out of operations in Iceland, where this hab will be deployed soon, is an analysis of the affect this increased roominess will have on operations, both directly by making room for more apparatus, and indirectly, by its affect, if any, on crew morale.

The 4th M.A.R.S. Hab will part company with its predecessors in using a pre-Mars-Direct design, the so-called Biconic shape for a habitat “flying in” for a landing rather than lowered to the surface vertically by parachute.



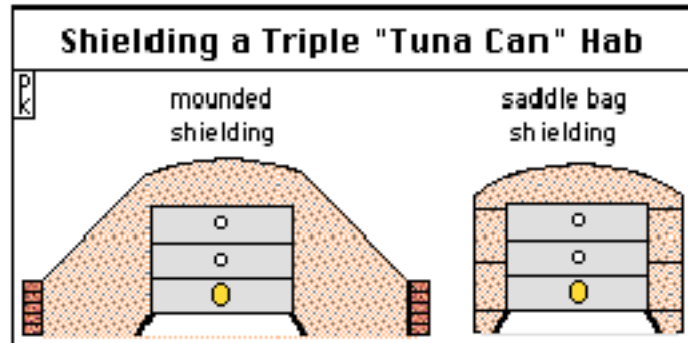
[http://www.marssociety.org.au/technical/tech\\_images/MarsOz\\_cover.jpg](http://www.marssociety.org.au/technical/tech_images/MarsOz_cover.jpg)

While the pros and cons of landing the two basic designs cannot be tested in Australia, the relative effectiveness of the two designs in supporting operations can.

The biconic design has the advantage of a lower profile, which will make it easier to shield with loose Mars regolith soil. In fact, it would be feasible to test various methods of robotic or teleoperated shielding emplacement in Australia.

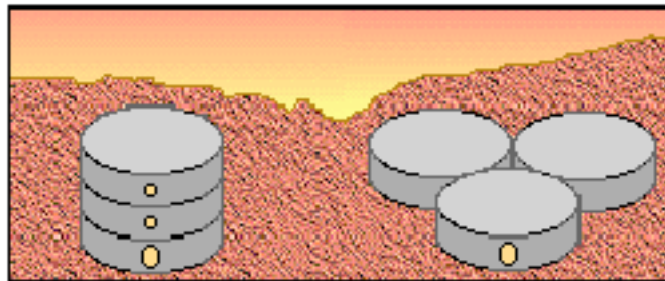
We do not know if that is one of their intentions, We do know that the need for shielding is a concern dismissed by Zubrin, both for the duration Mars explorers will be on the surface (30 days to more than a year, depending on mission profile) and in transit in spaces. An unfortunate attitude.

Shielding ease and methods are things we can pretest and pre-debug without spending a lot of money, and therefore should be one of the goals of the M.A.R.S. Hab program. There are ways the higher profile twin or triple tuna can design habitat (even with legs) can be shielded. A large mound with sloping sides can be bulldozed or otherwise moved in place. This mound would involve moving a considerable amount of soil. Starting with a perimeter ring of blocks sintered from packed soil, or of bags filled with soil, several rows high would help constrain the diameter of the mound necessary.



As shown in the illustration above, using fabric "saddle bag" held in place by straps to the habitat hull, and folded in pleats against the hull for the transit from Earth would reduce the total volume of soil needed as well as the footprint area of the shielded habitat. Both methods could be tested, and tweaked, on location in Utah.

It would seem, however, that the tuna can stack has disadvantages. Not only does the high profile complicate shielding emplacement, but it sacrifices volume to a ladder well. In Utah or another location, an "unstacked" version, in which all three separable floors are hoisted off the landing feet and onto a prepared flat soil bed, might have advantages. Access between units would be direct through doorways 120° apart. With the lower profile, shielding might be much easier, as well as adding expansion modules sometime in the future.



Perhaps all these experiments will reaffirm the choice of the stacked hab concept. There'll still be a need for additional testing. Zubrin's design is ideal for launch on top the external tank of a shuttle derived launch vehicle. Thus its 27 foot diameter. But by choosing an inflatable version, to fit uninflated inside the 15 ft. wide shuttle payload bay or in a same size faring on top of an expendable vehicle such as Titan 4, Delta 4, Ariane 5, Proton, etc. would help insulate Mars Mission plans from the uncertain future of shuttle-based systems. NASA's aborted TransHab project with similar 27 ft. diameter and 3 floors, could be resurrected. Meanwhile, a faux-inflatable stacked M.A.R.S. Hab with a TransHab like interior architecture would serve to test the ergonomics and effect on operations performance of such a design.

These suggestions do not exhaust the options, but if pursued, would provide invaluable experience and confidence in the appropriateness of the design chosen for the first Manned Mars Mission. Meanwhile, we support and follow the M.A.R.S. Hap project with enthusiasm.  
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MMM #181 - DEC 2004

## Grasshopper inspires Mars Gas Hopper

<http://www.pioneerastro.com/MGH/mgh.html>

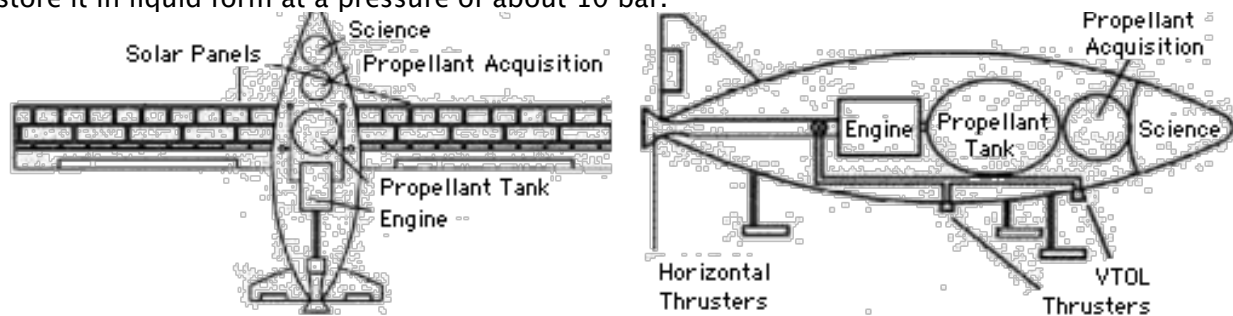
Commentary by Peter Kokh

Combine a mastery of physics and chemistry, an industrious imagination, and an inner drive to take us to Mars and the stars beyond, and it is no surprise that Robert Zubrin and his company, Pioneer Astronautics continue to brainstorm and develop breakthrough technologies. It always starts with a stubborn problem being accepted as a challenge. This time, the stubborn problem is that we can send at most a pair of robot rover investigators to Mars each window of opportunity, the windows being just over two years apart. If our probes land intact, as both did this time, they are still severely limited geographically in the amount of terrain that they can investigate, slowed down as they are by the speed of teleoperation over planetary distances. It would take a century at this rate to get a good grasp of Mars, if we want to call the grand sum of 100 sampled sites thorough. If my back of the envelop calculations aren't too far off, that would provide a spacing of 750 between sites on a hexagonal grid. A century!

Our Mars Exploration Rovers, **Spirit** and **Opportunity**, are performing beyond expectations, but can't go on forever. Power supplies, even refreshed by solar energy, will run out. The solar panels are covered with a thin coat of dust as views of the sundial color calibration device on each rover clearly shows.

Enter (into the imagination the image of) the grass hopper, or its swarming cousin, the locust. They land in a spot long enough to recharge their energy reserves by eating and off they bound for another location. This type of behavior has real survival benefits. The creatures don't run out of food. But the point is that they can hop and refuel, hop and refuel. If we could build robotic Mars probes on this model, they could sample many areas around Mars, and barring mechanical troubles, serve for many years.

How do we do that. Pioneer Astronautics took up this challenge and has come up with a design (c. 2000) that has now caught the attention of NASA as one of 219 research projects selected by the agency for Small Business Research and Development contract awards. The Mars Gas Hopper, or "gashopper," is a novel concept for propulsion of a robust Mars surface hopper vehicle which utilizes indigenous CO<sub>2</sub> propellant to provide Mars exploration with greatly enhanced mobility. The gashopper will acquire CO<sub>2</sub> gas from the Martian atmosphere, and store it in liquid form at a pressure of about 10 bar.





When enough CO<sub>2</sub> is stored to make a substantial ballistic trajectory hop to another Mars site of interest, the CO<sub>2</sub> propellant tank will be moderately heated to raise it to 70 bar. The propellant is then run through a hot pellet bed to form high temperature gas that is expanded through a nozzle to produce thrust. The gashopper uses its CO<sub>2</sub> propulsion system for major liftoff, attitude control, and landing propulsive burn(s), as required. Unlike chemical rockets, the gashopper's exhaust will not contaminate the landing site with organics or water.

The gashopper has a potential flight range of 10 to 100 kilometers. It can fly over terrain impassible to rovers, imaging as it flies, land to reconnoiter a remote location, and then fly again. Thus, it offers unique capabilities for Mars surface exploration.

Combined with greater intelligence, the ability to zero in on more interesting targets, and improved on site analysis systems, a fleet of Martian Gashoppers could vastly increase our current hit and miss picture of this fascinating planet, giving us a much better list of the best spots on Mars for Human-Robot teams to set up shop with confidence. about collocated resources and other considerations. Pioneer Astronautics built an anchored test stand to test its CO<sub>2</sub> engine, and now has built a free-flying version to test its aerodynamic qualities and hopping abilities. For more on this project, go to:

[www.universetoday.com/am/publish/mars\\_gashopper.html](http://www.universetoday.com/am/publish/mars_gashopper.html)

**MMM #183 - MAR 2005**



### **The Mars Desert Research Station (MDRS) in Utah**

The MMM editor spent two weeks in February, 2005, at this remarkable facility in Utah. Below, he tells about the achievements, the frustrations, the opportunities. Most importantly, he lays out the case for other organizations to support the analog station effort in various ways. Much of what we discover in this effort will apply to Lunar operations as well.

## **A Broad-Based Effort to Expand the Scope of the Analog Research Station Program**

By Peter Kokh

Member, the Mars Society, and of MDRS Crew #34, The Junk Yard Wars Refit Crew

Both the Mars Arctic and Mars Desert Research Stations (FMARS and MDRS, respectively) established by the Mars Society, have been working magnificently from the beginning to create environments from which we could learn better field exploration techniques. We have been learning what techniques and what equipment, that look good on paper, work in the field, and what does not.

By the simple means of having all crew members wear "space suits" whenever they go outside the Hab, the illusion that they are on Mars thus created is strong enough to induce the crew members' wholehearted participation in the experiments they conduct. Good choice of host terrain with minimal plant life, suggestive in coloration and land forms of what we expect to find on Mars certainly helps. The lack of phone and cell phone service as well as of TV all

reinforce the illusion. Understandably, there is no effort to impose 6–40 minute time delays on Internet downloads and uploads ( although that would be the case on Mars!) but a token 3 minute delay is worked into communications between the Hab and Mission Support in Denver or Ann Arbor.

We have learned that ATVs, “unpressurized rovers” not unlike the Apollo Moon Rovers used on A15, 16, and 17 are essential: rather than be replaced by larger, faster, longer ranging vehicles with pressurized cabins, they are necessary to accompany the later, much as in a naval fleet, many specialized smaller craft accompany the battleship. Taking it a step further, we have learned that small tele-operated robotic rovers operating on tether leashes from the ATVs or PEVs are enormously helpful. They can scamper up hills and down valleys unnegotiable by the wheeled ATVs and PEVs to greatly enhance the exploration and examination of terrain traversed.

We have learned what instruments are helpful in exploration: GPS units, and software that tells the explorer what route from A to Z will get him to Z in the least time with the least exertion and the least risk. That is something that is not easily determined by visual clues from point A alone. We’ve experimented with different types of tools to do geological field work as well as biological tools to look for evidence of microbial life.

While much was learned about space suit design and performance in the Apollo experience, we’ve learned a few more things on Devon Island and in SC Utah. The ingeniously designed mock-up EVA suits have brought to light a number of design challenges that must be addressed if our pioneers are to function as efficiently as possible.

We have discovered a few things about the human life support system as well, for example that we only need a third as much water ration per person per day for hygiene maintenance as NASA paper studies had supposed.

We have learned how to better organize daily work schedules, how best to divide the workload, how best to combine work with attention to personal needs and inter personal relations.

In short, the Analog Mars program has helped uncover lessons that never would have been learned on paper. We are helping to contribute to the success of future efforts by NASA and other space agencies.

These efforts have also attracted much publicity, resulting in increased anticipation and support on the part of the public and the media. The Mars Society’s strategy has been two-pronged from the outset.

### **How can we do more, and on a broader front?**

At this point, we need to take a look at some serious questions:

**Question:** What can we do at MDRS to learn more, without replacing the present hab with a new one?

**Question:** What useful simulations can be done in settings that are not “Analog Mars,” but which are more easily supported logistically?

**Question:** What useful work can be done at MDRS – and elsewhere – by other groups who share the goal of preparing the way for humans to establish permanent presence on Mars and other worlds beyond Earth? The past two decades have been ones marked by turf-protectionism, dare we say “turf-retentiveness,” on the part of separate space enthusiast organizations and their leaders. Looking forward to a 21st Century marked more by collaboration, what can we all pitch in to help achieve in the area of outpost and outpost activity simulations?

### **Lessons from a working visit to MDRS**

Last August, we announced a new Moon Society project to “rent” MDRS for a two week period in order to conduct a number of Lunar Outpost activity simulations. At first glance, there seems to be a good number of useful things we could do in south central Utah, some relevant to lunar outposts only, others relevant to outposts on both Moon and Mars. But without first hand knowledge of the facility, it would be difficult to plan an effective “Moon Mission.” It was important to go see for myself. Having long been a Mars Society member as well, I applied as a

“crew volunteer,” and with the help of long time friend Ben Huset of the Minnesota chapter, we both secured a spot on Crew #34. This was especially fortunate, as this crew would not be a simulations and research crew, but a “refit” crew: our mission was to replace the Hab’s wiring, plumbing, and heating systems -- bring them up to code and solving some major problems: repeated pipe freezing, uneven heating, etc. Crew #34 was an opportunity to learn how MDRS worked from the inside-out as assistant electrician and carpenter.

Necessarily designed as inexpensively as possible, and assembled as quick as possible to meet season use and publicity timelines, MDRS suffers as a result in some areas:

- **We cannot simulate a closed life cycle environment at MDRS**, even with a much more thorough biospherics module than the present GreenHab which recycles gray water from sinks and showers for use in flushing the toilet -- MDRS leaks like a sieve. It is not a sealed structure, and it would be cheaper to build a new one than to seal it effectively.

Air recycling and thermal management are not the only two casualties of the leaky hab. Dust control is all but impossible. Mouse control is a lost cause with a two inch gap under both front and rear hatch doors, besides oversize holes for pipes and conduits passing through the hab wall, and poorly sealed, uncaulked portholes, and a loose laying plexiglass door over the roof emergency exit hatch that flaps in the wind.

- **We cannot easily conduct Adequate Shielding Exercises** – First, the site is owned by BLM, the U.S. Bureau of Land Management, and our conditions of use require us to tread lightly on the site. Moving around large volumes of soil might not fly. Even should we get a “variance,” shielding the Hab would be a daunting proposition. It is too tall. Sandbagging the Hab dome alone would be insufficient and futile. A spread out, one story “Mars Ranch” structure, set on or into the local surface, would be much more practical to shield.

This situation is regrettable. While in Utah, we are not subject to the same cosmic radiation and solar flare threats from which Mars’ explorers and pioneers must seek shelter, our “Field Season” is needlessly shortened by the impracticalness of cooling the MDRS Hab from the fierce summer desert heat.

On the Moon and Mars as well as in Utah, the principal co-benefit of shielding is thermal equilibrium. Face it, Mars’ surface is as cold, or colder than Antarctica. Yet a few meters down, the soil temperature is the same year around, though the equilibrium temperature there is much lower than it is on Earth or on the Moon. Thermal equilibrium is the principal design benefit of underground housing on Earth. Soil-sheltered habitats simply make sense, however uninteresting they may look to the photo-grapher or artist. And we do need to simulate this, to uncover design challenges that are surely lurking. For in fact, while we do have considerable experience from building earth-sheltered homes here on Earth, they are not designed to the same set of constraints we will face on the dry Moon or on wet Mars.

### **The Hab has been designed for expansion**

The Mars Desert Research Station Hab structure was designed with two EVA hatches. The rear one has been used principally for quick access to the generator and diesel fuel station, to the propane tank, and to the water tank. But from the outset, this extra exit was looked on as a point of future expansion. Now the time may have come to take a new look at this option -- for on Crew #34, all these utilities have been relocated to a new area, shielded from the Hab by a thirty foot hill. That barrier provides quiet (the generator is a major noise contributor, day and night) and safety: should any of the fuel sources ever catch fire or explode, all of them would in a chain reaction -- the hill provides safety from the fireball that would result. Note: Crews 33 and 34 also installed a superior grounding system, a real feat in the low-conductivity soil, following the ideas and methods, and using the tools developed by a young volunteer from Caracas, Venezuela, Gregorio Drayer, under his supervision.)

Expansion modules, hard-shelled or inflatable, if designed in one-floor or “ranch” fashion, might support emplacement of removable (sandbagged) soil shielding. This would provide a test of the thermal-equilibrium benefits and a basis for redesigning future analog Habs.

The Hab now supports some activities that get in the way of one another. While it is important to design multifunction space that will see more round-the-clock use, it is equally important that these multi functions not interfere with one another. My choice for first candidate to move to new added expansion space is the workshop-tool-shop-fabrication area which could include an area in which to experiment with making things out of the local soil (even if it is chemically or mineralogically a poor analog of soils on Mars.) These activities are currently hosted by the Lab Science area.

A real Greenhouse engaged in food production as well as gray and black water recycling should be next. The principal impediment to growing food at MDRS is that the site is occupied only seasonally, primarily because of the desert summer heat, which could be managed by living under soil. But that facility still could not recycle the air of the leaky Hab (one reason winter season heating bills are so high.) It must be added, however, that even if we overcame the heat problem in this fashion, the volunteer supply is not great enough currently to handle year around operations, unless skeletal crews are used in the summer season.

#### **What else needs to be simulated?**

- **Simulating Human Crew Systems:** No matter how good our equipment is, no matter how well we have developed our procedures and processes, the most important system of all, because it is central to everything else, has been simulated only on a hit and miss basis, with the result that lessons learned, while valuable, are trivial in contrast to the need. We must not downplay simulation of human crew systems.
- **Simulating the Mars Frontier Diet:** There has, in fact, been a hit and miss effort to simulate the kind of diet Mars Pioneers will surely face: freeze dried foodstuffs from Earth rehydrated with water from Mars, supplemented occasionally by fresh produce from the garden, and possibly by not too frequent treats of Talapia filets: Talapia are a species of fish which thrive reasonably well in gray water systems integrated with greenhouse food production. The problem at MDRS is that individual crew members vary greatly in their willingness to go that far in simulating the Mars experience. All too frequently, their shopping trips in Salt Lake City where they gather to begin their mission, end up with a lot of menu-buster treats. The pioneers on Mars will have no such luxury.
- **Simulating Frontier Recreation, Art, and Hobby Options:** In after supper free time, if there is any, crew members at MDRS can read, play games, watch DVDs. In fact most are busy at their laptops. Simulating realistic frontier recreation and hobbies is something that can happen at MDRS but seems to have been given no real emphasis. We contributed a Mars analog version of the age old African classic game known by various names from tribe to tribe, and most commonly in the West as Mancala or Oware. The board was crafted from wood, but painted to simulate Martian ceramics. A "pit and pebble" class game (rated as one of the nine best of all time in strategy), our version has been dubbed Craters & Blueberries. We also took a look at Scrap and Trash generated at MDRS. On the future frontiers, such humble materials will jump start frontier arts and crafts.
- **Simulating Ergonomic Alternatives:** Ergonomics is important for good crew morale and efficient operations. A major opportunity was missed by the decision, in designing MDRS' interior, to copy the layout of the FMARS arctic facility. A clean slate redesign, finding new solutions to the same design constraints, would have yielded useful ergonomic information, comparing experiences at the two stations. The interior of the Euro-MARS station slated for Iceland, has indeed been redesigned from scratch, and whether it has the blessing of the Society's founder or not is immaterial.

#### **You cannot learn if you don't vary the conditions of the experiment. It is that simple**

Happily, the Aussies are proposing a Hab that is not of the double tuna-can stack variety, but going back to an earlier design for a more horizontal, easier to shield structure.

- **Hab Interior Ergonomics:** Getting back to my recent visit, I had hoped to get input from my fellow crew members on what they would change about MDRS, if they had a magic wand: what areas could function better by mutual isolation, which by being collocated more closely. What

functions of common areas would be better served by having a dedicated space to themselves? What activities, not supported by the current design should be worked into any proposed expansion. Alas, we seldom had free time after dinner. We were always behind in our refit schedule and worked often into the wee hours before hitting the sack. I was able to get only minimal feedback.

We hope to develop a questionnaire that future crew mission commanders can circulate on a voluntary basis, and thus get a wide spectrum of input. And by also circulating feedback forms to past crew members, we may get some return. Unfortunately, such debriefing will suffer from the staleness of memories. But it is also possible that some former crew members will have better digested their experiences and be able to pick out and identify things that bothered or irritated them that they might not have been able to “put their finger on” in a classical “fresh from experience” debriefing. Both fresh and digested experiences are helpful.

At MDRS, the interior of the Hab is very poorly simulated, along with living conditions. In the recent “refit” mission, we had no time to attend to even a partial facelift. There are materials other than wood and drywall that would simulate likely interiors at not too much extra expense. Right now, that is not a priority, though the money could be easily raised separately.

- **Acoustics:** The individual staterooms share the same floor as the wardroom common space: without any acoustic insulation, this is a problem for those early to bed and early to rise. Ear plugs are one way to cope. But this is a problem that could have been lessened with good design and involvement of an acoustics specialist. In fact, the Hab is a very noisy environment, and that can only dampen performance over the long haul. Relocation of the generator behind Engineering Hill has removed offender # one, however.

- **Logistics is important:** For MDRS, Salt Lake City, the nearest major air hub some 240 road miles to the north, serves as the staging point. (Denver and Las Vegas are both 400 miles distant. Grand Junction, CO at 160 miles is only a regional airport with higher air fares.) From Hanksville, the nearest hardware stores are 115, 160, 188 miles distant. Now remoteness from urban areas does have its advantages. It helps set the scene psychologically. And the MDRS clear moonless nights offer an awesomely star-spangled, Milky Way dominated gasp of what it must be like to be suspended in space, or on Mars or the farside of the Moon.

- **Dust Control:** A determined effort to identify all the holes and gaps in the Hab outer wall and bottom floor should be made, and a master plan developed to seal them with durable materials that blend in. A stop can be built into the hatch thresholds that will do away with the 2 inch gap along the floor that remains when the hatch is closed. And above all, let’s put out the call for a donor to cover the need of fabri-cating new porches and steps and apron approaches to the steps out of grating. When it rains even a little, the plant-free surface turns to mud, and with only wood and plywood surfaces guarding the entryways, transport of mud inside is guaranteed. That the Society does not have enough money in its general funds is no excuse. If it’s worth doing, and it is, we must ask for dedicated funds, special donations. People give more when they know it is going to something specific the importance of which they can appreciate. The porches and steps are a prime example of a false economy,

**Maintaining “Sims”** (doing all outside activity in EVA spacesuits; staying on Analog Mars):

Remoteness of hard-ware supplies from lumber to electrical, plumbing, and water supply needs was a major challenge for our “refit” mission. But simulation and research missions are designed to be more self-sufficient. However, the crew members on hand may be minimally capable of meeting various equipment and other emergencies and reliance on intervention from nearby Hanksville is openly accepted.

**We are making no progress towards simulating Real Mars Frontier Isolation from Earth**

MDRS is dependent on regular fuel supplies from outside: diesel fuel for the generator; propane for heating and cooking; and water. In short, we have not yet been able to upgrade MDRS to the point where we are generating our own fuels, Marslike, from the atmosphere, or tapping local water reserves underground. We use only some solar energy, for the GreenHab. We also depend on outside services to repair the ATVs, an all too frequent need. On Mars, the

outpost will have to be equipped for such emergencies, and have trained personnel among the crew consist.

That we pretend that Hanksville is a Mars Orbiting Station, and that Salt Lake City is Mars' moon Phobos, does little to simulate real Mars emergencies and real lack of options. There has been some hit and miss effort to document "out of Sims" activities. To minimize these occurrences will take a many vectored approach. And in preparation for developing such portfolio of strategies we will need more consistent, more detailed documentation, both on the part of the Crew Commanders and on the part of our offsite support people.

These many improvements can only be phased in, one at a time. The important thing is to realize that we must make progress in that direction,

#### **Place for a lower level of "Sims"**

Not everything has to be harder. On Mars itself, if all the things that needed frequent and regular attention and access where placed under a shielded, but unpressurized canopy or ramada, those attending to this area could wear lighter weight, more user-friendly pressure suits. At MDRS, those attending to the generator or other outside utility sources are supposed to wear full EVA suits. One of the personal projects I chose for my time at MDRS was to investigate the practicality of a demonstration of this system in Utah. Now that all the utilities have been relocated behind a noise-, fire-, and blast-buffering hill, we at MDRS could assume that they are under such a canopy, and wear designated lighter overalls and a special gas mask to simulate the lighter suit. A study of the ergonomic benefits recorded would give feedback on the value of such an innovation. Walk areas thus protected could be marked with simple color-coded poles, for fabric pretend canopies would not last long in our Earth desert winds.

#### **What can be done elsewhere to compliment the learning exercises at MDRS and FMARS?**

The Moon Society looks forward to the day when it can establish its own analog research station in terrestrial locations more suggestive of the Moon's surface than that of Mars. But that is not our concern here. What can be done elsewhere, in any type of host terrain (even verdant farmscapes and urban cityscapes) that will help us prepare for pioneering Mars and the Moon?

While exploring the surfaces of other worlds, and examining their chemical and mineralogical makeup may be the most obvious, visible, and high profile aspect of early outpost activity, it is only the above-horizon tip of a largely hidden iceberg. Far more basic will be the successful operation of the systems that sustain the pioneers: life support, including food production and recycling of water, air, and both human and agricultural biomass waste. And the systems that maintain both the physiological and psychological health of the pioneer teams. None of this depends essentially on the host terrain, at least not in ways that require some sort of visible match.

Life support, medical systems, human factors such as ergonomics, food menus, etc. -- all these can be simulated anywhere it is convenient to do so. Logistics: where do the principal investigators live? or where is it convenient for them to visit habitually Where are clusters of volunteers?

These questions are important. In Utah, only one person maintains real continuing presence to help ensure some degree of continuity between crews. Don FoutZ, a local resident of Hanksville and a strong supporter of the Mars Society's analog hab program is on call, ready to train incoming crews, trouble shoot problems with the balky generators, and fickle Internet uplinks, and so on. We are fortunate to have Don. Without him, the Hanksville-based facility would have collapsed after the first season, if indeed it lasted that long. Of extreme importance are both continuity in expertise and availability of critical personal who take ownership of ongoing programs that cannot be adequately managed from Mission Support in Denver.

It would be difficult to run a more ambitious Greenhouse Food Production and Water Recycling system without a principal investigator living nearby. That such a facility serves a crew of six persons engaged in exploring an analog Mars landscape is irrelevant. Whether this be a program managed by staff at some university or college or by a dedicated individual, continuity and dedication both demand that the site be convenient, on a weekly or more frequent basis by the person accepting responsibility, and responsible for the design elements,

and with authority to make changes. For “load,” such a system could be linked to any living space regularly occupied by the desired number of persons, six or whatever. There is no need for the persons imposing the load (food needs, waste generation) to be involved with Mars simulation activities of any kind, unless some such can be happily collocated.

A medical system designed to meet all reasonably expectable emergencies for a group of six (or whatever) adults could be tested in any isolated small community where access to medical services is extremely limited. Small Eskimo or Inuit villages might do, although most are too easily accessible, these days, by airplane or helicopter.

MDRS is both blessed and handicapped by its remoteness. Mars will be significantly more remote. All the more reason to go beyond field exploration techniques to pre-develop all the systems that will be needed to survive on Mars long term, without recourse to rescue or resupply.

At sites near stable clusters of dedicated individuals, simulations can be run by long term crews. Other groups, inside and outside the Mars Society, can conduct exercises elsewhere that complement work at MDRS:

- thermal management through soil (regolith) shielding
- identify and develop optimum models of outpost expansion and develop expansion architectures
- develop more tightly closed life support systems that recycle air, water and waste to provide fresh food
- develop realistic food–nutrition–menu systems that expand phase by phase in diversity and satisfaction
- experiment with different interior layouts to determine their ergonomic pluses and minuses
- develop crew recreation, arts and crafts, gaming, and hobby opportunities for greater crew morale

#### **Fringe Benefits of Multiple Networked Simulation Sites**

Distributing the simulation workload will allow the tapping of personnel and organizational resources not now accessible to the Mars Society’s Analog Mars Program. That benefit is considerable: more talent, more money, more publicity. This united effort will not be lost on the public nor on Congress which will soon pick up on the signal that “those feuding space groups” finally have their act together.

Geographic dispersal of the effort will also model the development of a multisite, multi-settlement Mars Frontier Economy. That too will help science popularizers sketch out just how a first human mission will evolve beyond flags and footprints into a second human home world.

There are already strong dedicated concentrations of volunteers in the form of focused chapters within the Mars Society, the National Space Society, and the Moon Society that could undertake some useful bite–size project, however humble, in support of the broader effort. SEDS (Students for the Exploration & Development of Space), and other groups might be willing to help. We have grounds enough to launch an Analog Mars “Extension” Program.

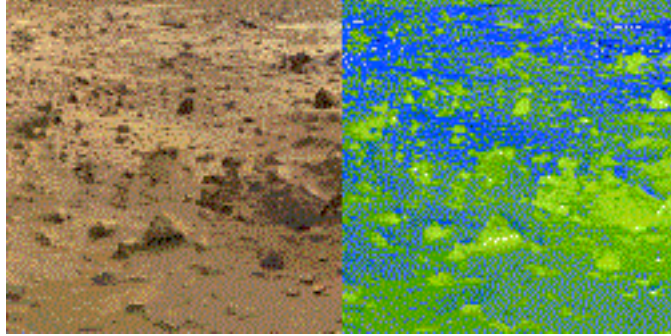
Benefits from many simulation exercises will apply with minor adaptations to both Moon and Mars. Others will apply only to one or the other. We call on other Space Organizations to endorse an expanded Analog Simulations Program and seek appropriate ways to contribute to it. This will grow chapters as well as public support. <PK/MMM>.

**Check out our blueprint for a Moon Society Lunar Analog Research Station IF MONEY WERE NO PROBLEM:**

<http://www.moonsociety.org/moonbasesim/proposals/QuonsetMoonbaseLayout.gif>

## **Testing Colors for Survival on Mars**

By Peter Kokh MDRS Crew #34



Representing the Wisconsin Mars Society Chapter, I devised a simple experiment to test which colors are most easily picked out against a Mars-hued background. I had my suspicions that lighter shades of green and blue would stand out most prominently. Why? If you take a color photo of a Marsscape and invert it in your paint program, that is what you get: light greens and blues: the opposite of Mars hues: "Mars' Missing Colors."

First, I picked up one each of every color paper sheet my nearest Kinkos had in stock, some 19 different shades including many pastels and all the astrobrights™. Next I bought a 24-pack of transparent plastic drinking cups from Walmart. The purpose here was to find something stackable and compact for air travel. I cut the bottom off of one cup, cut down one side, rolled it out and made a template.

Once on location, I used the template to cut out shapes from the color sheets. These I applied to the sides of intact cups, securing the paper with tape. I took my stacked color cups outdoors, found a pile of handy pebbles and put enough in the bottom of each cup to keep the cups from being tossed here and there by the wind. Then I looked for nearby hillocks and set the cups out randomly here and there in two different locations.

Later, results chart in hand, I stood at various distances from the cups, up to 200 yards. The round shape meant that sun angle did not matter much. I did return to check again at various times during the day, again at dusk.



**I was quite surprised by the results!**

- **any colors outside the background color range are visible, but especially lighter and brighter ones.**
- What really helps is that the cups are **areas of solid consistent color and regular shape**: both features stand out from random pattern and variegated coloration
- **Yellows, blue-greens, pinks & fuscias** (red is too dark), **mid to lighter blues** all arrested my sweeping gaze.
- In deep dusk, darker colors, even those well out of Mars shades, are hard to see.  
**Light, bright, astro colors best.**



- Vehicles, spacesuits, road signs of **regular shape** and **solid colors** will be easy to see on Mars.

<PK/WMS>

## MDRS Scrap & Trash vs. Spirit & Opportunity

Report by Peter Kokh, Wisconsin Mars Society MDRS Crew #34, the Junk Yard Wars Refit Crew



### Scrap & Trash at MDRS

One of the items on my list of things to do at the Mars Desert Research Station was to take a look at any scrap piles that may be on the premises and also at what was in the everyday trash. I found the area known as Antarctica or the Engineering Area just south of the Hab, hidden behind a pair of natural mounds both from the Hab and its access road. There I found discarded PVC pipe and fittings (from the old GreenHab), some copper, aluminum and steel; also some wood, old 5 gallon paint drums, and discarded (probably non-functioning) equipment.

Daily life in the hab itself produces a significant volume of items that would normally be recycled. Alas, Hanksville is quite small, and rather isolated; there is no place that accepts recycling within a hundred miles. So there really is no practical way to recycle paper, plastic bottles, or aluminum cans, unless one hauls them back to Denver or Salt Lake City. These items are not sorted, but just discarded with other household trash. Plastics #1 and #2, glass bottles, and aluminum cans are regularly available as well as the PVC and other items stored in the scrap area because they are too large or bulky to fit in trash bags.

### **With the right “spirit,” all of this scrap and trash becomes “opportunity” How so?**

On the frontier, art and craft will play a major role in making us feel at home. But the sort of preferred art and craft materials with which those with artistic and craftsman talent are

used to working will be in short supply, exorbitantly expensive to import from Earth. But even on Earth, many an artist and craftsman cannot afford the preferred materials. When you have more talent than money, anything free that is workable will do. All you need is the appropriate tools for the chosen materials, and inspiration.

All of the materials mentioned above have been used by others to create art and artifacts. For inspiration, simply do a Google search; you will find websites with content to get your imagination started on aluminum can art, PVC art, plastic bag art, and more. You will find more help at your local library or arts and crafts store.

Now you might think that this kind of “crude” art is good mainly to teach children creative self-expression or to give bored old folks something to do. But it is really a matter of talent and creativity. People who have it have turned out some beautiful creations out of trash. There have been prestige exhibits that feature creations from recycled items exclusively.

### **Art & Craft at Mars Desert Research Station**

What’s any of this got to do with the Mars Desert Research Station? In the evening after the work of the day is done, we write our reports and the balance of the time before we turn in for the night is ours to use as we each please. We can watch movies, play games, get lost on the Internet, or -- work on some project. There is no reason why art and craft cannot or should not be engaged in.

Not every volunteer will feel the urge to express themselves in some physical medium. While there is great effort taken to balance the talents of crew members, and almost every crew will have some creative people, that doesn’t mean that there will be a painter, sculptor or other kind of craftsman.

But if you are the type, and are chosen for a crew, you should know that these possibilities exist. Of course, nothing in the rules or guidelines prohibits crew members from bringing along art and craft materials of their choice with which to pass free time hours.

Wisconsin Mars Society intends to assemble and ship a kit of tools and books for future crew members to use to try their hands at creating things from commonly available scrap and trash items at MDRS.

Art & craft produced at the Mars Desert Station can be brought home as souvenirs or sold at auction at a Mars Society Convention to help raise funds for the analog program. But it can also be used to decorate the common and private areas of the Hab itself. And that would indeed be simulating what will happen on the frontier. These options seem exciting to me, and I just thought I’d like to share that with you. <PK/WMS>

## **The Moon Society’s own Lunar Analog Research Station? What we might want to do differently?**

By Peter Kokh

Even before my recent two-week stint at the Mars Desert Research Station in Utah, I started keeping a file of ideas under the heading “what we might want to do differently at our own Lunar Analog Station.” Grant you, that is not a near term project. But planning ahead is good.

**Location: there are two schools of thought here:**

- Put it in the heart of a high traffic tourist area such as Las Vegas or Orlando or even Chicago.
- Set it in a location where the terrain is suggestive of moonscapes: on a lava flow sheet, with access to lava tubes, perhaps

I do not believe you can satisfy both objectives without serious compromise. Further, tourist traffic and serious research without tourist interference do not go hand in hand. We do need both, however. The answer is to build two stations (two identical stations are cheaper than twice just one.) We have one in a high traffic area for tourists and public education, the other in

an isolated location where we can do serious work. Web cams at the research station will feed monitors at the tourist facility.

**Logistics:** While isolation is great, logistics can be a continuing problem. The closest major airport to MDRS is 240 miles away in Salt Lake City. Travel is over good roads, but only a quarter of it is by Interstate. The nearest hardware store is 115 miles away. The nearest home center 165 miles. Can we do better? Not sure. One site I looked at, the Black Rock Desert lava flow area in Utah is 150 miles S of Salt Lake City, almost all of it on I-15, but the terrain proved unsuitable. Craters of the Moon National Park and surrounding Bureau of Land Management area in Idaho are just as far from Salt Lake as MDRS, and only a little closer to Boise, only a regional airport. Bend, Oregon doesn't fare that much better. We have plenty of time to search.

**Habitat Design – Profile:** I understand the origin of the Mars Hab shape, but it is a mistake. The Mars Society has backed itself into a corner on this one. The two floor Hab would be a bear to shield (if the Mars Society wanted to do so.) I recommend we look for some sort of Lunar Ranch design. Shielding is essential on the Moon, both for radiation protection and for thermal equilibrium. By looking the other way on this, the Mars Society people have got themselves stuck with an unnecessarily short field season: a shielded Hab could coolly function throughout the summer.

The Artemis Moonbase triple SpaceHab is one floor but way too small to serve as a functional outpost, even as a starter outpost. Two or three of them, linked? Perhaps. Let's not be bound to the venerable SpaceHab design. We could either start from scratch, or sticking with the Artemis module for a starter core, add additional modules of the same or new designs, perhaps even an inflatable (so long as the height to width-length ratio is kept low.)

**Hab Design – Function Space:** The Mars Hab's two floors with a combined floor area over a thousand square feet or 110 m<sup>2</sup> is already much bigger (c.4x) than the Artemis Moonbase core module. But it does not serve all functions adequately. MDRS is in dire need of expansion. (See my report this issue, pp. 3-7) We need a separate tool and fabrication shop, and perhaps dedicated hobby and "puttzing space." An isometrics exercise room would be great.

Acoustics at MDRS are very poor, more so because it was given no attention in design and construction. Dust control is also a severe problem. Our facility needs to be much closer to air-tight, relying on air-exchanges and plants to keep the air fresh, not loose joints and holes. Proper design of entrances (airlock-hatches) and their porches, steps, and aprons will help.

**Hab Design – Utilities:** It would be ideal to mimic the situation on the Moon as far as practical. Heavy use of photo-voltaics (solar power) to run all the lighting (12 volt) and at least all the lower load outlets. Where we need appliances and equipment for which 12 volt versions are not available (yet) we will have to do with 117v AC power. MDRS uses diesel-fueled generators. Is there a more appropriate option for us? We should look for one. Fuel Cells? Again, solar power is the optimum, and that means picking a site with a high percentage of sunny days. No propane stoves!

**Hab Design – Interiors:** The first Moonbase will be manufactured on Earth. But we have time to incorporate into our research station features that mimic what pioneers can produce on the Moon. No wood 2x4s or Drywall (sheetrock) when for little more we could buy steel 2x4s and Duroc (cement) panels on interior walls, and something like glassboard on exterior surfaces. If we are going to set the mood for simulating outpost life on the Moon, we owe it to ourselves to do it right inside and out.

**Life Support:** We cannot expect to be able to provide total life support on any reasonable budget. But we should work aggressively to go beyond the gray water (sinks, showers) treatment demonstrated at MDRS towards at least partial black water (toilet wastes) treatment combined with food production. The Wolverton system is a place to start. This ambitious goal implies year-around occupation or tending.

**Medical Systems:** MDRS has an excellent first aid kit and daily email contact with a doctor. Can we do better? It is worth discussing. In reality, many medical emergencies will have to be

treated on location. On the Moon, transport to Earth is only an option for postponable procedures.

**Crew Life Styles:** We need prior commitment from our volunteers to participate wholeheartedly in experimental pioneer vegetarian food preparation and menu development. It's a matter of getting into the spirit and will generate good publicity. But we should also incorporate time, space, supplies and tools to allow experimentation with pioneer-appropriate arts and crafts.

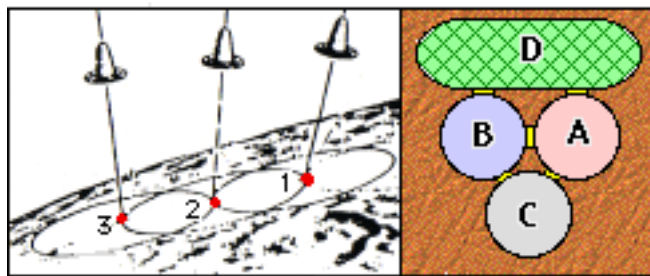
**Facility supported research:** Geology and microbiology are big items at MDRS, and that is quite appropriate for Mars. On the Moon, there is no question of life: those into biology are better occupied developing our biospheric life support systems. And we have already done considerable geological investigation on the Moon. More remains to do. The point, however, is that unlike a Mars base, where exploration is goal one, on the Moon, developing ways to tap local resources and start making stuff is at the top of the list. From that point of view, the visible appearance of the host terrain is less important than its geochemical makeup. Basaltic areas that do not necessarily remind one of the Moon will still do fine. If we can have both, better!

We need to prioritize the things we want to demonstrate: shielding emplacement; regolith handling; oxygen production; cast basalt technologies; ceramics; glass composites perhaps. There is a lot of things we can do.

**Talented volunteers or ....?** The Mars Society has done a splendid job of attracting talented students with masters and PhD thesis projects worth demonstrating at MDRS, projects in the fields of geology, biology, and astronomy. While we can attempt to do the same, changing the stress, however (especially in biology), what we want to do in the area of demonstrations suggests that we prime the pump by organizing engineering competitions on the college level: competitions for automated or teleoperated shielding emplacement systems, for example, with the winning team getting to do the final demonstration at our location. Such an effort would build enthusiasm and provides plenty of publicity at every step. It also builds local cores of support.

**Summing up:** I have been a very strong, ardent and outspoken supporter of the Mars Society's analog station program from the day it was first announced. They have done wonders on a small budget with volunteer resources. Their program deserves respect. Even after two weeks spent at MDRS in Utah, and seeing all the room for improvement, I am still a strong supporter. It will not be easy for the Moon Society to improve on what they have done. However, we have the benefit of time on our hands. We can afford a more deliberate, patiently methodical approach. Our needs differ in part. We can do it, given time, but only if we don't wait until we have the money to start brainstorming and planning. Let's start now. <PK>

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Send (3) Habs to (1) Site on Mars, not to (3) Sites!

[Left] The plan of Mars Direct would send successive manned missions to separate sites: good for exploration, bad for establishment of a viable outpost. Experience at the Mars Analog Stations shows convincingly that all the facilities needed for viability over many months cannot be crammed into one Hab structure. [Right] A) Residence, B) Laboratories, C) machine shop/fabrication, D) Greenhouse. See below.

## In Focus Where we're at & where we need to go in Mars Exploration

By Peter Kokh

The International Robotic Exploration of Mars has been in full swing now for several years. Every successive launch window, 25+ months apart, sees a number of new orbiters and/or lander/rovers sent out by NASA and ESA. The Japanese and Russians plan to get in/back in the fun.

While the twin rovers, Spirit & Opportunity are still hanging in there, sending back many thousands of fascinating pictures, their science is very, very local. The European Mars Express, and its bevy of instruments, however, have been revolutionizing how we see Mars. Mars was once wet, a loong time ago, and still retains some water ice reserves. Some of these may be near the surface, shielded from sublimation by a thin layer of dust. Other reserves have been detected at some depth.

### **What has not been detected is the widespread presence of underground aquifers such as we find on Earth.**

The implications of this are that we will have to be quite choosy where we decide to set down, so that accessing subsurface water-ice is not an improbable challenge. The Mars Express instrument readings also seem to rule out present day sources of geothermal power. This is disappointing but hardly a surprise.

The great Martian volcanoes seem to have been quiet now for billions of years. Get used to it: geothermal power won't be among our energy options.

### **A fleet of Mars Prospectors**

There is much more to learn about Mars before we can rationally plan a manned landing mission, especially to a location where we intend to dig in for an indefinite stay:

- **Orbiter Probe to detect Subsurface Voids:** Conditions for the formation of Karst limestone caves do not seem to have ever existed on Mars. However, we would be stupefied if the vast Tharsis Uplift and great Martian shield volcanoes were not laced with lavatubes that could provide voluminous shelter for settlements, industrial parks, and warehousing.
- **Lander driller(s)** to determine thermal flow subsurface temperature gradients)
- **Chemical Prospector Orbiter** to look for all the elements needed to support an industrial civilization: Fe,Al,Ma,Ti,Na,K,P,Lb,Cu,Pl,Th, etc.
- **Data Mining Challenge for Earth based team:** define the drainage basins from existing MOLA data; highlight future rivers and lakes in a terraformed Mars, as well as
- **Phobos-Deimos Prospector Mission** to analyze the chemical makeup of the surface regolith and any exposed bedrock on Phobos and Deimos. This is absolutely necessary if we are to determine the roles these two moonlets can play in bolstering the now weak Economic Case for Mars (realistic Export products that can competitively earn income for the settlements.)
- **Establish an Artificial Intelligence-run forward teleoperations base on Phobos and/or Deimos** to allow teleexploration of Global Mars in near real-time, without the ridiculous 6-40 minute time delays experienced in teleoperation of Spirit & Opportunity from Earth.

Evidently, we have quite a lot to do to prepare for an aggressive manned Mars Mission program. And it seems clear that with missions currently decided by Planetary Scientists who may be disinterested in a Manned Mars Program, that we will not get the type of orbiter and

landing probes we need without aggressive agitation, going over the heads of the “specialists,” if need be. Privately funded Mars Missions under the Planetary Society, may be our big hope.

The Planetary Society is at the top, when it comes to designing probes, or instruments to be added to them, that excite the public attention: e.g. the Mars Sundial, and the Mars Microphone. But NASA’s abandoned “Kittyhawk” project to fly a drone plane over Valles Marineris should be revived as well. There is obviously room for organized activist input! In the strange absence of Mars Society initiative here, the Planetary Society may be our best hope.

**The upshot is that while NASA/ESA are generally moving in the right direction, corrective inputs are much needed.**

One can ask who is trying to do the same for the Moon. True activists launched the effort that Alan Binder would bring to conclusion: a probe that would find indications of water ice particles concentrated at the poles. That was the “and behind door #1\*” (of the common perception that the Moon is no more than a rubble pile.) A similar effort that we might call “and behind door #2”, an effort to get launched a probe that could detect any subsurface voids such as lavatubes that would serve as safe harbor from the scouring cosmic weather has failed. Perhaps such an instrument first flown over Mars could be reflow over the Moon. [\*  
MMM # 133, Nov. 1999, In Focus Editorial, pp 1–3] – PK

## **From Arctic & Desert Analog Stations to a Real 1st Outpost on Mars Changing Mars Mission Plans to fit the many lessons learned on Devon Island and in Utah**

By Peter Kokh, MDRS Veteran, Crews 34 & 45

### **The Mars Direct Mission Plan Revolution**

Mars Direct, the Mars Mission Architectural revolution introduced by Dr. Robert Zubrin more some fifteen years ago, showed how we could mount exploratory missions to Mars with far less throw weight, total tonnage to be paid for dearly with fuel, than NASA’s then conventional mission architecture forecast as necessary. By the simple device of making the fuel for the return on Mars itself, instead of carrying it along, as well as all the fuel needed to get that return fuel to Mars, the cost of human missions to Mars was cut to a tenth. Now exploring Mars became something we could budget for, something in 1960’s dollars, not much more than another Apollo Program.

But another Apollo Program, a heroic Flags & Footprints Epic to be followed by yet another half century of nothing, is not exactly what we need. By the plan, if the first unmanned crew return ship lands successfully and produces fuel successfully, then, at the next launch window 25 plus months later, a manned Habitat would be landed at the same site, along with a second unmanned crew return ship with fuel making capacity to a site reachable by the first party if necessary. Then another manned Hab would be sent to that second site, etc. Over a period of 8 years, three manned Habitats would be established on Mars, each to be abandoned when its crew went home.

First things first! Settling in before Exploration!

While this plan introduces measures to guarantee a safe return of each crew, and to gradually extend the reach of manned exploration across the globe, it clearly puts exploration ahead of establishment of even one viable outpost. In fact, none of the three manned Habitats would be viable for more than weeks, in our opinion. They are each too small to house all that is needed to sustain a crew for up to two years in good physical and mental health. I say that having spent two 2-week tours (one month) of duty at the Mars Desert Research Station in Utah.

Before I make that particular case, let me advocate clearly and forcefully that exploration should follow, not precede establishment of a permanent outpost. We know far more about North and South America and Australia through exploration by their own settlers, than we could ever have learned from a series of expeditions leaving from and returning to Europe. Why? Logistics, logistics, logistics.

Exploration is best done from up close, by people living off the land, because it is their land. We must not let the curiosity itches of planetary scientists be scratched at the expense of settlement. In the long run, settlers will find out vastly more about Mars than “foreign” explorers bent on leaving the land they are exploring.

### **The Mars Analog Habitats tell the tale.**

The Mars Hab testbeds at the Flashline Mars Arctic Research Station on Devon Island and at the Mars Desert research Station in south central Utah, are classical cases of design according to the principal “function follows form.” Yes, I know that’s backwards. That’s precisely the point. Instead of defining the facilities and functions we need in a self-sufficient crew habitat, and then finding a modular architecture to house those functions, we have settled on a fixed volume structure, determined not by the needs of usage but by the needs of transportation to the site. Then we have sought to cram all the needed facilities and functions into that fixed volume.

And guess what? They don’t fit.

That’s not apparent to many crew members because they are there for a 2 or 4 week tour of duty. But Mars crews, on the real (not analog) Mars will make that Hab home for two years or more. If FMARS and MDRS veterans are honest, they will realize that neither Hab can produce its own food, produce its own energy, or keep itself in good repair without all too frequent outside inputs, help, rescue, and resupply – recourses that could not apply on Mars itself.

There is no real allowance for crew recreation – on two week tours, you can simply go without. There is no real attempt to rely solely on original rations and food grown on site in a greenhouse. There is no capability at either location for making parts needed for repair. Again, the Classic Double Tuna–can Hab does not have the space to provide these functions, yet we would send crews in such a cages to Mars. And rather than add additional structures to this complex of one, we would send new Habs elsewhere on Mars.

### **An Alternative Plan**

I think **we should send to Mars** three or more Habs, each differently configured, to the same site, along with other ancillary structures, including inflatable ones.

- **If we do not establish a viable outpost on the first shot, we may never, ever get another chance.**

- **Exploration will take care of itself.**

**Other things come first.**

### **For starters, we need:**

A food-growing greenhouse large enough to feed a double crew, should the firsts crew not be able to return home when their relief arrives. A diversity of crops, and several species each would be needed to protect from collapse from blight or disease. A greenhouse operation can never be too big. Witness Biosphere II.

- ✓ **A greenhouse-based life-support system** with air and water recycling with some chemical/biochemical assist, as needed, to be slowly phased out on Mars.
- ✓ **A complete machine shop and fabrication facility.** Mars is not the Moon. It can have no umbilical cord to Earth for repair, resupply, or rescue. A Mars outpost must make do on a Yolk Sac of parts and supplies sufficient to last for several years and with the capacity to self-manufacture unforeseen needs.
- ✓ **A complete pocket-hospital.** It is one thing to take a chance with crews on the Moon where return to Earth is relatively simple. The longer the stay, the more certain real medical emergencies, both trauma accidents and other emergencies will arise. A first aid locker won’t do.
- ✓ **An exercise facility,** diversified recreation facilities, support for hobbies, arts & crafts

- ✓ **A lab where experiments can be conducted** with locally produced building materials aimed at self-manufacturing as many of the physical needs of the outpost as possible, including expansion of the outpost.
- ✓ **A Remote Way Station**, a few miles away, where EVA exploration crews could overnight, and to which crew members could retreat for brief periods of quiet rest and privacy in relief of tensions.

### **Teleoperations Vantage Points on Phobos/Deimos**

Nothing leads to failure more surely than impatience. Impatience to explore is an example. Once we have a growing crew at a growing outpost, we will have personnel who can be tasked with the teleoperated exploration of Mars by a whole fleet of mini-rovers and drone aircraft, operated in near-realtime via relays on Deimos and Phobos where the transmission delay is only a fraction of that for the Earth-Moon loop. Manned expeditions could then be sent to the most interesting spots, rather than waste their time on less interesting areas.

### **Crew expansion leads to economic diversification**

Once an outpost, the outpost, is clearly viable and at least partially self-sustaining, crew members could be given the opportunity to renew or re-up their commitment. Compatible couples could choose to do so, forming the first families on Mars. We have to shut our ears to those who say we can't allow births until we know for sure that humans can survive long term on Mars. Why? Because the only way to know that is to see how the second native born generation turns out, and that means taking the plunge without delay. There is no believable ivory tower way to find that out. If humans had always been so "timid," (let's call a spade a spade) we would still be in the rain forests or plains of Africa or in the caves of Europe. It is human to take the plunge, as an exercise of faith in the capacity of the human genetic architecture.

One outpost, repeatedly revisited by supply ships, can grow methodically. As it grows, a more diverse slate of occupations can be supported. Made on Mars consumer goods will be first produced by workers with day jobs in their free time, as cottage industry startups. More and more personnel will be freed from outpost support duties to partake on further exploratory expeditions. Once the needs of outpost expansion can be met with home grown industries, we will have the start of a new civilization on Mars, one making real steps towards an independently viable future. And that, after all, is our Holy Grail.

Bidirectional lessons: MDRS to Mars and Mars to MDRS

Consequences flow forward and backward. We can see from what has happened at FMARS and MDRS that the Hab plan will not work for Mars as the plan now stands. The flip side of the coin is that it is not working even now in the Arctic or in Utah. Yes, we simulate exploration procedures, geology and prospecting procedures, exobiology procedures. But we don't simulate the isolation without hope of relief for two plus years.

It would be both valid and honest to say that the Mars Society has had to choose its battles. Some battles are more easily won. The engagement in others seems beyond our grasp as a small nonprofit society. But we ought to advance steadily in that direction, especially since those battles must be won before we dare set out for Mars.

### **Picking a site on Mars – a prime candidate**

If we are to settle on just one landing site, we need to pick that site with care. As of now, we have but a foggy start to an Economic Geography of Mars, tracing where all the resources are, the logistical advantages, the logical transportation corridors, a priority list for 2nd, 3rd, and following outposts needed for a trading economy on Mars itself. We can expect this hazy map to become a bit clearer by the time the first crew leaves for Mars.

In the meantime, this suggestion. **Pavonis Mons** is one of Mars four largest shield volcanoes. Almost as tall, but not quite as large in area as Olympus Mons, it more than makes up for any shortfall by its location, smack on the equator. Its summit caldera rim would be the best spot in the inner solar system to anchor a space elevator (we have to figure out how to avoid Phobos which crosses that path) and its gentle west slope, the ideal place in the inner



system for a mountain launch track. The eventual establishment of either would greatly lessen the cost of exports to the Earth–Moon system. More, as a shield volcano much like Mauna Loa/ Mauna Kea on the island of Hawaii, it is almost certainly laced with intact lavatubes. In “The Argument from Medicine Lake” (MMM # 74 March 1994, p. 3, republished in MMM Classics #8, pp 12–13) Bryce Walden conservatively estimates that Pavonis offers 333 km<sup>2</sup> = 128 mi<sup>2</sup> of usable sheltered floor space, the size of a major American central city in the one million population range.

But the outpost doesn’t have to be on/in Pavonis Mons itself. It could be to the west, between the outer mountain ramparts and the crater Ulysses – call it “Ulysses Junction.”

Or it could be east, between Pavonis Mons and the Head of Valles Marineris. While undoubtedly, other sites will have some merit, a location along the equator to either side of Pavonis Mons will certainly be in the running and hard to out-merit. Again, exploration goals and geological and scientific curiosities should score no points. They are irrelevant to the overarching need to establish an outpost beachhead of humanity on Mars “securely.”

### **De-marginalizing the Mars Analog Stations**

Back to the Mars Society’s analog research stations – FMARS is already pre-marginalized by the extreme climate on Devon Island as well as the order of magnitude greater cost of logistics: transportation and supplies.

MDRS has been marginalized unnecessarily, we believe, in the absence of a decision to shield it. Shielding, which will clearly be needed on Mars to attract those unwilling to sign waivers that accept the chances of cancer and risk of reproductive sterilization, is one of those things we have silently put on the list of things not to simulate.

The tall profile of the Hab (again, putting form before function instead of vice versa) makes shielding difficult. A Horizontal ranch-style complex would be much easier to shield. While the landlord, the U.S. Bureau of Land Management [BLM] would not take kindly to wholesale earth-moving, shielding could be simulated in easily removable fashion by bags of mulch, for example.

The thermal equilibrium to be gained would result in a significantly longer field season, now limited by summer heat, and thus make possible a true greenhouse, not the very limited graywater recycling GreenHab system we have. Yes, there are other summer heat related issues: cooling the EVA suits for example. But these too are surmountable.

The existing facility could grow, adding a horizontal crew quarters module, reoutfitting the present Hab structure for a more complete lab (whole second floor deck now given to crew berths, ward room, galley, computer stations) and a much expanded engineering, machine shop, fabrication space on the first floor deck. But where we put what is another question. The priority is to expand, create more usable space.

### **What about FMARS?**

The “first-born” has a special place in the affections of Mars Society members. Devon Island offers a different kind of Mars Analog Terrain. The fact remains that any facility not used full-time is too expensive per man-hour of use to maintain.

It would be a hard choice to take it down, ship it to some other location where it could enjoy full(er)-time use and reassemble and re-outfit it. There are cost-benefit issues that come into play but which can only be correctly assessed if we take the long view. Have we done about all we can do on Devon Island? If so, the time has come to take a fresh new look at this asset and how it can best serve the dreams of the Society.

Relocation of the Arctic Hab to a new home side by side to the Desert Hab and then rethinking how each is outfitted, is one option it will do no harm to brainstorm. The result? A more complete outpost capable of simulating more of the facilities and activities a real outpost must have.

Another idea would be to relocate FMARS to the Orlando or Las Vegas areas as a tourist center. Both MDRS and Euro-Mars have indeed been on display, but in each case, that was prior

to interior outfitting. The upshot is that the visitor did not get a good idea of what it would be like to live and work in such an outpost. Missed Opportunity!

In an FMARS tourist facility, visitors could see how and where crews live and work, both by walking through a near-identical layout and through live web-cams to all of the activity areas of MDRS. Such a facility could pay for itself and the whole analog station program by visitor donations.

Then with FMARS retired to visitor duty, MDRS could be logically expanded first by inflatables, outfitted with local materials, then by modules produced and outfitted from (simulated) local (Martian) materials. This would provide a much better model of the way we will need to do things on Mars if we don't want the Mars Program to end as the Apollo one did, as a futile "moment of glory" dead end. We are here to make "History," not an "Historical Moment!"

### **Summary**

The present goal of the Mars Analog Research Station Program is to establish a series of minimal stations at a multiplicity of sites that are each analogs of Mars in different ways. Many things cannot now be modeled or simulated because of the Procrustean limitations of the form/shape/size of the Hab design based on transportation constraints. It would seem better to go beyond the simulation of exploration procedures and the testing of equipment. We need to phase in simulation of transition from initial "bare bones" outpost into a viable and permanent beachhead.

Establishment of a more capacious foothold with endurance capacity is much more important than butterfly sampling of many locations. Exploration, and much, much more of it, will be best guaranteed by establishment of a viable beachhead as the primary goal of a Manned Mars Mission program.

Currently, the separate Mars Foundation works on its own to find pathways to settlement. The Mars Society needs to collaborate with the Foundation to vastly improve its analog program., which is currently aimed only at the exploration of Mars, not settlement.

**If we want to simulate what we will need to have on Mars,  
we must grow MDRS as we would the first outpost on Mars.**

It's all so simple, really.

<PK/MMM>

[We realize that this article will prove to be quite controversial, "cart upsetting." But it often happens in any movement that a time comes when we must stand back and ask, "are we still on the track? Or did we get off it somehow? If so, how do we get back on the path to our dreams?"]

## **From the Arctic & Desert Analog Stations to a Real 1st Human Outpost on Mars**

**Changing Mission Plans to fit the many lessons learned on Devon Island and in Utah**

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### **First things first! Settling in before Exploration!**

While this plan introduces measures to guarantee a safe return of each crew, and to gradually extend the reach of manned exploration across the globe, it clearly puts exploration ahead of establishment of even one viable outpost. Actually, none of the three manned Habitats would be viable for more than weeks, in our opinion. They are each too small to house all that is needed to sustain a crew for up to two years in good physical and mental health. I say that having spent two 2-week tours of duty at the Mars Desert Research Station in Utah.

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### **Crew expansion leads to economic diversification**

Once an outpost, the outpost, is clearly viable and at least partially self-sustaining, crew members could be given the opportunity to renew or reup their commitment. Compatible couples could choose to do so, forming the first families on Mars. We have to shut our ears to those who say we can't allow births until we know for sure that humans can survive long term on Mars. Why? Because the only way to know that is to see how the second native born generation turns out, and that means taking the plunge without delay. There is no believable ivory tower way to find that out. If humans had always been so "timid," (let's call a spade a spade) we would still be in the rain forests or plains of Africa or in the caves of Europe. It is human to take the plunge, as an exercise of faith in the capacity of the human genetic architecture.

One outpost, repeatedly revisited by supply ships, can grow methodically. As it grows, a more diverse slate of occupations can be supported. Made on Mars consumer goods will be first produced by workers with day jobs in their free time, as cottage industry startups. More and more personnel will be freed from outpost support duties to partake on further exploratory expeditions. Once the needs of outpost expansion can be met with home grown industries, we will have the start of a new civilization on Mars, one making real steps towards an independently viable future. And that, after all, is our Holy Grail.

### **Bidirectional lessons: MDRS to Mars and Mars to MDRS**

Consequences flow forward and backward. We can see from what has happened at FMARS and MDRS that the Hab plan will not work for Mars as the plan now stands. The flip side of the coin is that it is not working even now in the Arctic or in Utah. Yes, we simulate exploration procedures, geology and prospecting procedures, exobiology procedures. But we don't simulate the isolation without hope of relief for two plus years.

It would be both valid and honest to say that the Mars Society has had to choose its battles. Some battles are more easily won. The engagement in others seems beyond our grasp

as a small nonprofit society. But we ought to advance steadily in that direction, especially since those battles must be won before we dare set out for Mars.

### **Picking a site on Mars – a prime candidate**

If we are to settle on just one landing site, we need to pick that site with care. As of now, we have but a foggy start to an Economic Geography of Mars, tracing where all the resources are, the logistical advantages, the logical transportation corridors, a priority list for 2nd, 3rd, and following outposts needed for a trading economy on Mars itself. We can expect this hazy map to become a bit clearer by the time the first crew leaves for Mars.

In the meantime, this suggestion. Pavonis Mons is one of Mars four largest shield volcanoes. Almost as tall, but not quite as large in area as Olympus Mons, it more than makes up for any shortfall by its location, smack on the equator. Its summit caldera rim would be the best spot in the inner solar system to anchor a space elevator (we have to figure out how to avoid Phobos which crosses that path) and its gentle west slope, the ideal place in the inner system for a mountain launch track. The eventual establishment of either would greatly lessen the cost of exports to the Earth–Moon system. More, as a shield volcano much like Mauna Loa/ Mauna Kea on the island of Hawaii, it is almost certainly laced with intact lavatubes. In “The Argument from Medicine Lake” (MMM # 74 March 1994, p. 3, republished in MMM Classics #8, pp 12–13) Bryce Walden conservatively estimates that Pavonis offers 333 km<sup>2</sup> = 128 mi<sup>2</sup> of usable sheltered floor space, the size of a major American central city in the one million population range.

But the outpost doesn’t have to be on/in Pavonis Mons itself. It could be to the West, between the outer mountain ramparts and the crater Ulysses – call it “Ulysses Junction.”

Or it could be east, between Pavonis Mons and the Head of Valles Marineris. While undoubtedly, other sites will have some merit, a location along the equator to either side of Pavonis Mons will certainly be in the running and hard to out-merit. Again, exploration goals and geological and scientific curiosities should score no points. They are irrelevant to the overarching need to establish an outpost beachhead of humanity on Mars “securely.”

### **De-marginalizing the Mars Analog Stations**

Back to the Mars Society’s analog research stations – FMARS is already pre-marginalized by the extreme climate on Devon Island as well as the order of magnitude greater cost of logistics: transportation and supplies.

MDRS has been marginalized unnecessarily, we believe, for lack of a decision to shield it. Shielding, which will clearly be needed on Mars to attract those unwilling to sign waivers that accept the chances of cancer and risk of reproductive sterilization, is one of those things we have silently put on the list of things not to simulate.

The tall profile of the Hab (again, putting form before function instead of vice versa) makes shielding difficult. A Horizontal ranch-style complex would be much easier to shield. While the landlord, the U.S. Bureau of Land Management, BLM, would not take kindly to wholesale earth-moving, shielding could be simulated in easily removable fashion by bags of mulch, for example.

The thermal equilibrium to be gained would result in a significantly longer field season, now limited by summer heat, and thus make possible a true greenhouse, not the very limited graywater recycling GreenHab system we have. Yes, there are other summer heat related issues: cooling the EVA suits for example. But these too are surmountable.

The existing facility could grow, adding a horizontal crew quarters module, reoutfitting the present Hab structure for a more complete lab (whole second floor deck now given to crew berths, ward room, galley, computer stations) and a much expanded engineering, machine shop, fabrication space on the first floor deck. But where we put what is another question. The priority is to expand, create more usable space.

### **What about FMARS?**

The “first-born” has a special place in the affections of Mars Society members. Devon Island offers a different kind of Mars Analog Terrain. The fact remains that any facility not used full-time is too expensive per manhour of use to maintain.

It would be a hard choice to take it down, ship it to some other location where it could enjoy full(er)-time use and reassemble and reoutfit it. There are cost-benefit issues that come into play but which can only be correctly assessed if we take the long view. Have we done about all we can do on Devon Island? If so, the time has come to take a fresh new look at this asset and how it can best serve the dreams of the Society.

Relocation of the Arctic Hab to a new home side by side to the Desert Hab and then rethinking how each is outfitted, is one option it will do no harm to brainstorm. The result? A more complete outpost capable of simulating more of the facilities and activities a real outpost must have.

Another idea would be to relocate FMARS to the Orlando or Las Vegas areas as a tourist center. Both MDRS and Euro-Mars have indeed been on display, but in each case, that was prior to interior outfitting. The upshot is that the visitor did not get a good idea of what it would be like to live and work in such an outpost. Missed Opportunity!

In an FMARS tourist facility, visitors could see how and where crews live and work, both by walking through a near-identical layout and through live web-cams to all of the activity areas of MDRS. Such a facility could pay for itself and the whole analog station program by visitor donations.

Then with FMARS retired to visitor duty, MDRS could be logically expanded first by inflatables, outfitted with local materials, then by modules produced and outfitted from (simulated) local (Martian) materials. This would provide a much better model of the way we will need to do things on Mars if we don't want the Mars Program to end as the Apollo one did, as a futile “moment of glory” dead end. We are here to make “History,” not an “Historical Moment!”

### **Summary**

The present goal of the Mars Analog Research Station Program is to establish a series of minimal stations at a multiplicity of sites that are each analogs of Mars in different ways. Many things cannot now be modeled or simulated because of the Procrustean limitations of the form/shape/size of the Hab design based on transportation constraints. It would seem better to go beyond the simulation of exploration procedures and the testing of equipment. We need to phase in simulation of transition from initial bare bones outpost into a viable permanent beachhead.

Establishment of a more capacious foothold with endurance capacity is much more important than butterfly sampling of many locations. Exploration, and much, much more of it, will be best guaranteed by establishment of a viable beachhead as the primary goal of a Manned Mars Mission program.

Currently, the separate Mars Foundation works on its own to find pathways to settlement. The Mars Society needs to collaborate with the Foundation to vastly improve its analog program, which is currently aimed only at the exploration of Mars, not settlement.

**If we want to simulate what we will need to have on Mars, we must grow MDRS as we would the first outpost on Mars.**

It's all so simple, really.

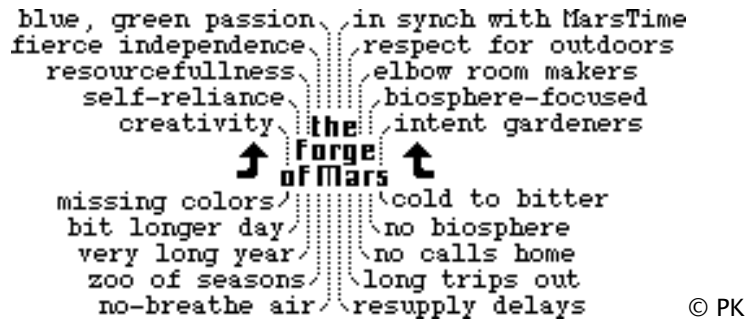
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### **NOTE:**

We realize that this article will prove to be quite controversial, “upsetting the applecart.” But it often happens in any movement that a time comes when we must stand back and ask, “are we still on the track? Or did we get off it somehow? If so, how do we get back on course to our dreams?”

It is as a strong supporter of the Mars Society's Analog Research Station Program that this constructive criticism is offered.]

## New Words for our Vocabulary from the Martian Frontier



### Slang, Figures of Speech, Names

By Peter Kokh

#### Frontiers have always expanded our Languages

There are those who loathe the introduction of new words into the language. But its enormous capacity to adopt new words and make them its own is a major reason why English is the most widespread language on Earth. Indeed, Dictionary publishers accept this as a matter of fact.

All past frontiers have contributed a wealth of new words, phrases, and names to their languages. America, the American West, Canada, Australia, New Zealand, South America and other newer adopted homelands have all contributed and continue to do so. Stretching old words to convey new meanings can only go so far.

As we move out into frontiers beyond Earth's familiar shores, we should accept and encourage coinage of new words and expressions, not fight futilely against them. For it will be no different as we establish ourselves on the Lunar and Martian and asteroidal frontiers ahead.

#### New Words and Expressions from the Mars Frontier

There will be new types of structures, new occupations, new sports, new hobbies. There will be new kinds of dangers, and new strategies to meet them. New strange environments will contribute many new terms. New time reckoning systems and new holidays and festivals will bring new terms and phrases. Seasons only crudely analogous to any on Earth and new weather phenomena as well as ways the settlers find to deal with them will give birth to new words and figures of speech.

New human places will generate new place names as imaginative, colorful and varied as have the new terrestrial frontiers previously settled. It could hardly be otherwise.

We have already chosen new class names for types of geological features special to Mars. See the next page. As we explore Mars, we will had to the list of words that denote topographical landscape features unique to Mars.

#### Habitats and Transportation

Mars will see the birth of new types of architecture and new types of construction. Martian homesteads will have new features, new types of rooms, new types of furniture and furnishings. The new Martians will develop new kinds of sports and sporting activities, new kinds of hobbies and new kinds of art media and craft.

The same goes true for new, evolving types of transportation designed for the Martian environment. New types of wheeled vehicles private and public, of trains, even of aircraft will evolve to make the Mars civilization as mobile as our own. And just having to deal with new kinds of obstacles, emergencies, and vulnerabilities will generate new expressions and figures of speech.

#### Elements of a Unique Martian Culture

Any frontier gives birth to its own unique holidays and festivals, events that promote group solidarity and cohesiveness. These will be special items on a new Martian calendar. On

that score, many have attempted to invent and publish Mars calendars, hoping to have the honor of creating the one adopted by the pioneers. The pioneers, and not us, not the Mars Society, will pick their calendar and their timekeeping system. All we can do is supply models for them to consider.

Mars has its own unique rhythms: a slightly longer day, a nearly doubly long year, and very uneven season lengths. Sol, meaning Sun, now designates the 39 minute longer Martian day. I must say that this choice is reprehensible and I harshly censure those who picked this term. Sol means the period from one noon to the next, and as such applies to ANY (yes, I am shouting) noon to noon period on ANY planet or satellite, not just Mars, and no one had the right to reserve it to Mars alone. Sorry, pet peeve big time.

The same goes to economic and political systems. The Mars Society Civilization & Culture Task Force, at least for the period in which I tried to moderate it, attracted many utopians slow to realize that when all was said and done, it would be the pioneers themselves who will choose and have the sole right to choose any and all systems by which they want to live. Mars will be their planet, not ours. It's our lot to prepare, no more.

The arid desert rock and soil tone pallet of mars will also generate new words. This palette is very narrow and introduces serious color deprivation. The eye wants to see more, and for many colonists, the priority will be to surround themselves with the Mars Missing Colors: blues and greens especially, but also yellows, reds, purples, and even blacks and whites. They will introduce missing colors into their home decor, into inside window box planters so that they can look at the barren exterior scapes through the reassuring filter of green foliage and floral colors. For fast safe identification of suited personnel and vehicles out on the surface suits, signs, and vehicles will hardly come in colors that blend into the background. Unlike the case on Earth, Mars camouflage will have no greens anytime soon!

Marspeak, whether it is an off shoot of English, of some other terrestrial language, or a new construct will have terms to distinguish newcomers from those born on Mars as well as those who have lived on Mars for some time. There will also be words and expressions to describe the isolation that comes from launch windows two plus years apart and from message transmission lags of 6-40-some minutes.

That the new Martians must live off a Yolk Sac of supplies and parts, and not at the end of an umbilical cord (as is the case for Lunar settlers) will give rise to figures of speech as well.

Whatever language or languages we bring to Mars will evolve with the frontier. Pull a Rip van Winkle and awake a hundred years from now to a made-on-Mars movie, and you will be hard put to understand. Life moves on, and language moves on with it.

#### **Words, Expressions, and Names from the Mars Society's Analog Research Station Program**

The experiences of volunteers at the Mars Society Analog research Stations will also contribute words and phrases that have some real chance of surviving on the actual frontier of Mars. There may be place names such as New Boulder, New Resolute, New Hanksville, to mention some of the more obvious choices.

There will also be names and phrases that will ring a bell only with FMARS and/or MDRS veterans.

**"Mommy, why is the road from the spaceport to the settlement called New Cow Dung Road?"**

**"Daddy, why is the first paved highway on Mars designated Highway 24?"**

**"Daddy, why is that flat mountain top named Factory Butte? There's no factory up there, is there?"**

And so on. At least we veterans would be pleased to know that some of our experiences may be immortalized in MarsSpeak one day. After all, our hard work is aimed and dedicated to making it possible for the real drama to unfold in the not too distant future.

</MDRS>

**From MMM #133 March 2000**  
**Mars will Forge those who Pioneer it**



Alien beauty, endless monochrome horizons, thin breathless air, trans-Siberian cold, a tad longer day, doubly long year, irregular seasons, remote from Earth. Mars! Here is a world that will take its pioneers and reshape them to the core. In the end Mars will tolerate only “its own kind of people.” And Mars will make them “the best.”

More Relevant Readings from MMM #s Past

MMM # 41 December 1990, p 6. To Inject a Unique Flavor into Martian Settlement Culture, add the Romantic Touch of Old BARSOOM

MMM # 73 March 1994, p 5. Canal Names of Yore

MMM #133, March 2000, p 3. Seeds & Wellsprings of Martian Culture, P. Kokh: A One-Sided Mars Palette;

p 4. Cont.: Mars Time: A Tad Longer Day; p 5. Cont: A Doubly Long Year; Diverse Seasons Lengths; p 7. Cont.: Outdoor Mars: Thin Atmosphere, Cold Climate; p 8. Cont.: No Open Water; No Biosphere



## Oops! We forgot a Color!

“So you want to terraform Mars? Wake me up when you’re all done!” Don Foutz

By Peter Kokh

We can begin to breed Mars-hardy plants even now, here on Earth, in conditions where the needs of the most cold-hardy and arid-hardy Earth plants meet present Mars conditions “halfway,” so to speak. See our previous article on “Redhousing,” MMM #93 MAR ‘96 [MMM Classics #10]

But we won’t be very successful in introducing them to the unprotected surface soils of Mars until:

- a) **the atmospheric pressure has been increased by an order of magnitude** or so (to 7-10% Earth-normal) and
- b) **until we have bodies of liquid water (seas)** which evaporate, produce rain, and drain back into the same or other seas.

And guess what happens when you rain on exposed plant free soil? You get mud, lots of mud, too much mud, enough mud to make all surface operations very difficult and discouraging. Anyone who has served at the Mars Desert Research Station knows that all too well.

Now that poses quite a challenge to devotees of Kim Stanley Robinson’s epic Mars Science Fiction Trilogy “Red Mars, Green Mars, Blue Mars.” It challenges those also who have become attached to the Mars Society Tricolor.

**The challenge? Either invent and develop processes to “fix” the soils of Mars before the first rains fall, or change the tricolor to a 4-color flag. No middle ground.**

Now it may be possible to fix the soil, and an ideal location for experiments on a small scale is the Mars Desert Research Station outside of Hanksville, Utah. Small plots a few yards/meters square could be treated without significantly violating the terms of our lease with the Bureau of Land Management [BLM].

What would you use as a fixative? It had better be something we can easily reproduce on Mars, perhaps something eventually biodegradable from the ingredients in Mars’ own atmosphere; something cheap enough to produce on an enormous scale. That means not only

that the involved elements must be easy enough to produce with low energy inputs, but that the process of producing the fixative from them must be inexpensive on a vast scale.

We offer no suggestions, just make the challenge. **Find a solution or change the flag!**

There are benefits here and now for a solution. We could treat the area immediately surrounding the MDRS Hab and contiguous structures. That will greatly reduce the tracking of mud into the Hab and the consequent chore of cleaning it up, over and over again.

We'll even name the fixative after you! </MDRS>

## 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 has significant protection from the incessant micrometeorite 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 that 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 but 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 propulsion 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. Further, 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 and ever increasing variety of consumer goods
- ✓ Many food and beverage specialties
- ✓ Many hobbies, even indoor ones, that cannot be supported on the frontier, at least not yet.
- ✓ An endless list of tourist destinations when it is time to escape for a while
- ✓ 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 immense 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 it will the same on both Moon and Mars

**They will face similar challenges to their resourcefulness, ingenuity, and adaptability**

- ✓ Having to make do with a different set of resources and tools
- ✓ Having to make substitutions when the material of choice on Earth is not available
- ✓ Having to make do without when substitutions are not feasible
- ✓ Having to learn to respect the alien, mindless dangers of life on the new frontier
- ✓ Having to learn to express one’s artistic creativity in new ways
- ✓ Having fewer distinctively different changes of scenery available for getaways
- ✓ Having to raise 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 much about.
- ✓ Having to develop new sports that play to the new gravity level

✓ Having to learn new ways to dance in the new gravity level

**They will need to be made of the same “right stuff”**

✓ Resourcefulness, ingenuity, creativity, and adaptability

✓ Willing to make sacrifices

✓ Willing to try new ways to do old things

✓ Accepting the frontier as “home” at the very core of their souls

**UPSHOT – The Moon’s sky may be black while Mars is bright.** They have different color palettes, different gravities, different landscapes, and different suites of commonly available elements. **But underneath, the Moon and Mars and the pioneers of each, will have much in common.**

## **Moon Society – Mars Society Collaboration & Joint Project Areas**

### **FUTURE ROBOTIC PROBES**

- **Push development of instruments to map near subsurface voids (lavatubes).** Such instruments can be test flown in Earth orbit where ground truth is in hand to calibrate the readings. We suspect these in shield volcanoes (Olympus Mons, and the three Tharsis Ridge volcanoes, Arsia, Pavonis, and Ascraeus) on Mars, and in lava sheet flows (maria) on both worlds. The Oregon L5 Society has two projects:
- **Software to detect any exposed lavatube entrances** by their shadows in photos taken at high noon lighting conditions [e.g. Clementine data) – to narrow down the list of sites to be searched.
- **A radar “flashbulb” impactor** with two parts that would “telescope” on impact, creating a signal illuminating subsurface voids within 8 kilometers, the signal to be received by an orbiter overhead.
- **Push development of permafrost–mapping instruments** that can also detect concentration (percentage soil moisture) and depth. A Permafrost Mapper could be tested in orbit above the Earth, where, with the advantage of available ground truth, we can establish the capacity and calibration of the instruments

**LIST AND DEFINE ELEMENTS OF COMMONALITY:** Structures, systems, infrastructures, and procedures needed for Exploration & Outpost Establishment Missions on both Moon and Mars – without prejudice to separately designing things that must be different.

This will result in shared cost assignments, or in the case of items designed and engineered for the Moon first, part of the Moon front effort, with only incremental cost of any needed adaptations being assigned to the Mars front effort.

### **MODULAR ARCHITECTURES FOR HABITAT & BIOSPHERE EXPANSION**

- **Develop a versatile “language” of habitat modules**
  - ✓ That can be manufactured from locally processed building materials such as metal alloys, glass–glass composites, and fiberglass reinforced concrete.
  - ✓ That can be quickly and safely assembled on location with minimal man–hours on the surface, saving labor–intensive customization for indoor customizing.
  - ✓ A family of modules that allow diverse habitat designs.
  - ✓ Connections must be quick, secure, leak–resistant, and durable. Utility run interfaces must be standardized.
- **Toilet / greenhouse modules** that provide primary treatment of human wastes will allow the settlement biosphere to grow in modular fashion along with the mass and maze of interlinked habitat structures.
- **Modular Factory & Modular Industrial Park Concepts.** Capital equipment is likely to be sized to fit available cargo holds and farings en route to the Moon or Mars. Developing a Container architecture and infrastructure will allow industrial parks to grow modular fashion.

Modular Power Units, thermal management, and product and by-product movements should all be part of such designs, along with designing for both human tending and teleoperation.

There is already considerable progress made on developing container factories for use in the Third World. That is experience we can build on.

- **Work on the “Economic Case for Mars”** incorporating Moon–Mars Trade along with the mutual development of other “in-space” sources and markets to include Earth–orbiting stations, factories, and tourist facilities; and asteroid mining efforts.

- **Design & Test dust control measures** to impede migration of dust into habitat interiors through air–locks. Space–suit design and airlock design should be integrated. Entry and exit of goods and materials should be handled separately. Dust repellent surfaces, especially surrounding airlocks, are worth developing. Dust can render lubricants nonfunctional and ways to protect bearings and other lubricated areas must be found.

- **“Spin–up, not off”: List & Define the various technologies, not yet developed, that we will need on the frontier.**

- ✓ Then brainstorm these technologies for potentially profitable terrestrial applications.

- ✓ Next layout the basis for a business plan for an enterprise that would develop such technologies just for those terrestrial applications.

- ✓ The hoped for result is that these technologies will be on the shelf, ready to apply when we need them, the cost of their development reimbursed by consumers.

- ✓ If we don’t do this, and leave it to NASA, some of these technologies may be victims of budget cuts, others developed in expensive crash programs paid for by taxpayers. By pursuing the spin–up route we are taking charge, making sure that the technologies we need to open the lunar and Martian frontiers are there when we need them, and not subject to budget scrutiny.

- ✓ Many, not all, of these future frontier technologies will be needed on both worlds. .Many of the technologies needed on the Moon, but not applicable to Mars, may be needed on Phobos and Deimos

**OUTPOST SIMULATION:** some Moon Society members could volunteer to crew an MDRS in Utah, to further simulate conditions common to both frontiers from a new perspective.

**JOINT CONFERENCE COSPONSORSHIPS:** The Moon Society has offered to host the Moon track at the National Space Society’s annual International Space Development Conference. We could invite Mars Society personnel to help us turn this into a Moon & Mars track. We might also want to contribute presentations to future Mars Society Conventions on topics of shared interest.

**UNITED PUBLIC POSTURE:** coordinating our public positions on the Moon–to–Mars initiative. This can include joint position papers and press releases, when appropriate, and when touching on area of mutual interest and collaboration.

**JOINT PUBLISHING VENTURES,** for example "Lavatube Sanctuaries (word)? on the Moon and Mars" (alternate title, "The Hidden Valleys of the Moon and Mars" // "Pioneering New Worlds: The Moon and Mars," etc., etc. Again, spreading the message of a united front. Another idea is joint CD–ROMs on Moon and Mars

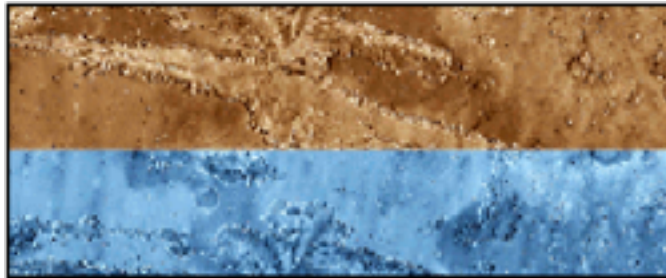
**This is but START OF A LIST of what Moon and Mars enthusiasts and supporters can fruitfully pursue together.** The areas of collaboration and cooperation are open and fluid. The above are but some suggestions that appear to be especially worth pursuing to mutual advantage.

**Note: The Moon Society will pursue such a collaborative and cooperative posture even if corresponding good will is not always shown by those interested only, or primarily, in the opening of the Martian Frontier.**

Suggestions and constructive criticism are invited.

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MMM # 203 – MAR 2007



#### How will Mars Pioneers Handle Climate Shock?

**Above**, courtesy of a PhotoShop color inversion, we try to capture the “feel of Mars” as it looks. Somewhat like our Four Corners area: SE Utah, SW Colorado, NW New Mexico, NE Arizona – which can be quite hot on summer days. **Below**, the color inversion captures Mars “as it feels” – mirroring the full temperature range of Antarctica, a place very few would pioneer despite its fresh breathable air and abundant sea food. More, below

### In FOCUS NASA Moon Plan gets an “F” as “Preparation for Mars”

In our MMM #191 DEC. 2005 editorial, “Dear Santa: a Moonbase made for Mars,” we pointed out that if NASA’s goal is to build a workable Mars Base and try it out on the Moon first, we would get several things advantageous to a moonbase that we might not otherwise get:

- **A life support system that went beyond umbilical cord style resupply, rescue, and repair**, but had to work without relief for extended periods of time, two years or more. This most likely would involve a considerable greenhouse food-growing operation, a system that could be easily dropped from a Moonbase-only program, given inevitable budget pressures.
- **A design that had to take “shieldability” into account** because the long stay times on Mars will demand such protection. On the Moon, in contrast, you could do without shielding if you rotated crews frequently enough.
- **A robust machine shop and repair facility**, because on Mars, one might have to fabricate a critical part if the last spare had been used.
- **Development of an adequate power system** not reliant on “eternal sunshine”, which is something that would not be available on Mars. We might end up with a power system that would let us operate anywhere on the Moon, not just in the misnamed polar cul de sacs of “eternal sunshine.”

Unfortunately, NASA seems to have dropped the ball on at least some of these considerations.

NASA has zeroed out the budget for all further advanced (biologically based) Life Support Systems, shutting down both the BioPlex at Johnson Space Center in Houston and the NSCORT project at Purdue. To save money in the classical penny-wise pound-foolish manner, NASA will rely on just in time supplies of oxygen and water to the Moonbase, just as it does to ISS. Only in the latter case, the Russians are there to come to the rescue when NASA is grounded. This decision makes it unlikely that a Moonbase will be staffed indefinitely without short or long interruptions. We all know that the “penny wise, pound foolish” approach is sheer stupidity. Of course, we can always blame it on the financial black hole otherwise known as the war in Iraq.

Some NASA moonbase designs show a modular ranch-style horizontal layout. But other mockups show the highly vertical, difficult to shield, Zubrinesque double tuna-can, in which at best, “sandbags” will be placed on top, is if the only direction of incoming radiation was from

the Zenith. We are only at the paper stage as of now, so NASA may yet adopt the easier to shield horizontal approach. We predict NASA will take the cheapest “out,” no matter what the consequences downstream.

No indications of a machine shop, repair facility, or fabrication shop yet. We’ll have to wait and see.

NASA seems determined to take the easiest way out in developing a lunar power system, and that means that the agency probably will not predevelop a nuclear power plant for Mars to pretest on the Moon.

Is all this necessarily bad for Moon-buffs? We think so, but would be happy to be proven wrong.

1. That NASA has decided that the moonbase will **not** pretest systems intended for Mars, **will cost Moon-supporters what support we had from the more thoughtful fraction of the Mars-enthusiast community.** This “predesigned for use on Mars” formula was something Robert Zubrin insisted upon to earn his concessionary support for prior moonbase deployment. **NASA having renege, the cautious support of Zubrin and other Mars supporters has evaporated, probably for good.** I think that is sad. As I pointed out in last month’s issue, on the face of it, Moon-supporters and Mars-supporters have many reasons to be allies.
2. This means that it is up to the Moon Society and private enterprise to push the development of practical biospheric life support solutions. This is not all bad, as I strongly feel that NASA was taking the wrong track. Biospheric life support should be modular, growing apace with the modular physical settlement complex. The private enterprise/academia success with the Antarctic South Pole Station Food growth Chamber is something to cheer about and pursue further.
3. Whether or not NASA includes an adequate workshop and fabrication shop in its moonbase plans, we should include one in our Lunar Analog Research Station designs, following the lead of the Calgary Space Workers.
4. The Moon Society should also push and promote research and development of robust power storage systems adequate to manage the two week-long nightspan solar power drought on the Moon. This will allow us to set up shop wherever on the Moon it makes sense to do so on resource utilization grounds. Lunar industrialization is necessary if the Moon is to play its destined role in helping solve Earth’s heretofore intractable and intertwined energy production and environmental degradation problems.
5. Passing the R&D torch to private enterprise and non-government funded societies and institutions is the only way to sidestep what it is becoming increasingly clear will be only a gestural NASA-led presence on the Moon. We will be there, in the sense that Kilroy was – if that means nothing to younger readers, don’t worry about it. Baby Boomers and older persons get the allusion.

Unfortunately, there seems to be no way to insulate NASA projects or any other worthy government endeavors from the financial Katrina we are now experiencing currently and into the foreseeable future. On paper, the world economy is booming. In reality, accumulating debts are outpacing accumulating assets, and to this observer, it looks very much like a house of cards.

However, what is happening now in the private sector, especially with the COTS initiative, promises the development of private launch systems which could easily scale up to “do the Moon.” On that silver lining note, we bring this discussion to a pregnant pause. PK

**NOTE 12.05.2010:** We wrote this 3 some years ago, and in retrospect, NASA’s failure to design “a moonbase meant for Mars” has cost it enough support from potential allies, that the Obama Administration decision to cancel the Constellation Moon plan was a forgone conclusion.

One can protest that there was not enough money “to do it right.” But in the end, “doing it right” is the only plan that makes sense. In fact NASA has never even tried to design its moonbase “for Mars” as the Bush plan clearly suggested it do. We cannot blame the pro-Mars community (Mars Society and Planetary Society) for urging the new administration to change course. We had our chance and flubbed it. Impatience always fails. The space advocacy community bears some of the blame, for failing to give constructive criticism. Many wanted the Moon period, not the Moon as training ground for Mars. Well, the result is, that for the time being, we have nothing.

In the end, we will do the Moon: even “we” is other space agencies and commercial contractors. Have faith. PK

M O D U L A R

B I O S P H E R I C S

O N M A R S

By Peter Kokh

While in general, what we have been saying in the past few issues about the importance of integrating biosphere components with the architecture of an outpost and settlement in modular fashion, applies to Mars as well. It makes sense to adopt an expansion strategy that will automatically grow the biosphere as the physical pressurized complex grows. Not to do so would be a prescription for disaster.

So why is no one else talking about “Modular Biospherics?” Simple. No one else is talking about expansion of outposts or settlements in the making. Be that as it may, the situation facing the pioneers on Mars will be less challenging than that facing early Lunans.

#### Note these advantages for early Martians:

- **Availability of CO<sub>2</sub>, N<sub>2</sub>, O<sub>2</sub>** – Mars air can be made on demand. The need to recycle CO<sub>2</sub> from exhalation into fresh oxygen will not apply. However, it will be a good idea and any amount of plant life within the complex will help. The other tasks of keeping air fresh, cleaning the water, and growing food remain.
- **Reaching sustainability** may be easier since future Martians will find it much easier to make up for losses from leakage or deficiencies in plant production of fresh oxygen and processing of waste water.
- **The natural softer sunlight** on Mars can be easily intensified, but more importantly, it is available on a **more Earthlike 24 hr 39 min cycle**. Getting the plants through the nightspan will not be the challenge that Lunans must meet.

#### Agricultural advantages:

- **Vegetation** provides a sink for excess CO<sub>2</sub> (but that is so on Moon also.) But on Mars, there is an **abundant external source of CO<sub>2</sub>** in the atmosphere, and much more frozen at the poles or locked into the rocks, but releasable upon heating. The Martian settlements will find it easier to have a much more generous ratio of tonnage of vegetation to tonnage of the human population.
- **This much greater abundance** of the volatile elements needed for life may make it easier for Martian pioneers to justify the food expense of **raising live stock**.

#### Rejuvenating Mars' Climate:

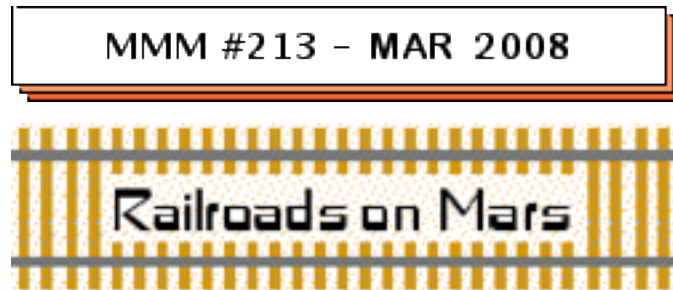
- **Note: we reject the word “terraforming.”** What we need to do is not to make Mars “more Earthlike” (all we really know how to do is make Earth less Earthlike) but to restore the much warmer, wetter, life-friendly climate of the early Mars: “rejuvenescence.”



- **As we slowly increase atmospheric pressure** by finding ways to permanently melt CO2 frost and ice at the poles, we can be developing plants hardy enough for partly pressurized areas, then finally for the Martian outdoors. – on Mars, biospherics will begin inside and then progresses to the outside

Check the article “**Redhousing**” in MMM #93 March ‘96, republished in MMM Classic #10

<MMM>



By Peter Kokh

Most of us are familiar with the critical role that railroads played in opening up the American West. The story was repeated, with some differences, in Canada and Australia. And with the railroads came the benefits of the Industrial Revolution. The railroads extended communications (telegraph) and by providing access to the territory they passed through, predeveloped the land.

#### **How railroads can help**

On the Moon and Mars, we aren't going to find building materials that we can “throw together” to provide shelter from the cosmic elements. We will need pressurized structures. Pressurized modules made in a first quickly industrializing settlement can be shipped by the railroads to points along the route to provide the nucleus of new settlements. Pressurized modules have to be handled with care. Try to haul them overland on unimproved roads and the stresses of bouncing around are going to compromise seals and maybe open cracks. Rails on the other hand will provide a smooth low-friction ride to a prepared siding complex where they can be dropped off and docked with one another to provide an instant starter outpost. Such new “town starters” might even be called “sidingments” or “sidlings” instead of settlements. Every new train could bring another module or two including ready to plug in “container factories.”

Now it is going to take some time before we are building pressurized modules on the Moon. Until then, inflatable modules will cost significantly less to produce and ship from Earth, and the railroads could carry these to desired locations as well. Clearly railroads could establish chains of interconnected settlements much faster than by any other option. That goes for the Martian frontier as well.

If the human frontier on Mars advances this way from one point of origin, we won't have the problem of distant settlements isolated from one another. But if we are going to open Mars by railroading, we need to do some homework first. Top priority is production of a high vertical resolution map of Mars so that we can plot logical rail corridors where along which grade changes are slow. We may soon have a good start on such a map from altimetry data from the present and planned fleet of orbiters. We need to look for the elevation change **pinch points** are located. On Earth, these are straights and passes through which traffic funnels. Those will be critical anchors along proposed routes.

Between such narrow points the doable routing options are greater, and attention can be paid to scenic areas that would draw tourist traffic, for example. Scenic and Geological treasures along the selected route would go to the top of the list for boundary determination, and for location of adjacent visitor concession areas to set the stage for tourist and excursion companies, serving Mars pioneers.

Next we need to really work to define a useful “**economic geography**” of Mars. That’s a map that shows where “all” the critical resources are to be found, and in what degree of concentration. Where the elements from which building and manufacturing materials can be made are found to cluster, we have potential new industrial centers. Feasible routes that do not connect resource clusters would be options for development at a later date. These considerations are to the point on both worlds.

### **Routine aviation on Mars may be further in the future**

Why take the train when we can fly on Mars? I do believe that we can, but I also think that aviation on Mars will be uncomfortably pushing the envelope and that because of that, it may be risky for some time.

On the one hand, we are confident that flight is possible at 125,000 feet on Earth, and perhaps that has already been demonstrated. But no one has ever demonstrated take off and landing at that altitude. The suggestion is to design Marsplanes like Harrier VTOL fighters.

It still has to be demonstrated. And unless we are to be flying only at the Mars version of sea level, say within the northern ocean-sized basin or within Hellas, and if we are not going to just skim just over the surface, Mars aircraft are going to have to be stable at pressures a lot thinner than that at 125,000 feet on Earth.

Another thing I have never heard a Mars aviation fan (other than myself) concede is that the equivalent of 125,000 feet on Earth only describes the situation in spring and fall when much of the polar carbon dioxide snow over both polar caps is vaporized. As we go into either summer or winter, a significant part of the atmosphere, as much as 30%, will freeze out over one or the other poles. If Mars flight is possible only seasonally, it will not become the backbone of transportation on Mars. Another question is to what extent will dust storms that can last months, make flight dangerous.

Now maybe we can fly even when the atmosphere is at its thinnest. I hope so, but do we know? And more to the point, will we be able to hoist heavy cargo by air? I believe that railroads on Mars will become the backbone of global transport in the early decades

### **Mars-Specific Design Challenges**

Seasonal thermal extremes on Mars (from just over the freezing point of water to temperature lows far below the lowest ever reached in Antarctica, means that **tracks must be designed for thermal contraction and expansion**. Now on the Moon, the challenge is greater. It gets just as cold on the Moon as in the Martian winter, and in-between far hotter than the highest temperatures ever experienced on Earth on a monthly schedule. On the Moon we may have to shade the rails somehow. unless we can find an alloy with a **very low coefficient of thermal expansion**. The same will hold true of whatever we come up with to keep the lateral rail-rail separation within close tolerances: a functional **equivalent of our railroad “ties.”**

On Mars we must use elevation contour maps to identify locked, no outlet basins, which could, in a terra-formed future Mars become lakes or small seas. No sense pushing tracks through such depressions, no matter how conveniently smooth.

On both worlds, we have to **design out the possibility of derailment** that would involve upturned cars losing pressurization with a total loss of life. We will be dealing with lower gravities while momentum and mass remain the same. Very **wide gauges** (rail to rail separation) and very **low centers of gravity**, even some amount of banking of curved track sections may be part of the answer. But perhaps the best approach would be to take a page from modern all **steel roller coasters with wheels above and below the rails** so that the cars cannot come off the track.

If we have to complicate rail design to meet these constraints, then track switching becomes more complicated as well. But there should be ways to do it other than the roundtable.

For passenger trains, there is another issue. On Earth our passenger cars are “vestibulated.” They have flexible accordion like passageways above the couplings that allow protected access between cars. On Moon and Mars it is **unlikely that flexible corridors could long be maintained** without a pressure loss. There would seem to be at least two ways around this problem.

- (1) Restrict car to car (in Europe, wagon to wagon) passage to periods when the train is at the depot, or otherwise parked on straight level track sections. While so parked, the cars could snuggle up to one another, effectively docking as we do in space. For breathing purposes, Mars might as well provide a high vacuum, as does the Moon.
- (2) There is another option. As the railroads will be pushed through new unoccupied lands with no in place transportation infrastructures in place, there will be **as yet no overhead clearances to observe**. Nor will the rights of way be expensive to acquire. Mars, and the Moon, are virgin territories and the railroads will have the chance to set both rail gauge and clearances.

There is no reason why a Mar/Moon passenger car/wagon could not be double the width, double the length, and double the height (two floors) **able to carry as many passengers as a Jumbo jet**. Not that traffic will mandate such jumbo one-car trains at first, but the point is we should design the system so that in the future, when and if traffic warrants, we could build such capacious cars. The word "train means an coupled row of cars, one following the other, pulled/pushed by an engine car.

On the new frontiers of Moon and Mars, we have the option of starting with a clean slate blackboard, and we should take the opportunity to design for a more densely populated frontier with many major settlements. Now most people are not thinking that far ahead, but if we don't, then we risk making a slew of unnecessary, stupid, contraceptive dead-end decisions.

### **The Railroad as Land Developer**

Another thing worth paying attention to well in advance of the time when we starting to expand out of an initial outpost, is the role the railroad land grant system in place when railroads opened the American west. What were the good points? What points were not so good.

The Martian (and Lunar) railroads could be a major force in developing the strips of land that they passed through. This is too significant an opportunity to ignore. We will need to get it right.

### **Many more issues**

How will railroads be powered? Nuclear power is an option that was taken quite seriously back a few decades ago by the Norfolk and Southern running between Cincinnati, Ohio, and Norfolk, Virginia. I am not sure how far along that brainstorming effort got before being abandoned. If we can make a nuke sized to run a submarine, then why not a railroad? But they are heavy units requiring water for cooling.

The tops could be paneled with photovoltaic cells. The railroad could be paralleled with communication and electric power cables. On Mars, there is another option. A small nuke on board could **process methane fuel from the atmosphere** as the train travels! This is an option not available on the Moon. This system would be self-contained, ideal for day-night **all-season operation through territories without any other infrastructure**.

### **Choosing between options**

Some options will be realizable and practical before others. Yet if the most desirable option will save many headaches down the road, it's worth predeveloping. The bottom line is what percentage of the various options involves the least mass to be shipped from Earth – Earth sourcing is by far the most expensive option of all.

So we need to design a railroad system that has many features with no guarantee that they will all be ready on time:

- Lowest total component mass to be upported out of Earth's deep gravity well
- Highest percentage of component mass that can be manufactured on location (English for technospeak "in situ") in time to start building the system
- Most rugged in terms of wear and tear, especially to constant exposure to the (Moon's naked) Mars almost naked cosmic environment.
- Overall architecture that best supports spread of settlements as well as route-side development

- The system is the most rugged and least prone to degradation and early repair or replacement.
- The system design that best supports quick deployment of new settlements (“sidings”)

So if this article intrigued you, whether or not you have always been a train buff or a model railroader or you have simply enjoyed train travel, and if you enjoy a engineering challenge, why not join our brand new design brainstorming group: teasing illustrations on next page.

## **Bringing the Ocher Martian Outdoors In & Taking the Green Inside Outdoors**

**Overcoming the “alienness” of Mars by integrating indoor and outdoor elements**

By Peter Kokh

A home furnishing and decorating goal growing in popularity, particularly but not exclusively in warmer, sunnier climes is “bringing the outside in, and taking the inside outdoors.” For example, a home with a window wall and a patio beyond, will have the floor/ground space on either side finished with the same tile, patterned concrete, etc. There will be a visually uninterrupted flow of green foliage on both sides. Similar indoor–outdoor furniture will be placed on both sides. The idea is simple: the outside space should appear to be an extension of the adjacent indoors; the indoor space an extension of the outdoors. In the process, the boundary between home and homesite, between artifact and nature is blurred. The uplifting effect on the spirits of the home dwellers is significant and satisfying.

Future homesteaders on the Moon and Mars can do something similar, translating the above devices into the environmental languages of each world. Here we look at the opportunities before future Martians.

Window walls are not a near term: the pressure differential and the need to maintain radiation shielding create quite a challenge to this concept. However, the device of periscopic picture windows can be tweaked to create an illusion of a similar situation. A neat architectural choice would be to place any airlock so that anyone entering or leaving will do so in plain view out this picture window. This would make the outside area in view an obvious area for a “patio” treatment.

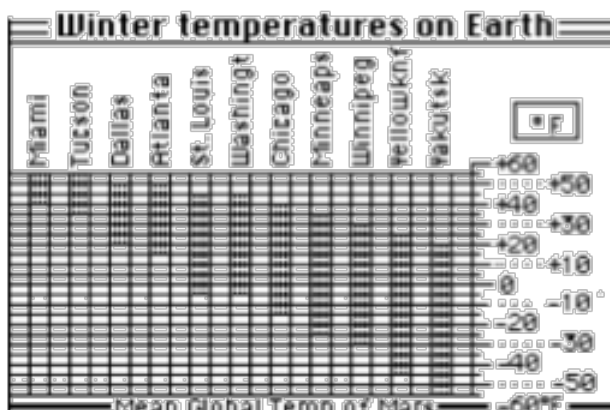
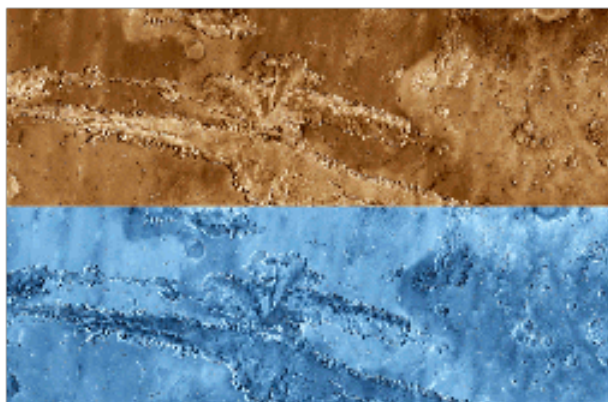
The same choice of Mars–tone pavers and/or tiles made of Martian materials can be used on both sides to suggest an uninterrupted flow of the homestead (or hotel, etc.) floor into the outdoors. Similar sculptures and other accessories could be used on both sides of the divide. Iron furniture with or without a pre–rusted surface could be used, a bench at least.

A Zen type stone and sand garden is another feature that could grace these two diverse juxtaposed environments. As for plants, faux plants made of stained glass elements could grace the patio. Long term, there are more exciting options: “Mars–hardy” plants bred to handle the slowly increasing air pressure of the slowly warming atmosphere. While that is not in the cards near term, there is no reason to delay experimentation now, here on Earth, by breeding various arid zone terrestrial plants to survive in increasingly more Marslike conditions. See the article “Redhousing” cited in the previous article. Once we are on Mars, “redhousing” may become a very popular hobby among the pioneers, not content to just wait, wanting to help make it all happen.

To ramp up the possibilities, a well–sunlit quartz–domed (UV safe) “patio” area would be an environment transition zone between pressurized indoors and the raw outdoors. It could be lightly pressurized to 10 times Mars normal, 1/10th Earth normal. One would enter this “arearium” via an airlock with only a light pressure suit. This would serve as a “redhouse” for plant breeding experiments, blurring the inside/outside barrier. <MMM>

## Aclimatization Shock on Frontier Mars

By Peter Kokh



Mars as it looks, top – and as it feels, bottom:  
cold!

Mars is

### Being Honest About the Cold

From MMM #103 March '97 "Tempering Enthusiasm for Mars as The Next Human Frontier with Personal Honesty"

"A cherished dream dies hard. We have known for a couple of decades now, that the real Mars is a much colder, drier, thinner-aired world than the one we used to dream of colonizing, than the Mars of Lowell and Clarke and Heinlein and Bradbury, the Barsoom of Burroughs.

"We had ourselves prepared for thinner air, say that of Earth's high mountain plains 20,000 feet up. Alas, Mars' air is more comparable in pressure to Earth's at 125,000 feet, more than four times the height of Everest. We had ourselves braced for cool Martian summer days in the 60's (F) and winter nights perhaps the same number of degrees below zero (F). But Viking meteorological stations showed a year in, year out pattern much much more bone-chillingly cold than that. Mars has no Florida.

"We still don't quite believe it. For the cold is "invisible" – there is no surface ice or snow – away from the polar regions – to give us a clue. We look at the Arizonesque scenery and we expect Arizonesque temperatures. Mars looks seductively tolerable."

### Who will find Mars inviting enough to pioneer?

Most of us can put up with dismal conditions for a while, if we know that things will change in the foreseeable future. Those who by birth or by life-style decision live in sunny warm climates still must experience periods of unusual storminess, drought with fire hazard, etc. But those who live in colder snowbelt areas are somewhat hardened to seasonal changes, and many "join what they cannot beat" and learn to love winter. We northerners have to bear up under occasional blizzards and with frequent sunless cloudy periods sometimes two weeks long. Those with an internal sun flooding their lives with sunshine regardless of the weather, do best. But for all of us, we know that dismal conditions will sooner or later change for the better. Not on Mars!

### How we do the indoors is critical

How will pioneer Martian settlers cope? Spacious interiors lushly green with vegetation, and pools of sunshine-like over-illumination will work wonders on the soul. So these things are important. The longer we house ourselves in sardine cans, the sooner the settlement will catastrophically implode with general mental illness.

But will this be enough? The deceptive warm colors of the Martian landscapes hide an ice-blue reality. Even near the equator, only a handful of days will have highs well above

freezing (“shirtsleeve” temperatures will be exceptional) with 22+ Earth months to go before the next warmup.

Homestead design options which allow the pioneers to “bring the outside in, and the inside out will also help. Homestead attached “redhouse” gardening spaces will further psychologically buffer that invisible ice-blue bone-chilling, life-sucking cold.

### **Selecting the Pioneers for Mars-hardiness**

Volunteers from cold desert regions, even from arctic and subarctic tundra regions, will make for a significantly hardier stock of immigrants. Even so, the most arid desert is more lush with vegetation than Mars, and tundras are abloom with low-lying plants and flowers come spring. Spring will come to Mars only in terms of lighting conditions, astronomically, without signaling the awakening of life as it does on Earth.

Native-born Martians, even the first generation of them, will take the Mars climate for granted, even though they will be familiar enough, second hand through a video screen, that conditions on Earth are different. If the settlement is to survive, we absolutely must but childbirth on the fast track. If that means that women recruits board the ship to Mars pregnant, then we must do so and all considerations of caution become trivial.

There will always be fresh immigrants to Mars, but the quicker we can reach that state where the Earth-born fraction of the settlement population is a minority, the more assured we can be that settlement on Mars will truly “take.” If, out of timidity, or moral pretense, we defer childbirth, then all we will succeed in doing is building a ghost town. As strange as it may seem at first impression, only Martians can truly settle Mars. The rest of us Earthlings can only make a pathetic attempt. None of us will have the right stuff. Only native-born Martians will truly have what it takes.

If this attitude sinks in, we have a chance. Human civilization will have taken root on Mars. <MMM>

## **Mascots on Moon & Mars – “Pixel”**

**A stray cat finds its way to the Mars Desert Research Station and stirs up a firestorm!**

By Peter Kokh



**Editor’s Opinion Piece:** Pet lovers and non-pet lovers cannot see each other’s viewpoint. It’s as if we are two kinds of human, or, as we animal lovers think, human and not-quite human. **Fact:** Humans evolved side by side with animals. Bones of domesticated wolves and dogs have been found in the relics of campsites dating back 100,000 years. In comparison, cats seem to have been domesticated by the Egyptians just 6,000 years ago. The upshot is that wolves became dogs as our ancestors became fully human, together, in each others’ presence, possibly with results that could not have been achieved separately. In that light,

non-animal lovers would seem to suffer from some kind of deficiency, perhaps via lack of reinforcing experiences. Sorry if I offend non-animal loving readers, but this is a subject on which I prefer not to pull my punches.

In "The Greening of Mars" Lynn Margulis and James Lovelock allow no place on Mars for animals. They give their reasons, but not reasons at all, only challenges to be overcome. The case histories of the mental health of both children and seniors who do or do not have animals in their lives are quite telling. Mars without animals will be a people colony, but not a human one. If Earth were ever to be destroyed and only an animal-free Mars survive, the humanity of humankind will have perished. - PK

### The MDRS Email Salvo



Per Robert Zubrin's direction, the cat is NOT to be returned to the Hab because it is not in sim [can't wear a spacesuit]. We have to add more traps and poison (unless someone has a better idea). I'll see if I can come up with more sticky traps. -Tony

Muscattello, MDRS Program Manager



Pixel seems have to become THE Mascot of MDRS. The very odor of the cat may ward off rodents wishing to board MDRS. [snip] The cat is good for repelling rodents, and "damned good" for Crew Morale. Methinks kitty gets hungry enough, the ancient instincts kick in and putty-tat goes and kills a mouse to eat. No chemicals, just old fashioned hunting. [snip]

- Peter Gray



This is an ongoing discussion and some progress has been made but not finalized. I'm a cat lover.

- Maggie Zubrin, Mars Society Executive Director

[The editor does not want to give the impression that Dr. Zubrin is an animal hater. Maggie has horses kept at another property, and I have seen a photo of Robert obviously beaming, watching his daughter Rachel ride one of the horses. Rather, this is a debate on how animals can fit in, given the starting presumption that they don't.]

### Previous treatment of this subject in MMM

MMM #8 Sep. '87 "Animal Life in Settlement Biospheres" followed by "Colonists' Animal Life Quiz" -

both online at: <http://www.asi.org/6/9/3/2/008/animal-life.html>

We do not want to butt in on deliberations About an Animal Policy for MDRS. We might have to humbly retreat when we deploy a Lunar Analog Station! However, we must make these observations: The Mars Society could announce that only those non-allergic to pet hair and dander need apply for crew assignments, and then keep the cat (and any future successors.) Or animals can be summarily banned.

Now that won't work, because MDRS has long been infested with mice and occasional desert rats. The many openings in the hull make it all too easy to enter. So there will always be exposure to animal hair and dander. And the odor of Pixel may remain for some time.

The Mars Society can either live with this reality or choose to do something effective about it. That does not simply mean eradicating the present rodent population from their many hiding places. It means, first of all, denying access. Otherwise they will simply return. In that light, "a cat out of sim" doesn't seem that bad. Morale wise, it can be a big boost for those crew members who have left beloved dogs or cats at home to come here.

**Space group integrates animals into their vision** [www.calgaryspaceworkers.com/animalsinspace.html](http://www.calgaryspaceworkers.com/animalsinspace.html)

"Part of the Calgary Space Workers agenda is to demonstrate the subsistence and human-animal interaction needs in a lunar habitat analog situation. Lynn Gustafson, owner of a beautifully-run zoo just north of Calgary hosts some animals that might be expected to find a place in humanized outer space. Human interaction with animals in space is also

therapeutic and therefore some desired animals may not be subsistence related. It is important to realize that it is easier to take a dozen eggs to space, have them hatch and then have the hatchlings mature and lay eggs and so on to produce both the chicken and the eggs for subsistence purposes. This is called "bootstrapping" and is like using computers in the manufacturing of more advanced computers. "Humans are more relaxed and enjoy the company of animals as animals are not as susceptible to the stresses of daily activities."

### **A Mascot on real Crewed Mars Missions?**

Dog, cat, or something else? A pet that interacts with humans would be best, with dogs better at that than cats, but requiring more care. Any animal would boost morale, worth any inconvenience!

## **Killing Time Productively on the Way to Mars and on the Return to Earth**

By Peter Kokh

**Background:** Apollo astronauts complained about the long boring 3 day trips from Earth to the Moon and then again on the way home.

We wrote about the problem back in November, 1989. "Wanted" MMM #30, republished above

### **WANTED: Split personality types for Mars Expedition**

Besides being willing and able to leave Earth, family, and friends behind for three years or more, must for the trip out and back, have a high tolerance for sensory deprivation and thrive on boring routine tasks; and, at the same time, for the period spent on the surface, must be thrill- and challenge - positive, keenly attuned to external situations with all their unpredictability. If you are such a Jekyll-Hyde combination, please send your resume to:

- Mars Expedition Personnel Office, Mars Training Camp, Spitsbergen Island, Svalbard

### **Continued:**

"For as long as the era of chemical rockets lasts, interplanetary journeys to Mars or the asteroids, will be long tedious affairs that will be very trying for the kind of people ideally suited for the kind of life that awaits them at their destinations.

"This presents us with a choice. We can either look for persons with such chimeric personality combinations as suggested above who will perform reasonably well under such diametrically opposite circumstances, or we can start now to plan ways to structure the times of transit to better fit the personality traits of those best cut out for the exploratory and/or rugged pioneer life on the untamed worlds of their destination".

"First, we must recognize that the trip out and the trip home are radically different in the deep psychological challenges they present. Outbound, the crew will be filled with anticipation. Homebound, they may experience both anticlimactic letdown and an impatience to get back home."

## **Suggestions from this Earlier Article**

### **Outbound Leg**

- Equipment Assembly: Items manufactured on Earth for use on the Martian surface, after all parts had been tested and checked individually and in verifying assembly, could, if they would travel more compactly unassembled, be disassembled for the trip out.

En route, they would be put together in a Big Dumb Volume inflatable module, launched uninflated and compacted. Ultra-critical equipment can be shipped preassembled, with less sensitive equipment and backup equipment shipped "knocked-down" (KD) for assembly en route.

The assembled equipment would have to fit into the fixed volume part of the landing craft. This limits this option to compact objects and compact subassemblies.



Is this “make work?” I would not be so quick to dismiss the idea so casually.

### Return From Mars Leg

- **Preliminary chemical & physical analysis of samples** being returned to Earth, along with some building materials processing experiments. Surface samples could be separated into two quota portions, those held safe and untouched for labs on Earth/LEO, and those on which preliminary analysis and experimentation can proceed en route. Trained geologists, mineralogists, chemists, micro-biologists exobiologists and other scientists will be essential to the crew.
- **Debriefings and reports**, while experiences are fresh, can be followed by round table discussions of how the success of a follow-up mission could be best enhanced (new equipment, added tools, improved lab facilities, more comfortable housing, more ample life support, better fresh food growth chambers, greater menu diversity, etc.; better training; additional talents to be represented in the crew mix, etc.) Sensory and other impressions can be set to canvas or disk by those on board of artistic, poetic, or philosophical bent.
- **EVA Sports:**

To NASA’s abject horror, no doubt, there is a very real opportunity for totally new tethered-EVA sports outside rotating structures. By shortening a tether to the hub, one would advance on the structure. Conversely, by paying the tether out, one would fall behind – simple conservation of angular momentum.

Using such maneuvers in tag matches might be risky, but rally-type events in which one faced the clock, one at a time, to land first on a forward perch or tag ring, then on one to the rear, before returning ‘home’, all by manipulating the effective length of the tether, could provide healthy, adrenalin-racing sport. This could be welcome stuff to a crew chosen to be optimally tuned to the pace of activity of the Mars surface part of the expedition.

Sports Media coverage of such “Space Games” might draw big audiences and could work to get across the idea that we can, if we but try, make ourselves at home in Space! Of course, there will be the critics who decry money spent on making such options possible. Providing the necessary equipment by Private Enterprise sponsors would cut that drivel talk short.

When such sport is embraced, either on the sly or with reluctant official consent, we’ll have come a long way towards making the space lanes home. We recommend it for the way back. That way, should an injury or mishap occur, the ground mission on Mars will not be compromised.



“Dangle-Jectory” Rallye: From A to B to C to A

(The above illustration presupposed a three-armed rotating structure, should three craft travel to Mars together, not necessarily the likely option.)

### What else can keep our Martian Explorers productively busy on long trips out and back?

- **Continuing education courses**, in their line of expertise or outside it, to develop other talents & interests, whether helpful only on Mars, only on Earth, or both
- **Observations & measurements** of the solar wind and other astronomical objects and phenomena even if these observations could either be done just as well from LEO, or if not, by robot probes.
- **Data mining & digesting latest robotic feed news.** It is a sad commonplace that budget pressures have forced NASA to prematurely halt data analysis from various missions leaving potential discoveries undiscovered.

**Outbound only:**

- **Backup Expertise Training:** Learn as much as possible about each other's areas of expertise to provide talent redundancy should a crew member be injured or sidelined in any way.
- **Self-schooling** in useful areas of talent and expertise not represented in any of the selected crew members

**Return bound only:**

- **Expressing their recent experiences** and fresh memories in painting, poetry, essays, song
- **Comparing notes** as the individual crew members each wean themselves from preoccupation with Mars and begin to focus on homecoming events and their anticlimactic afterlife on terra firma. Many of the Apollo astronauts experienced "anticlimax" effects. After all, being on Mars (or the Moon) is a hard act to follow!
- **Webcasts & podcasts** to students on Earth about various aspects of the just completed mission. (The Interplanetary Internet [InterPlaNet (IPN)] will be in place in 2008.) These broadcasts won't be truly interactive until the crew is much closer to Earth. Even at a mere million miles out, the round-trip signal lag will be about 11 seconds. Prior simulations could suggest at what distance live conversations can effectively be maintained. This would be a near zero-budget chapter experiment. We suggested this in MMM #131. "The COLLOQUIPAUSE: end of conversational space" (republished in MMMC #14)

**Recommendations: inflatable "elbow room"**

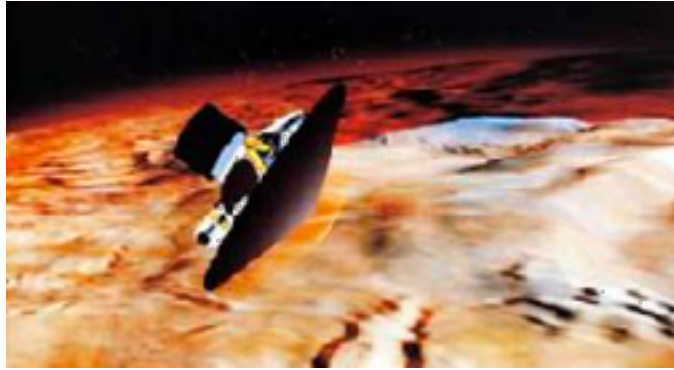
Provision of inflatable "elbow room" space on both legs is vital for morale and proper exercise. Simply designing in space that would make it possible to take "a walk" would be of immense benefit. Whether for exercise, to "cool off" tension or rising anger, or for "constitutional" purposes does not matter.

But space for individual exercise and perhaps for small team sports would really top it off. Health is essential not just for morale, but for productivity once the crew arrives on Mars.

If the return crew ship is different from the Mars crew lander, the inflatable module for the outbound trip could be designed to be easily deflated, compacted, and stored for entry through the atmosphere to landing on the surface of Mars. It could then be removed from the lander and transferred to the homebound ship. Or both craft could have their own built in detachable inflatables.

Our scouts, no matter how exemplary cases of the "right stuff" they may be, cannot be expected to bear up in cramped conditions for many months at a time, either outbound or return-bound, without severe strains on interpersonal relations that could adversely affect the mission's success, and without suffering from low morale and depression. Unless we are going to put them to sleep for the duration, an old science fiction trick that we are not able to pull off at the present time.

It's not a simple proposition, however; at least, not if artificial gravity is to be provided at the end of a rotating tether with cargo etc. at the opposite end. In this case, the inflatable structure must be in line with the tether so as not to displace the crew module proper off center. The inflatable could be bottom-mounted, side surrounding, or top-mounted. If an aerobrake shield is used for Earth atmosphere reentry, the inflatable could be in the form of a torus that sits on the rim of the shield as already suggested. An aerobrake is illustrated below.



[http://www.spacephotos.com/catalog/images/detail\\_phototheque/S00308.JPG](http://www.spacephotos.com/catalog/images/detail_phototheque/S00308.JPG) – credit

A torus structure, while it is more difficult to construct, could be ideal, providing a walking/running track. It could be top-mounted with the tether through the donut hole, bottom mounted around the fuel tanks and just above the edge of the aerobrake shield as in suggestion (c) above, or simply surround the crew module in the ‘donut hole.’ (suggestion (a) above. All of these options will require design and engineering ingenuity. We have the “right stuff” to do that, don’t we?

Yes there would be a weight penalty. But I posit that we will owe our returning heroes this morale-boosting “luxury.” They will already have deprived themselves of too much for too long.

#### **Recommendations: Artificial gravity**

On the way out, artificial gravity is essential. Our scouts must be in tip top physical shape on arriving on Mars, without having to rest up for a while, wasting a few weeks. The gravity level should be 3/8ths earth normal, the gravity level of Mars.

On the way back, an initial Mars level gravity should be increased gradually to full Earth normal over the months of the return, to put them in tip top shape when they next set foot on Earth after an absence of as much as three years. <MMM>

## **Terraforming Resources for Mars Rejuvenating Mars Might be both easier and more troublesome than we had dared imagined**

By Peter Kokh

**Source:** This Week in SCIENCE, Volume 315, Issue 5811  
[www.sciencemag.org/content/vol315/issue5811/twis.dtl](http://www.sciencemag.org/content/vol315/issue5811/twis.dtl)

The bulk of Mars original generous atmosphere and water, may not have “escaped” into space.  
**The New Good News**

We have realized for some time now, that early in its history, **Mars was once wetter and warmer, and possessed a denser atmosphere than it has today.** It was natural to assume that this early thicker atmosphere, being constantly battered by the solar wind and held in place by Mars lighter gravity, evaporated into space.

However, Barabash et al. (p. 501) (report dated January 26, 2007) find that the escape rate today for gases in the martian atmosphere is very low, based on measurements from the orbiting Mars Express spacecraft. Propagating these rates backward over a period of 3.5 Gy would result in the removal of 0.2 to 4 mbar of CO<sub>2</sub> and a few centimeters of water. Rather than having left the planet, CO<sub>2</sub> and water could instead be locked away beneath its surface.

## Implications for “terraforming” rejuvenating Mars

The early “easy” climate improvement projects still seem the right way to start. Dust the polar caps with carbon soot, derived from the atmosphere itself, to decrease the planet’s albedo (sunlight rejection capacity) and heat the polar water ice/carbon dioxide ice caps to free the carbon dioxide. This just makes permanent a process that happens at each pole each summer. Frozen CO<sub>2</sub> evaporates but only to refreeze over the opposite (winter) pole. By using the carbon soot dusting technique, we will prevent refreezing and thus permanently increase the global atmospheric pressure, which in turn will moderately warm the planet, again, on a global permanent basis.

Now we know that we do not need to follow this initial improvement up with a period perhaps centuries long in which water-rich comet chunks would be redirected to impact the Martian surface. That would be a risky proposition, not only increasing seismic activities, but bearing the risk that an errant ice payload might take out a key settlement!

We can skip all that! A favorite of science fiction from Edgar Rice Burroughs John Carter on Mars series right through the ghoulish film “Total Recall” is the “atmosphere plant” which takes martian soil in and spits volatile gasses out.

1. We almost certainly have enough CO<sub>2</sub> locked in the Martian rocks that can be released through heating by solar concentrators, whole farms of them! This process would be slow and gradual, at a pace at which increasingly more Mars-hardy breeds of redhouse-raised plants could sooner than expected survive on their own outdoors.
2. Most of Mars water could be preserved in aquifers, some of which might be deep enough (as on Earth, Mars crust is likelier to get warmer with depth) to have remained permanently liquid. That means that once the atmospheric pressure and temperature were great enough to support liquid water, underground reservoirs could be pumped up to surface basins. The deepest basin on Mars, where the air pressure will always be highest, is not in Valles Marineris, nor in the suspected northern ocean basin, but in Hellas. Hellas is one feature that has survived from pre-orbiter mapping to the present day. Called a planitia (rather misleading) it is the deepest and largest impact basin on Mars, and unlike similar basins on the Moon, not subsequently (post-impact) filled with layers of lava sheets.

## The Good, Bad, & Ugly of Accelerated Climate Change

If the new calculations and findings hold up under scrutiny, and if future deep drilling confirms extensive and voluminous subsurface water aquifers, Mars could become a much friendlier place within the first century of the onset of a determined settlement effort.

### Sloppy Mars

But forget about the progression “**Red Mars, Green Mars, Blue Mars.**” First of all, Mars will get greener and bluer at the same time. More unwelcome is the news that **Muddy Mars** will come first.

With the onset of natural or chemical-induced precipitation (rain and snow), Mars’ unfixed soils will be subject to substantial erosion, without vegetation ground cover which can only now first begin. It will take some time before vegetation starts to win battles with erosion.

### Redhousing, now, to the rescue

The sooner settlers, following the lead and improving on the work of those terrestrial fans of Martian settlement who abandon the comfort of cheering from the of their demotivating sofas and roll up their sleeves and get their fingernails dirty by attempting to take arid-zone hardy terrestrial plants and breed them into ever more Mars-hardy strains via “redhousing.” the sooner we will get a handle on the mud.

We need to have a diverse variety of fully Mars-hardened plant varieties ready to plant as the first rains start to fall – if we are going to win the battle with mud and erosion. [Check the article “Redhousing” in MMM #93 March ‘96, republished in MMM Classic #10]

### The Upshot: Mars in shirtsleeves? Not quite

Sooner than expected, Mars could become a much more benign, and attractive world than it is now. This requires both industrial projects like atmosphere plants and deep aquifer tapping, but also horticultural projects, breeding the plants that can thrive on the new “young again” Mars.

But this new Mars will not let settlers go outdoors with the same minimum of protection we are used to wearing. The atmosphere will be thicker, but still mountaintop-thin by our standards. UV dangers will be high. We may need light pressure suits and oxygen masks, and more than “sunscreen lotion” protection from UV. That said, the new Martians will begin to develop an abundance of outside sports, sporting, and recreational activities. And the climate will still be cold by Earth standards, with doubly long seasons. But in this born again Mars, the settlers will begin to truly thrive. Our human exclave will become permanent.

<MMM>

## MMM Platform for Mars v. 2.0: Dare to Dare!

By Peter Kokh

### PART I – Basics

#### ● Getting Humans to Mars

No rocket, no matter how powerful or fast, can deliver humans safely to Mars without a **life support System weaned of frequent “umbilical cord” resupply of oxygen and water.** Preferable and to be prioritized are biological/agricultural/biospheric life support systems on which outpost expansion and future settlements can be based. Had we now all other equipment ready to go, humans could not go along. This need underscores the importance of testing such systems on the Moon where any test failure would not be catastrophic.

#### ● Atmosphere Mining: Methane, Oxygen, Water

Yes, this technology has been repeatedly demon-strated. But there has been little follow-through. We need to perfect methane or propane fueled generators. We do have methane and propane fueled vehicles. We should tweak these technologies for use on Mars. We also need to develop/demonstrate atmosphere-derived production of organic chemistry feedstocks for the production of plastics and many other useful products. Such industry would have an export market on the lunar frontier.

#### ● Inflationary Growth of Human Presence

Having crews return to Earth to be replaced by fresh crews is not an efficient plan for maximum growth. We must identify the architecture and systems needed in a first Habitat landed on Mars capable of indefinite occupation. We need to identify the set of perks necessary to encourage crew to remain on Mars indefinitely, so that with each new crew ad Hab, both the physical complex and the population grows. While this idea will meet with enormous ridicule and opposition, any other plan is doomed to failure, so become good social citizens in order to survive. Of course, that must be sooner rather than later. This “Option toe Stay” is the superior tactic for the Moon as well. This is so important that the Sydney Gambit should not be ruled out. Sydney, Australia was founded by British Convicts who were forced to voluntary!

### PART II – Filling in the Holes in an Economic Geography of Mars

[http://en.wikipedia.org/wiki/Economic\\_geography](http://en.wikipedia.org/wiki/Economic_geography)

“is the study of the location, distribution and spatial organization of economic activities across the **Earth.**” To this writer, that is not an adequate definition. Economic geography includes a set of maps which show where resources of economic significance are to be found. It also should identify geographic, geological, topographic features and other physical features of potential economic significance, including features that affect transportation routes (navigable waters, straights and passes, etc. In application to Earth, it also identifies population density, relative use of transportation routes, industrial concentrations and more. For Mars, as uninhabited we are concerned with potential features that will affect how a human frontier will expand globally,

as well as what choice of sites will optimize future expansion.

- **Mars Permafrost Explorer** — The opportunity to pretest such a probe in Earth orbit to improve our knowledge of terrestrial tundra resources, makes this an easy sell. While current orbiters can locate water ice very near the surface they cannot identify ice or liquid aquifers at the depth at which they are more likely to be found.

Once we have mapped these resources, ground truth probes which can drill down to identified reservoirs, and characterize the water resource as to salinity and other features are in order. Siting a first outpost without such a comprehensive study would be plain stupid.

- **Mars Lavatube Explorer** — We have already identified lavatube entrances on the flanks of Olympus Mons. Lava tubes of a scale larger than terrestrial ones but smaller than Lunar tubes are likely to pervade the great shield volcanoes on Mars as well as the entire Tharsis Uplift. The opportunity to pretest such a probe in Earth orbit to improve our knowledge of lava flow terrain, makes this a logical priority. We could re-fly such instruments around the Moon where tubes lie deeper below the surface. The results could be far less important for geology than for future Mars settlement scenario options. Ancient near-surface Martian limestone caves could also be identified. Meanwhile robotic mobile probes should be targeted to already identified tube openings.

- **A High Vertical Resolution Topographic Map of Mars**

With accurate elevations, a contour map of the entire planet potential watershed basins and their downward linkage, as well as basins that have no outlets. No sense in putting a settlement in a location that might someday be under water!

- **A global network of weather stations**

A better knowledge of area weather patterns through all seasons over several years would help crews and pioneers prepare for weather related eventualities.

- **A global seismic activity monitor station network**

There is no wisdom in continuing to assume that Mars is geological dead. We should also look for any “hot spots” that could be a source of geothermal energy. It serves no purpose to assume the answer is known when we could check.

- **Potential resources on Phobos & Deimos**

Russia’s probes Phobos 1 and Phobos II both failed to reach their target. Fortunately, Russia’s current **Phobos Grunt** (Phobos Soil) mission may give us some answers. Resources developed on one or both of these moonlets could not only help open the planet itself but provide valuable exports to the Lunar frontier, earning credits to be applied to purchase of badly needed equipment and supplies from Earth. This knowledge will be a cornerstone of any realistic “Economic Case for Mars.” Relying solely on handouts from Earth is a sure invitation to wholesale cessation of support.

We thought at one time that these moonlets were captured carbonaceous chondrite asteroids. Now we are not sure. If so, this would be a supply of hydrogen, carbon, and nitrogen high up the shoulder of Mars’ gravity well, that could routinely be shipped to the Moon. We need to know. Any attempt to bypass these moonlets in developing Mars, grounded solely on impatience, will bite us in the butt sooner or later. We need to know what resources are there so as to plan intelligently.

- **Outline of Mars Economic Geography topics:**

- Subsurface water / ice
- Iron, other metals
- Thorium & uranium
- Gold, silver, platinum, copper, zinc
- Cementitious/silica materials/salts
- Regolith/sand depth over fractured
- Bedrock/basalt
- Sedimentary areas, sediment depths

- Topographic clues to transportation corridors
  - gaps, passes for roads and railroads
  - aqueduct/canal/pipeline routes
  - future rivers / lakes
- Atmospheric pressure seasonal variations
  - Mons summits, Tharsis plateau
  - Boreal Basin bottom, Hellas, etc.
- Outgassing
- Geothermal areas
- Likely lavatube areas
- Tourist sites – historic & scenic sites
- Geological wonders

### **Part III – Needed Equipment**

The excuse that we don't need something right away, surely to be the mantra of those only interested in exploration of Mars and not interested in Mars as a future human frontier, if not entirely hostile to that prospect, is no excuse for those of us who do care, to leave it to NASA whose interest in developing equipment needed on a Mars Frontier is minimal and peripheral.

- **Mars Aviation** – NASA has indeed looked into small drone aircraft for use in exploration. We believe that flight on Mars is possible. But takeoff and landing from an equivalent altitude of 125,000 feet on Earth has not yet been demonstrated. If we are to rely on passenger & cargo aircraft to facilitate travel and trade on Mars, we should be thinking of how to develop the needed technological advances here on Earth.
- **Mars Railroads** – Railroads were essential to the opening of the American West, of Canada, Australia, and Siberia. It could be so on Mars. See RR articles this issue.
- **Solar Sail "Pipeline" Cargo Deliver Systems** – The descendants of Cosmos 2 provide the best option to bypassing the 25+ launch window intervals between Earth/Moon and Mars. In pipelines, how long it takes something to go from source to market is irrelevant as long as something is always entering the pipeline and something is always coming out the faucet at the end. This is a system vital to tapping asteroid resources as well. How can we help? Supporting the Planetary society Cosmos 2 Solar Sail project with donations is certainly one way, for those of us technically challenged!

### **Part IV Mars Analog Activities**

It was a deep honor, a great privilege, and a matter of pride to have served on two crews (# 34, #45) at the Mars Desert Research Station in Utah. I have great respect for the program and detractors have taken many cheap and unfounded shots out of ignorance and lack of first hand knowledge. But my enthusiasm did not blindfold me to the limitations, and failures, of this project.

The Mars Society was founded on the belief that Mars is the best location for a second basket in which to put human and Earth life eggs as a hedge against the possibility that human civilization could collapse on Earth, whether from a possible untimely asteroid impact, from human strife, or from total collapse through overpopulation and runaway exhaustion of resources.

All the same, these two stations, in Utah and on Canada's far north Devon Island, are totally designed to demonstrate Mars exploration tactics only. The vertical Hab standing above the Mars surface, fully exposed to temperatures that can range at the equator from just above freezing to lower than anything we have experienced in Antarctica. Such an architecture invites catastrophic collapse of any Mars exploration mission of anywhere from six months to up to two years. What is easiest to ship and land is not necessarily the easiest to maintain on Mars. Nor is the solitary Hab structure designed for expansion. What should be the demon-station goal of the project are technologies that make expansion towards a more comprehensive permanently manned outpost leading to real first settlement.

What is needed is not the phase out of this analog program, but a whole new start based on a whole new philosophy. Perhaps some of the design and research objectives under consideration for a proposed Lunar Analog Research Station will produce knowhow and experience useful on Mars.

### **Part V – Building an Economic Case for Mars**

“Mars First/Only proponents are fond of pointing out that Mars has a more complete set of resources on which to base a sustainable frontier. That is partially true.

Partially, because it will be a very long time before the Martian Frontier could sustain itself should all resupply and supply of things that the pioneers could not yet provide for themselves somehow cease whether from economic collapse on Earth or international weariness of supporting the young Martian frontier. To create “An Economic case for Mars” means identifying realistic potential export products to earn credits to pay for imports. Outside of potential but as yet uncertain exports of volatiles from Phobos and Deimos to the lunar frontier, we have not seen a single realistic export suggestion. Gems not found on Earth? Unlikely, and purely speculative. Medicinal plants that grow only in Mars Soil? Again pure speculation. Income from Earth tourists? Who but the rich terminally ill are going to take two or three years out of their lives for the round trip experience?

Partially, because three other resources, none of which Mars offers, are really hard to do without. We all know what they are: “**Location, location, location.**” The Moon has it, Mars does not. Like Japan which lacking steel, coal, and rubber, developed the entire Pacific rim for markets of raw materials and markets for exports created from these raw materials. The Moon, a handier source of materials for building out the human presence in LEO and GEO, and of capital goods for Phobos, Deimos, and even Mars, is poised to become the Japan of Space. Japan has proved that by far the most important resource is not physical at all. It is **resourcefulness.**

In a future in which both Lunar and Martian frontiers are expanding apace, there will be a trade economy between Earth, LEO, GEO, the Moon, and Mars in which a greater Mars, Mars PhD, will have a place as a supplier of goods to the Lunar Frontier that will earn them credits for purchasing equipment from Earth. Prevent the Lunar frontier out of blindness, and perish.

**It is in the Moon Society’s best interests,** and in the interests of all who want to see a health lunar frontier develop, **to help develop a strong Economic Case for Mars** – even if Mars enthusiasts don’t care to do it themselves, or scorn our help. The Moon and Mars will either thrive as trade partners or []=both whither on the vine.

### **Accessing the Asteroids**

Isn’t Mars closer to the asteroid belt? This point that has been made by science fiction writers from long before the Space Age began. It is both true and a curse. Why? Because of a catch 22 of celestial mechanics:

The closer two orbits are to one another in period, the less frequent the launch windows between them. And the corollary: the further apart two orbits are in period, the more frequent the launch windows between them.

This may look like a cruel trick, but we could not have solar systems without it. Mars’ greater proximity to the Belt, but this is actually a disadvantage that will make the Moon the preferred transportation “hub” of the asteroid belt.

Observatories on Mars or on Phobos or Deimos) can help identify and keep track of asteroids and astro-chunks that could threaten Earth. So that is one investment we ought to make.

So how do we build the Economic Case for Mars? It would be deceitful to say we have a plan. But we have outlined the starting point: **Promote completion of the Economic Geography of Mars:** A chemical and physical resource map will help us plan where first settlements should be located, and facilitate global expansion.

Shouldn’t a first outpost be sited near the places of most scientific interest? Yes if you are self-destructively impatient. In the end we will explore Mars much more thoroughly if we



have a permanent human frontier on Mars, than we will if we rely on hit and miss landers and rovers. Impatience always bites one in the butt.

We first gave a presentation on the need to build an Economic Case for Mars at ISDC 1994 in Toronto at the request of Chair Paul Swift. There was no response from the mostly pro-Mars audience. Nor do I expect more input from Mars fans to this new report. That's why we Moon-enthusiasts must take the lead. It is in our own best interests to do so. We do not now have the needed information. We have pointed out that a Mars alone (damn Phobos and Deimos) approach is doomed. We are trying to jump start brainstorming on potential Mars transportation infrastructures: aviation and railroads. We have tried to point out that the Mars Analog Research program is not optimized to produce the best results.

For now, the most helpful thing we can do to ensure that the Mars Frontier gets off to a good start is to keep on working on the Economic Case for the Moon. The lunar frontier will be a cheaper source, once capital costs are amortized, of goods for Mars, as well as the best source of field-tested hardened pioneers, for whom, Mars will be "a walk in the park." <MMM>

**MMM has a Mars-dedicated issue of Moon Miners' Manifesto every March!**

**Why? Because it is our firm belief that both a Lunar frontier and a Martian frontier will have a better chance at Economic Viability as trading partners than either could have on its own. PK**

**MMM #223 - MAR 2009**

## **"Moon or Mars" is the Enemy of Both**

Guest Editorial By Shaun Moss, Melbourne, Victoria, Australia

Both the Moon and Mars have important advantages, which is why I've always advocated colonization of both. They both far surpass any other known destinations followed by Earth orbit, NEA's, Mars's moons, Mars orbit and the main asteroid belt.)

### **The Moon**

- The Moon has abundant natural resources that can improve the quality of life on Earth, including helium-3 (fusion energy), and engineering metals such as titanium, aluminum and magnesium (spacecraft, computer and robotics components).
- It's one of the most interesting destinations in the entire Solar System scientifically, since information about the formation of the Solar System is better preserved on the Moon than any other location.
- It's an arena of activity that can unite the people of Earth, being a highly visible and beautiful shared resource. The Moon is the future international space **station**.
- Due to its low gravity well, the Moon is an excellent launch pad for robotic and crewed exploration of the Solar System.
- The far side is an excellent location for both optical and radio astronomy, e.g. searching for extrasolar terrestrial planets/extraterrestrial intelligence, being shielded from the radio noise of Earth. The VLBI and OLBI telescopes we can and will build on the lunar far side will utterly dwarf the capabilities of Hubble, Kepler or any other orbital telescope.
- It is an excellent tourist destination, being relatively close to Earth and having the potential for many fun low-g sports, plus the Solar System's best view of Earth.
- Being close to the Sun and not having an atmosphere or magnetosphere, it provides one of the best ground-based locations in the Solar System for solar energy production, second only to Mercury.
- Being also cold, dry and dusty, the Moon is a suitable location for testing Mars exploration and colonization technologies before transporting them to Mars.

I find it astonishing that anyone could consider that we have "been there and done that" with regards to the Moon. The Moon has a surface area equal to Africa and Australia together (30.93+/-0.01 million km<sup>2</sup>). If 12 people visited various locations in Africa and Australia, would we think that we had seen all of both? Or that Africa and Australia had nothing left to teach us?

Do people really think the Moon is that dull? I think people forget that humans are smaller than microbes on ants when compared to planetary bodies. I will bet you stars to asteroids that in 1000 years, when the lunar population is in its millions, we will still be learning things from and about the Moon.

### **Mars**

- Mars is expected to have undergone much the same types of geological processes as Earth, thus it is expected that concentrated deposits of metals can be found there using similar techniques and technologies. Furthermore, these can be discovered and accessed more easily due to the absence of trees, oceans, and human settlements. Metal is wealth.
- Mars has all the elements necessary for DNA-based life and may indeed currently harbor DNA-based organisms (e.g. methanogenic chemotropic cryohalophiles).
- Mars is comparatively close to Earth (only the Moon, Venus and NEA's are closer).
- Mars has a diurnal cycle of 24 hours and 40 minutes, almost exactly equal to Earth's, which means that Earthly organisms, including humans, should be able to adapt relatively easily to Mars.
- Mars has an axial tilt almost equal to Earth's, which, combined with the presence of water, results in familiar patterns of seasons, climate, clouds and weather. These will also help many Earthly organisms to adapt.
- Mars is the only Solar System body other than Earth with a tangible yet translucent atmosphere (i.e. you can see the planetary surface from space).
- Mars's similarity to Earth captures human imagination, having a colorful sky, clouds, weather, fascinating geological formations and excellent views. It is easier to imagine (and actually build) human settlements on Mars than any known extraterrestrial world.
- Mars has more potential as a second home for humanity than any other known astronomical body. Colonizing a 2nd planet is essential for the guaranteed long-term survival of the human species because ELE-scale asteroid impacts, while infrequent, do happen.
- Mars is an excellent location from which to launch an asteroid mining industry, being closer to the majority of the Solar System's asteroids and having a much lower gravity well.
- Mars is also an awesome tourist destination, offering endless possibilities for hiking, climbing, exploration and low-g sports.
- It is widely believed that Mars can be terraformed, or in other words, engineered to support an uncontained biosphere. This means Mars may eventually support ecosystems that grow and evolve with no or minimal technological assistance. Mars may therefore eventually support billions of humans and other organisms. We know of no other extraterrestrial world with that kind of potential.
- Mars is a place where we can create a largely legacy-free society, without all the corruption, baggage and ugliness of Earth culture. On Mars we can introduce the very best economic, political and environmental strategies, beginning, as we can, with a whole-planet perspective.

Given that both the Moon and Mars are highly desirable targets, why bicker constantly about which deserves more attention? Send humans to the Moon first to test technologies for Mars, then send them to Mars. Then develop both in parallel, while supporting private enterprise as much as possible so that the expansion becomes economically feasible and self-sustaining. The result will be nothing less than world peace on 3 worlds. **SM**

**“Mars: The Audacity to Stay”**

By Peter Kokh [kokhmmm@aol.com](mailto:kokhmmm@aol.com)

“All the scenarios currently being floated aim at a one-time scientific orgasm of activity -- and then we come home, probably never to return, once the public thrill with early results begins to wear thin.

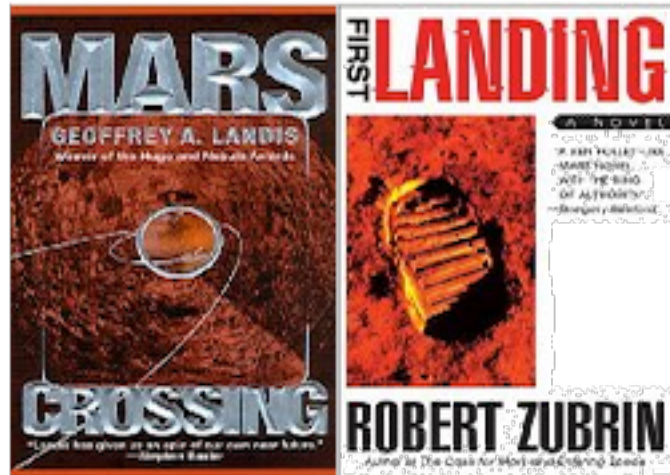
“It goes without saying that all these people doing the careful planning will want to return to set up a permanent base. But once it finally sinks into the mass consciousness that even Antarctica is a friendlier place, political support will vanish and funding will disappear, unless ...

“Unless we plan the very first Mars expedition with a built-in OPTION TO STAY.”

– From “Mars: Option to Stay,” by Peter Kokh, MMM #19, October 1988, pp. 3–5

It is now 20 plus years later, and nothing in the prospects cited above has changed, including the blindness of most Mars activists who think an Apollo-like Mars program will actually lead somewhere other than to the dusty pages of old history books.

However, in the meantime three other voices in favor of a revolutionary bold “let’s just do it (settle Mars) approach have joined in. First was **Geoffrey A. Landis** in his 2001 novel **Mars Crossing**; then **Bob Zubrin** himself in his 2002 novel **First Landing**.



In both these novels, some of the first explorers end up refusing to return to Earth. Now Buzz Aldrin has made a strong statement in favor of the only decision that makes long-term sense.

<http://www.universetoday.com/2008/10/23/aldrin-mars-pioneers-should-not-return-to-earth/>

“The first explorers of the Red Planet should stay there. Following similar lines of the first European pioneers who settled in America, a small group of interplanetary explorers should expect to land, build, live and retire (probably even die) on Mars.”

{Quote from the article, not necessarily Buzz Aldrin’s exact words.}

Obviously, this is not the usual cautious “toe in the water” approach of NASA, and talk like this must either horrify the agency or be dismissed with ridicule. But anyone who thinks that while it failed on the Moon, a “Flags and Footprints” approach to Mars will really lead somewhere, is the fool, not Aldrin, not Zubrin, not Landis, and going back two decades, not this writer.

### Rationale for the one step at a time approach

The standard approach allows us to

- (1) Concentrate on transportation technology, and
- (2) Give minimum attention to the much more demanding requirements
  - (a) Long-term life support,
  - (b) Outpost agriculture and food production

(c) Processing local soils to produce local building and manufacturing materials.

We've said many times that "the rocket scientists can get us there, but it will take a lot of other expertise to allow us to stay, and frankly, those needs are not NASA's area of expertise.

But we can't really fault the agency. What the agency is, and its in-house talents are a reflection of the vision, or lack of it, of US Administrations and Congress. Given that, is it realistic to believe even for a moment that some other approach is possible? No!

That is, it is not realistic unless we stop pinning all our hopes and dreams on the shallow intelligence and timid vision of elected politicians.

Yes, in the past, the establishment of some frontiers was a national policy of some nations. Yet other frontiers were established by mass movements of many individuals who were motivated to take things into their own hands in an effort to find and establish a better world for themselves and their families.

We've said it before: Those who were doing well-enough in Europe stayed there. It was those with talent and drive and ambition, but with little opportunity to advance "at home" who left to found and develop new frontiers. The same thing is true in the animal kingdom. Males frozen out of leadership moved out to claim new turf. And the process continues. In the 1800s, those who were comfortable in Boston and Baltimore (nothing personal!) stayed there. Others with talent but finding all positions at the top taken, settled the west.

I've called this the 11<sup>th</sup> Beatitude: "**Blessed are the second best!**"

The point is clear, establishing new frontiers is something that the people who would do so, must take ownership of, counting only on themselves. If they can get governments to help them "partway" all the better.

Establishment of a Mars frontier, one on the Moon too, may have to be by revolt: refusal to return home. Of course, agencies will try to weed out candidates suspected of harboring such nonsense attitudes. But it will happen anyway. And that is what I loved about Bob Zubrin's novel especially. Two people took the leap and made the decision to stay behind, no matter how great the odds were that their effort would fail and they would die a lonely and premature death, "for nothing!"

### **It's all about preparation**

Clearly, any group intending to stay behind on Mars and actually survive and thrive, must, in concert with sympathizers and supporters on Earth with no intention to join the movement themselves, must do a lot of preparation! This will include robotic exploration, getting NASA, ESA, ISRO, JAXA, Roscosmos, and China to send probes that will:

- (1) Thoroughly map all the key resources of Mars at very high resolution
- (2) Produce an altimetry map of high resolution both vertically and horizontally
- (3) Map unseen water reserves
- (4) Explore known lavatube entrances

These are all things of great interest to scientists who only want to understand Mars, and who could care less about Mars ever becoming a second homeworld for humans. It is thus reasonable to believe that we could get this part of the needed homework done for us, by the established space agencies and space-faring nations.

### **Learning to use Mars' resources**

Now comes the hard part. This is the sort of stuff NASA talks about for the Moon, but won't do anything about, because it is not part of the Agency's current mandate. We who want to go or who want to make it possible for others to go, need to see to it that this kind of research gets done.

### **Atmosphere mining**

Thanks to Bob Zubrin, we know how to produce methane, for use as rocket fuel, from the Martian atmosphere. But if we are going to stay, we need to be able to mine the carbon, oxygen, and nitrogen rich atmosphere to produce many more substances than methane.

Propane is another useful fuel, and a step up from methane. Ethylene is a feedstock for plastics. Atmosphere mining can be the basis of a Martian equivalent of our terrestrial petrochemicals industry. Oil, of course, includes a greater list of elements to start with, as does coal. The point is that Mars air is a resource lacking on the Moon, and any prospective settlers who go to Mars unprepared to hit the ground running with a developed atmosphere mining byproducts industry deserves to fail.

We need to know not only what we can make out of Mars Air, but also how we can do so. That means experimentation in the lab, and verification with production-type processing demonstrations.

### **Building Materials – nonmetallic**

We should have no trouble finding raw material suitable for making ceramics, glass and glass fibers, and glass composites, as well as concrete. What we do not know at present is where the best feedstock material for each of the above is to be found. And if it is not to be found in the form upon which we base our terrestrial industries, we need to experimentation to find alternate paths, and develop those to the point where we can design production plants ready to start turning out product one they arrive on Mars.

Our concrete industry is based on limestone, calcium carbonate, layers of which are made from fossil seashells. We would be astounded and flabbergasted to find such handy deposit on Mars – there are none on the Moon – so we have to be ready to make cement from other sources of calcium and carbon.

### **Building Materials – metallic**

Mars should be abundantly endowed with the four principal engineering metals: iron, aluminum, magnesium, and titanium, as is the Moon's crust and regolith blanket of pulverized rock powder. But in contrast with the Moon, Mars may have reasonably abundant copper and other strategic alloying materials in which the Moon seems to be deficient. We need to determine before our arrival where the richest or most workable deposits of each are to be found. And if the metal-bearing ores are different from those we rely on here, then we must predevelop the processes and the equipment to produce these metals on Mars.

### **Building materials – organic**

We will find no forests of any kind on Mars, but there is no reason that we cannot plant them in suitably pressurized greenhouses. We will want to concentrate on fast-growing species like bamboo and cottonwood. – <http://www.fast-growing-trees.com/FastestTrees.htm>

We are currently exploring many new ways to use bamboo, and we could do the same with other very Fast growing trees.

We could experiment with all sorts of waste biomass products. This is something that would not be suitable on the Moon, where the constitutive elements of carbon, hydrogen, and nitrogen are so rare that we will need to plow all waste biomass back into the biosphere.

On Mars we can afford to splurge. That said, the Martian settlers would have to be careful. When we have a fire we can open a window and let out the smoke, on Mars as on the Moon, opening a window will not be an option, so we cannot “allow” fires to happen in the first place, and that will mean many strict protocols on how we use and store combustible organic products.

### **Who is working on what?**

The Mars Society seems to be concentrating on pushing a series of manned exploratory missions, and not at all concerned with how we might set ourselves up to stay. On the other hand, the spin-off **Mars Homestead Project™** of the **Mars Foundation™** is doing just that. So if you support the “Mars to Stay” vision you may want to support this group. – <http://www.marshome.org/>

### **Mars Homestead Project Research Goals**

<http://www.marshome.org/research.php>

1. Create a unified planning document with requirements for the first permanent settlement on Mars.

- Identify core facility, mining, manufacturing, agricultural, and other technologies needed.
  - Determine how relevant terrestrial research can be conducted to advance these technologies.
  - Determine schedules for terrestrial research
2. Conduct research into core technologies and methodologies with terrestrial facilities
    - Determine best methods to utilize materials & resources on Mars
    - Create prototype terrestrial-based hardware to demonstrate utilization techniques
    - Build analog terrestrial facilities to finalize Mars settlement-building techniques and test operations
  3. Establish key commercial and financial interests to support a Mars settlement.
    - Emphasis is placed on Mars resource utilization and manufacturing to reduce transportation requirements and cost.
    - Partner with other organizations (commercial & non-profit) whose goals align with permanent settlement design.
    - Develop a framework for coordinating activities that are in the common interest of perspective private, commercial, and public involved parties.
  4. Generate a detailed plan for launching & building the settlement on Mars
    - Not tied to specific hardware
    - Determine methods to deliver cargo and crew for an initial permanent settlement of 12 crew members.
    - Settlement would possess an integrated manufacturing capability
    - Settlement would possess capability to seed other settlements
  5. Assist with the exploration of Mars with a focus on permanent settlement enablers
    - Survey Mars for underground water & mineral sources
    - Gather data to determine adequate locations o permanent settlements

#### **Analysis of the Mars Homestead Project effort**

I am not sure that an initial complement of twelve is quite a “critical mass” – two or three times that number would be a more promising start – but in general the Mars Homestead Project™ is on the right track and I have personally lent my support.

Some, certainly not all, of their research will apply to our efforts to open a real civilian industrial frontier on the Moon as well, and sooner, not later.

There are many, perhaps an overwhelming majority ready to concede that a long period of cautious exploration will come first. And that is the hurdle we face. Perhaps the majority of Moon and Mars frontier supporters are overly conservative, won over by the “Oh, we can’t do that!” experts. It is the can-do people to which we must listen. That is not the same as ignoring the obstacles and difficulties and hurdles of all kinds. It is about finding ways to surmount them and do it anyway.

**“First tell me all the reasons why this can’t be done.  
Then tell me how we are going to do it anyway!”**

#### **Excerpts from Mars: Option to Stay**

(article cited at the beginning of this essay);

“All the scenarios currently being floated aim at a one-time scientific orgasm of activity -- and then we come home, probably never to return, once the public thrill with early results begins to wear thin. It goes without saying that all these people doing the careful planning will want to return to set up a permanent base. But once it finally sinks into the mass consciousness that even Antarctica is a friendlier place, political support will vanish and funding will vanish, unless ...

“Unless we plan the very first Mars expedition with a built-in OPTION TO STAY.”

**A Complete Phobos or Deimos Base** could be critical for the success of the effort.

- A Phobos Base could earn its keep by processing regolith volatiles (carbon, hydrogen, and nitrogen) in the form of methane (CH<sub>4</sub>) and ammonia (NH<sub>3</sub>) for back-shipment to thirsty Luna, as well as for fuels for actual Mars landings, and for return trips to Earth. Note: at this time we are not sure that either Phobos or Deimos are endowed with such volatiles as would be the case if these moons were of the Carbonaceous Chondrite family. The upcoming Russian **Phobos-Grunt** mission, could answer this question.
- Final preparatory Mars telescience from this forward position. A separate Mars-synchronous station could best direct the tele-exploration and tele-preparation of a selected site, and
- Oversee the carefully plotted siting of parachute-landed robotic production plants on the Martian surface to stockpile nitrogen, oxygen, argon, carbon monoxide, water, methane, and ammonia -- all processed from the atmosphere -- [written prior to Mars Direct ]  
A Phobos Base would vastly enhance chances of success for a crewed Mars surface mission as well as assist the economic bootstrapping of the early Moon Settlement so that it could manufacture and ship some items ... at considerably less expense than they could be sourced from Earth.

#### **Launch Window circumventing Solar Sails**

A steady stream of “tackliners” – container pods hauled by great solar sail freighters, with some measure of freedom from launch windows, could build up caches of supplies in Mars orbit to be on hand when the sprinting human crews arrive, or to be fetched by shuttle when needed by crews already on Mars surface.

#### **One very big “However ...!”**

Those who would open a lunar frontier, while being less blessed with mineral resources than pioneers on Mars, will have the enormous advantage of “location, location, location” which will allow the Moon to become an integral part of an expanded terrestrial “Econosphere” allowing pioneers to earn their keep producing products and services that will help those on Earth ameliorate their two intertwined critical energy supply and environmental degradation problems.

That its all about mineral “resources” is not quite so. Japan lacks key resources. But its people had something more essential: resourcefulness, inventiveness, and ingenuity. The Moon could become the Japan of Space.

In contrast, the economic case for Mars has yet to be written. This was the topic of our presentation at the 1994 ISDC in Toronto, and little has changed that outlook since. Worse, very few Mars enthusiasts are paying any attention to this problem. True, Mars has what it takes to be self-sufficient. But to get to that state, it must rely heavily on imports, and to keep those imports coming, it must develop products and services to sell. Touting Mars eventual self-sufficiency is clearly “playing ostrich.”

It is in everyone’s interest, Moon and Mars advocates alike, to try to develop the Economic Case for Mars, without resort to science-fictional discoveries of unobtainium, or priceless pharmaceuticals developed from Martian microbes etc.

In this essay, we have tried to show how we could go to Mars to stay. But to really make it work, we need to do a lot of economic homework so far being pushed aside and ignored. This is in the interest of Moon-settlement advocates as well. Products and materials from Mars and especially from Phobos and Deimos would be much cheaper in terms of shipping costs than equivalent items shipped up the steep gravity well from Earth. In our estimation, the Moon and Mars will both have a better chance of economic survival as trading partners than either frontier would have in a future in which only one of these frontiers were to be developed.

Those impatient to dismiss and undermine the prospects of the “rival” frontier, only prejudice their own dreams. Meanwhile, it has been 40 years since Apollo 11 and will be 15 more until we are back on the Moon only to leave again. Let’s do it right or not at all. **PK**

### **What is needed for a Mars to Stay Plan**

- A shielding plan, water plan, energy plan, farm plan, machine/fabrication shop, ISRU facilities
- Total reusability and function reassignability for everything arriving on Mars except return vehicles

NOTE: some return vehicles assigned to areosynch orbit to teleoperate probes in near real time. A fleet big enough to cover all of Mars (120° apart and replacing one another for crew relief) = 6 minimum other "return vehicles" used as Mars airplanes for manned scouting missions.

- Prior spin-up development of analog Mars building/manufacturing materials
- Prior diversification of atmosphere mining products
- substantial, diverse, redundant yolk sac
- Solar sail pipeline already inaugurated
- Teleoperations forward base on Phobos, Deimos, or in Mars-synchronous orbit
- Site identification considerations
  - Thermal management (tropical site)
  - Water (e.g. buried glaciers, identified aquifer)
  - All needed elements present nearby
  - High ground above possible flood line
  - Easy overland access to a wide area of Mars
  - Easy surveillance from Phobos
  - Proximity to tourist destinations
  - Proximity to Pavonis Mons {premium site for west slope launchtrack, lavatube-ridden

### **Suggested Additional Reading**

[www.moonsociety.org/publications/mmm\\_classics/](http://www.moonsociety.org/publications/mmm_classics/)

"The Moon's Role in the Opening of Mars" – and – "Yolk Sac Logistics: a Strategy Tailored for Mars" – and "Pantry Stocking: the role of Creative Smuggling in the Building of Marsport" MMM #113 above

"Tempering Enthusiasm for the Red Planet as 'The Next Human Frontier' with Personal Honesty" P. Kokh  
MMM #103 above

"REDHOUSING: breeding 'Mars-hardy' plants in compressed Mars Air" – and – "Mars will require a hardier breed of pioneer" MMM #93 above

"Urbs Pavonis – the Peacock Metroplex: site for Mars Main Settlement" – and – "The Mars Heritage Zoning Resolution" MMM # 73 above

"Convincing 'Economic Case for Mars' Yet to be Made" – and – "The Triangle of Earth-Moon-Mars Trade Routes" P Kokh MMM #62 above

"Mars: plenty of time to wait, but none to waste" April, 2003 and "Importance of Lunar 'M.U.S./c.l.e.' plan for opening Mars" MMM #18 above

## **MMM Platform for Mars, V. 2**

**MMM sees the following developments as part of "the critical path" to a successful opening of a human frontier beachhead on Mars.**

- **Mars Permafrost Explorer** — The opportunity to pre-test such a probe in Earth orbit to improve knowledge of terrestrial tundra resources, makes this an easy sell.
- **Ground Truth Permafrost Tappers** — Orbital surveys will not be much good unless calibrated by scattered on site drill cores. Further, only by actual on site taps can we tell either the percentage of water content or its fresh-ness or salinity or how we can best tap the deposit.



- **Mars Lavatube Explorer Orbiter** – We can pre-test such a deep-penetrating radar probe in Earth orbit to improve our knowledge of lava flow terrain. The results could be far less important for geology than for future Mars settlement scenario options. Ancient near-surface Mars limestone caves might also be identified.
- **Mars Lavatube Entrance Robotic Probes** – The recent development of the “Axel” “marsupial” rover that can winch itself down a crater rim, makes it possible to explore (7) recently discovered Mars lavatube entrances
- **Ground drilling probe to assay “buried glaciers”**
- **Mars topographic map** with accurate elevations: from which basin and watershed divides can be traced along with their overflow dam points. From this potential primitive and immature drainage patterns can be sketched, avoiding siting outposts in future flood plains.
- **Geochemical orbital mapper** — reflight of Moon Mineralogy Mapper (Chandrayaan-1) over Mars
- **Geochemical ground truth probes** — where needed to determine abundance, methods of production, etc.
- **Antarctic Mars Training Camp Base** in one of the cold “Dry Valleys” like **Wright** or **Taylor**. A permanent facility at which survival gear and methods developed for the Mars frontier can be tested, and expedition members trained.
- **Mars Analog Program II**
  - Modular Marsbase that can grow
  - Modular biosphere contributions in each module
  - Shielding: thermal management/radiation protection
  - Year-round real biowaste management, agriculture
  - Experiments: using Mars regolith simulants to pre-develop Mars-appropriate building and manufacturing materials
  - Compare productivity of teleoperation with Mars-Deimos equivalent time delay (0.2 seconds) vs. Earth-Mars equivalent time delay (6-40 minutes)
  - Experiment to find the smallest crew complement that embodies all needed frontier talents with redundancy
- **“Redhousing Experimentation”** Breeding “Mars Hardy” plants to survive in compressed (0.1 atm) Mars Air (CO<sub>2</sub>).
- **Predevelop a Mars atmosphere organic chemical feedstocks industry** with simple methods to mass produce as many useful compounds as possible out of Mars’ atmosphere (carbon, oxygen, hydrogen, nitrogen).

**"The human race shouldn't have all its eggs in one basket, or on one planet. Let's hope we can avoid dropping the basket until we have spread the load." ----- Stephen Hawking**

**MMM #233 – MAR 2010**

## **The Pendulum of “Mars”**

From **“Once Earthlike but Dying World”**  
to **“Dead World from the Start”** to  
**“Once Earthlike, and still living World”**

**A Remarkable Journey!**

By Peter Kokh

Saturn's rings notwithstanding, and no matter that Venus is Earth's twin in size; reddish Mars has always been the planet with which we have been most fascinated – by far. Those readers who became aware of Mars after Mariner 4's flyby visit in 1965, which by misfortune, happened to be over the heavily cratered southern hemisphere, have always seen Mars as a dead, almost moonlike world.

But those of us born in the 1930's and 40's grew up with a vision imprinted on us by Percival Lowell, of a dying planet laced with canals, evidence of intelligent civilization that sent spring melt water from the polar caps to the temperate and tropical regions of the planet. That the canals were still working, whether their builders still survived or not, was clear from the season changes in shading, some areas getting darker every Martian Spring, a sign, no doubt of vegetation springing back to life. We knew of course, that Mars air was thin, maybe 10% of the atmospheric pressure we enjoyed on Earth.

Speculative writers differed on whether we would find the Martians still alive, just barely hanging on, in a brave old world, or whether we would find only ruins of a now long dead heroic civilization. If we found writings, we hoped to find a "Rosetta stone" of sorts so that we could glean from them their accumulated science, and wisdom. Maybe there would be some surviving wildlife.

Mariner 4's view of a surface as crater-pocked as the Moon's southern highlands, erased that dream picture in one quick second. But the romantic view above had already been under attack. Modern telescopes could not detect the canals of Schiaparelli and Lowell, and in 1961, Carl Sagan had come up with the correct and non biological explanation of the seasonal shading changes: the seasonal trade winds on Mars blew darker soil over lighter areas, which were later blown clean again.

Worse, we soon found out that Mars atmosphere was far thinner than anyone had expected, only 10% of the 10% we had expected, that is, only 1% of Earth-normal. The surface was exposed to radiation and raw, untempered solar ultraviolet. Mars was a harsh, life-squelching world. It might never have been "alive."

But then observers found what looked like beaches in the great northern depression called Vastitas Borealis – the Northern lowlands. For the past thirty years the debate has raged. Did Mars once have an ocean?

The brave and romantic among us were shakingly confident that it did. Others could see no evidence. As you may know, none of us are perfectly objective. Our temperaments influence us one way or the other. There are those with a "need" to "know" that we are alone in the universe and prejudge all evidence accordingly. There are those of us who wax eternally optimistic, buoyed by the dictum "nature never does anything once." Our temperaments determine what we think of as evidence.

Suddenly, the impasse has been broken. We now have overwhelming evidence that the valley networks to the south of the northern depression are twice as extensive as thought and that their dendritic features could only have been produced by regular seasonal rains over millions of years. We are now suddenly confident that, yes, Mars did have an Ocean! There is still room for debate on how deep that ocean was, that is, how far up the slopes of the great northern depression the waters reached. In time, we will find the maximum shoreline elevation. Regardless, we now know that Mars once had a considerable ocean-scale amount of water.

Where all that water went is the question. Some of it must have sublimated, as the air got steadily thinner. But it is impossible to believe that there were not subterranean aquifers that must still exist, however frozen. And it is likely that at that point drilling down where Mars internal heat begins to be felt, there may be some appreciable volume (in toto) of liquid water.

Water must have subsisted on the surface long enough during a period when Mars enjoyed warmer temperatures, to have favored the rise of living organisms from the amino acids that it now seems clear have been spread by interstellar gas and dust clouds everywhere in the universe. Life is not unique. It is natural, and must arise everywhere that it is given a chance.

The discovery of persistent methane in Mars' thin atmosphere suggests that microbes or bacteria native to Mars still survive. The "conservative" (temperament, remember!) view that this methane must be of geological origin flies in the face of the evidence that Mars has been geologically dead for some eons now. Pursuing the arguments further, it is the suggested abiological/geological mechanisms that are not holding up.

Finally, the evidence from Mars meteorites (it is their trapped gas species and ratios that tell us their origin) that what looks like fossilized life must be just that, is clearly routing all the abiological explanations offered. NASA has indicated that it will soon announce convincing evidence that Mars once had primitive pre-cellular life, and very well still may have.

In the past 45 years, we have come full circle, almost. Mars was wet and alive in its youth, and maybe through human intervention, can be restored to something of its former self. I personally do not like the word "terraforming." First, our whole experience is in DE-terraforming our own world. Second, to be true to Mars, we should be talking about "rejuvenating Mars," bringing it back to what it once was, and then meeting it halfway, adapting to that Mars, not to a recreated Earth. **Rejuvenance**, or **rejuvenation** if you will. I fear we will try quick schemes to raise air pressure and temperatures that will box us into dead ends. Best results come slowly.

Still not back with us are the mythical ancient Martians. There will be Martians someday. But they will be our descendants, not beings restored from trace DNA of former inhabitants that never existed. Plain put, Mars did not enjoy its Spring and Summer long enough to have evolved any type of advanced life.

All the same, it is good to be back believing that we have a human-welcoming sister world in our own Solar System, back believing that Humankind will someday thrive on another world, that all our eggs will no longer be in one basket. Meanwhile, here is a toast to the overoptimistic visionaries that once stirred our romance with Mars! – vive les Martiens! We will be them. PK

## **Mars: Exploring Now, to Settle Later**

By Peter Kokh

### **Robotic Exploration Goals: Guiding Principles**

**"Learning whatever we can now with robotic probes, so that when we are ready to send first crews to Mars, we will be able to send them to the most promising sites for starting (a) viable self-reliant settlement(s)."**

- Good sites are not good enough. We need enough information to pick the best. Optimization of our chances of success in establishing a second egg basket for humanity is at stake.
- At present, there is no guiding principle for choosing instruments to go on Mars orbiters or landers. Prospective Principal Investigators make proposals, and a team of scientists, not settlement experts or designers, pick on the basis of weight, cost, and design readiness. We end up with good missions, but not good enough to get the job done.
- The Mars Society has not lobbied for needed instruments. But it is in the Moon Society's interests, to make sure that the Mars Settlement(s) is (are) a helpful trading partner for the Moon Settlements, to take up this cause.
- In short, the Moon Society owes it to our own goals and interests to pickup where the Mars Society has failed to take the initiative.

**What kind of probes do we need to learn what we need to know in order to pick best sites?**

- 1) We need more complete mineralogical mapping of all elements** needed for settlement supporting industry
- 2) We need ground-truth core samplers** in sediment areas of the presumptive boreal ocean bed, and of river systems to the south
- 3) We need ground-truth core samplers** of suspected permafrost areas in order to design adequate water recovery systems

- 4) **We need superior altimetry data** of 10-meter vertical resolution to plan for future drainage systems and for road and railroad routing

#### **Finding the best places to begin Settlement**

There are many things to consider:

- ✓ **water access:** is there handy subsurface ice or permafrost that can be tapped?
- ✓ **Coastal areas:** areas near both ancient river tributary systems (exposed sedimentary layers: material of varying mineral composition) and the northern (presumably oceanic) basin whose mineralogy may be different and somewhat complementary
- ✓ **Proximity to Pavonis Mons:** This shield volcano massif is known to be ridden with lavatubes and sits astride Mars' equator. More on these assets below
- ✓ **Proximity to the deepest basin, Hellas:** once remedial climate change ("terraforming" or "rejuvenescence" of Mars, i.e. to an earlier friendlier state) has begun, this basin will always have the highest air pressure.
- ✓ **Low equatorial areas (best climate)** Note that Mars northern hemisphere has shorter winters and longer summers than the southern hemisphere

#### **Exploiting the Assets of Phobos & Deimos**

Semiofficially, the Mars Society position would seem to be that Phobos and Deimos are irrelevant. The fear here is that a first manned mission might be to one of these mini-moons, delaying a manned exploration mission to Mars. But we do not need a Manned Exploration Mission! We should do all the exploration needed to determine a shortlist of settlement sites with orbiters and surface probes, so that the first manned mission to Mars will be "a Mission to Stay." Anything short of that runs an extremely high risk of being a one-time "Flags & Footprints" ("Kilroy was here") symbolic mission to be followed by more decades of nothing. We don't need another Apollo type dead-end repeat. Impatience always fails! Of course, the impatient never get that.

#### **Phobos can help in two major ways:**

- 1) **A forward base for the teleoperation in sub-second delay real time** of a whole fleet of ground truth rovers and core samplers, including lava tube explorers and polar cap miners. If we were controlling Spirit and Opportunity from Phobos instead of from Pasadena, the amount of productive exploration could be magnified a hundredfold or more. They go so slow because with a 6-40 minute time delay, we cannot afford to let them get too far ahead of us!
- 2) **If Russia's Phobos-Grunt mission should determine that Phobos is a carbonaceous chondrite**, rich in volatiles such as hydrogen, carbon, and nitrogen, an automated industrial operation to produce liquid methane and ammonia for export to the volatile-thirsty Moon could be a major source of income to any Martian settlement with which to pay for dearly needed imports. Given the lack of any other "identified" economic exports from Mars itself, this is not something to be dismissed.

#### **Short-term goals of geological and exo-biological exploration are immaterial.**

If this seems a brash statement, consider how much we would know about North American Flora and Fauna, about the continent's geology, its geological and paleontological past if only one or two "scientific expeditions had been sent (even with today's instruments and expertise) in comparison to how much we now know about the continent because continuous settlement has supported far more widespread, continuing, and in-depth scientific exploration of all kinds. Obviously, **those scientists who dismiss settlement and want one or two scientific expeditions are willing to sell out the possibility of ultimate in depth exploration in order to get quick Nobel Peace Prize results now.**

Settlement of Mars is the only way to support ongoing and thorough scientific research on Mars of any and all types. Here as everywhere, impatience always backfires. The corollary is that settlement sites must be assessed not on the grounds of potential scientific yield but on the grounds of access to a complete suite of materials needed to support settlement should financial backing from Earth dwindle or disappear.

Those with scientific curiosity will arise in every settlement, just as on Earth, and eventually will explore every bit of Mars, and far more thoroughly. It is important to go to Mars for the right reason: to create another basket for humanity's eggs. Exploration will follow.

**Long term, two sites on Mars stand out**

**1) Pavonis Mons:**

“Peacock Mountain” astride Mars’ equator, is an enormous shield volcano, second to Olympus further to the NW. Its gentle western slopes offer **the ideal site for a launch track to orbit and beyond**. In Mars thin atmosphere, the track may be able to launch directly into orbit, with a minimal course adjustment motor.

More, the crater rim itself is the best/only place on Mars to **anchor a space elevator** to Mars-synchronous orbit: a far, far superior site to anything similar on Earth, and requiring a much less massive cable.

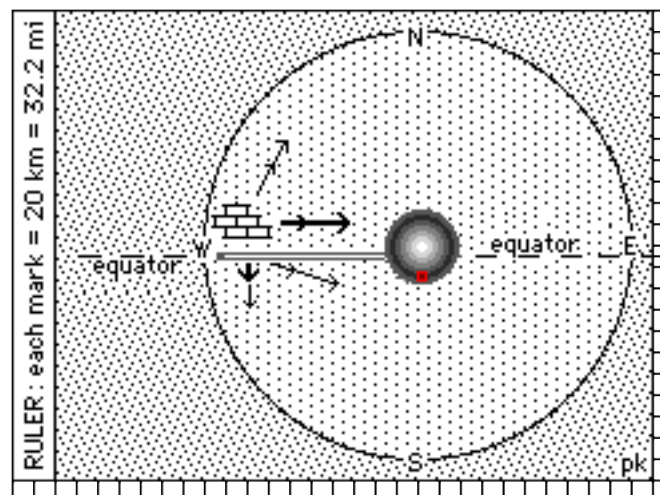
Judging on the basis of the similar, but much smaller northern California shield volcano of Medicine Lake, Bryce Walden, of Oregon L5, per our request [1994], deduced that Pavonis Mons

“has a volume 700–1000 times larger than Medicine Lake. (Pavonis is 7 times the diameter of Medicine Lake, covering 50 times the area and is perhaps 15–20 times taller). Taking the smaller figure and extending the same argument, we might expect 10 billion cubic meters involving wider, higher, longer caves spaced further apart. If we postulate an average Martian tube interior ceiling height of 30 meters, that gives us a floor space of about 150 million square meters = 333 sq. km<sup>2</sup> = 128 sq. mi., the size of an American central city in the 1,000,000 population range – in a host mountain with a footprint of 40–45,000 square miles, bigger than Iceland and comparable to the size of states like Ohio, Tennessee, Virginia, Mississippi, Louisiana, or New York.”

**Pavonis Mons is midway** between the coast of the long-dry northern basin ocean to the WNW and the Valles Marineris canyonlands system to the ESE.

The western flank of Pavonis Mons would be our suggestion for the first major settlement on Mars, very possibly in a lavatube, with ample room for expansion into major urban complex. Pavonis Mons is arguably the most valuable piece of real estate in the system, by far, and Mars’ single most priceless asset.

**Plan of the Pavonis Mons Metroplex Area:** The lavatube-riddled shield volcano slopes cover an area about 250 mi. in diameter. The corridor for the launch track up the west face of this equator-straddling mountain is shown, along with the site for a Pavonis Space Elevator Base on caldera rim. The brick-pattern area indicates the suggested site for the first settlement with arrows showing logical directions of early metropolis expansion. Eventually, the entire base of the mountain could be occupied, attaining a population of up to a million citizens or more.



### **MMM Sources:**

**MMM Classic #2** "Pavonis Mons: Possibly the most strategic mountain in the Solar System"

**MMM Classic #8** "Pavonis Mons/Peacock Metroplex" The site for Mars Main Settlement

Both issues freely downloadable from: [www.moonsociety.org/publications/mmm\\_classics/](http://www.moonsociety.org/publications/mmm_classics/)

### **2) The Hellas Basin:**

Halfway around Mars in either direction from Pavonis Mons, and between 30–50° South of the equator, this major impact basin sits more than 8 km (more than 5 miles) below Martian mean ("sea") level. Mars' highest atmospheric pressure is now, and will always be, in this basin. **Hellas will be the site on Mars where conditions will first allow Mars-hardened hybrid plants to survive out in the open.** Hellas will always be the front line of any effort to improve Mars climate (e.g. by permanently melting polar ice cap carbon dioxide ice. In other words, once deliberate climate improvement projects begin, **Hellas north "shore" will be the place to be.**

Hellas does have some drawbacks. As a basin it is landlocked, and thus any Hellas Sea will very slowly become salty, but over hundreds of millions of years. It will be subject to longer winters and shorter summers than equivalent latitudes north of Mars' equator. In sum, for the near term, Pavonis Mons is the place to start. In centuries to come, Hellas will grow in importance.

**Another ancillary location: the edge of the north polar ice cap** 50° west of the latitude of Pavonis Mons. If there is no adequate permafrost or other subterranean aquifer handier to the Pavonis Mons site, an enclosed, pressurized, and insulated aqueduct could transport polar melt water towards the equator. There would need to be pumping stations along the entire route. Once the aqueduct reached the tropics, it would have to climb up the Tharsis ridge to Pavonis Mons. This would be no easy feat, and the energy to pump water all this distance, and then uphill, would be daunting. Sites still within the northern Boreal basin would have the advantage. We picked a point 50° west of Pavonis Mons for the easiest route south to the equator.

### **Liquid Subterranean aquifers?**

We suspect that there may be a level below the surface where Mars residual internal heat is sufficient to keep subterranean aquifers in a liquid state. We would have to find such aquifers. Their depth below the surface may be intimidating to engineers. The best place to look for residual heat may be below the Tharsis ridge itself on which Pavonis, Arsia, and Ascraeus Montes all sit. If an aquifer is found, it could be a source not only of water, but also of residual geothermal energy for a metroplex. However, the expectation is that Mars' core has been cold for some time. Yet "cold" is a relative term. The much smaller core of the Moon may still be hot.

### **Summing up**

We must prioritize science missions that will tell us where the clusters of needed elements needed to support settlement can be found. All other science goals are postponable. Exploration can wait for settlement. **PK**

## **Mars Analog Research Stations**

**Settlement-related research should have priority over geological and exo-biological research.**

By Peter Kokh, member MDRS Crew #34 Season 4;

Commander of MDRS Crew #45 Season 5

It has been a very special honor to have served on two Mars Desert Research Station crews and to have become a member of the very unique and privileged fraternity of those who have also been so fortunate. Both of these experiences will always be especially treasured for the rest of my days.

This participation would never have occurred were it not for connections made by my longtime friend, Ben Huset of the Twin Cities, who back in August 15, 1986 came to Milwaukee with others, in concert with a team from Chicago, to help launch what became the (Milwaukee) Lunar Reclamation Society.

I went to Hanksville, Utah in early 2005 to learn about the Mars Society operation and to prepare for a 2-week rental of this facility in the following year by the Moon Society. One goal was to identify any logical differences between a Mars Analog research program and a Lunar one. It was clear, that the Mars Society was trying to prove the value of human-robotic exploration of Mars, something the Apollo program had long since proved invaluable on the Moon. The Moon Society, if it had the opportunity, would concentrate on technologies and methodologies of expanding an initial outpost in the direction of settlement.

But while that difference seemed logical to me for some time, I now think that the Mars Society has been on the wrong track. Demonstrating the value of human explorers does not demonstrate either the importance or the value of human settlement, through which far more exploration would be done long-term. We now think that the program being designed for our proposed lunar analog research station would be a much better fit for Mars analog stations as well.

It has bothered me from my first visit that the Mars Society has not tried to expand beyond the original Hab and largely symbolic (ineffective) GreenHab. There is an observatory, but that does not expand the living space! In fact, at both the Arctic and Desert sites, the only expansion was made by the Moon Society on our time and dime: the framework of a "pretend pressurized" tunnel from the Hab to GreenHab that would allow crew members to pass from one to another without a "space suit" and preserving the useful pretense of being "in sim."

**But if you haven't been there, you wouldn't understand.**

The sad thing is that the Hab has two airlocks which makes expansion out of one of them a real structural possibility. A ground-hugging "ranch" style one floor annex, perhaps to replace the crew quarters, could easily be shielded with sandbags for warmth in winter and for cooler temperatures in summer, making year-around operations feasible. And that would in turn make a real crop-growing greenhouse operation doable.

The two-story hab is a big mistake, both for Utah and for Mars. Two self-contained floors could ride the way to Mars on top of one another, then be connected side by side for better thermal management, and for safety. The ladder between floors is a major cause of accidents. The unshieldability of a tall vertical structure has exacted its price: a short field season.

Expansion of an original structure into a modular settlement should be a major vector of any Mars (or lunar) analog research program aimed at demonstrating the feasibility of settlement. This option has been totally ignored. The effect is to reinforce the belief that the only reason to send people to Mars is to explore. Yes, people and robots make a better team than people-only or robots-only. But strategically, it is far more important to the Mars Society's mission and goals to prove that settlement of Mars is possible, and that far more research by human-robot teams will be accomplished if settlement is the primary and fundamental goal, not something to keep hidden because of "the giggle factor."

No one wants settlement of the Martian Frontier more than Robert Zubrin. Yet no one stands more in the way of that happening than his strategic misdecision to support exploration alone first. On this point, the Moon Society is a stronger supporter of the opening of the Frontier as an essential trading partner for the Lunar Frontier in an interdependence, which will enhance the viability of both.

If the Moon/Mars Atacama Station in Chile becomes a reality, modeling modular expansion and modular biospheric systems will be a core vector of the program. The shift of the drive to settle Mars will be to this site in Chile.

MDRS can be redirected. Rebuild the Hab with the two floors separated and then placed side by side with new modules being added at ground level, and insulated by sandbags or mulch bags in lieu of regolith. A thermally moderate year-around season now possible,

experiments with modular biospherics can begin so that as the physical complex keeps growing, its contained biosphere can grow apace.

While field research in geology and exobiology can continue, experiments with simulated lunar- and Mars- producible building materials should be a major focus. To better stretch expensive manpower on both worlds, experiments in pushing the limits of teleoperation should be a major focus as well.

Currently, by gambling everything on an Apollo-like one-time exploration mission to Mars, we risk selling out our dreams to those who do not share them. Yet we can't change or alter the MDRS/FMARS Research program and goals. You can lead a horse to water, but you can't make it drink. We can help by doing research at lunar analog facilities (and in Chile) that help promote settlement of both worlds.

The direction of the Mars Society is its own worst enemy. If any other MDRS/FMARS alumni/veterans would like to join us in developing a superior Mars Analog Research Program, please write [kokhmmm@aol.com](mailto:kokhmmm@aol.com) and tell us about your own experiences, interests, abilities, etc. If it is true, as we have long expected, that the Lunar and Mars Frontiers will either thrive together or both fail separately, an effort to salvage the Mars Society's analog program can only help support our own analog program.

Not all Moon Society members feel this way, and the Society is anything but a topdown dictatorship. But petty "either us or you" rivalry is self-defeating. We all owe it to ourselves to get out of the Moon or Mars mentality and into the Moon and Mars frame of mind. Start by reading this document:

[www.moonsociety.org/reports/mars\\_conv2004/Moon\\_Mars\\_Similar.pdf](http://www.moonsociety.org/reports/mars_conv2004/Moon_Mars_Similar.pdf)

Beyond Moon & Mars! On to the Stars! <PK>

## Mars Settlement-Preparation Research Outside of Analog Station Environments

By Peter Kokh

Some twenty years ago, Robert Zubrin revolutionized manned Mars Mission scenarios by demonstrating that we could produce the fuel needed for the trip back to Earth from Mars' Atmosphere. This could reduce the total mass of the ship(s) setting out from Earth by as much as 90%. NASA eventually bought into a modified version of Zubrin's "Mars Direct" plan. See MMM #30, November 1989, "NIMF: Nuclear rocket using Indigenous Martian Fuel: An Enabling Technology for manned Mars Missions with Global Access in a Single Launch" by Robert M. Zubrin. In MMM #23 above

This was a historic and brilliant step forward, and he proceeded to build a working model of his adiabatic reactor, since duplicated by others. Unfortunately, in failing to pursue this research further, he/we have dropped the ball.

### **1. What besides Methane can we make from Mars Atmosphere? Other fuels? Useful chemicals? Plastics? Shielding? Feedstocks for a basic aero-chemicals industry?**

If our goal goes beyond manned exploratory sorties to real settlement, we ought to have been asking that question, and finding answers over the twenty years since! Mars' atmosphere is 97% Carbon Dioxide, 3% Nitrogen, some water vapor, and with a sampling of other elements such as argon and other noble gasses. Methane CH<sub>4</sub> is certainly useful. But so are its "upgrades" Ethane C<sub>2</sub>H<sub>6</sub> and **Propane** C<sub>3</sub>H<sub>8</sub>, a liquid fuel.

Ethylene, C<sub>2</sub>H<sub>4</sub> is the most produced organic chemical in the world. And its polymer, **polyethylene** is the most abundant plastic. Low density and high-density polyethylene resins (**LDPE** and **HDPE**) are extremely versatile and fully recyclable manufacturing materials, whose diverse products most of us use on a daily basis.





Polyethylene has been shown to be a superior thermal and radiation barrier. On Mars, it might be more difficult to loosen up pulverized powdered regolith soil to use as shielding than on the Moon. Mars' regolith may be more densely compacted because of the planet's 2.25 times greater gravity. Use of an atmospheric product for shielding could be a desirable solution, and allow keeping outpost landscapes in a more pristine condition.

Here on Earth, polyethylene is produced from petroleum. While all the needed elements are present in Mars' atmosphere, we may need catalysts and reagents to produce it directly from the atmosphere. If these are recyclable, to be used over and over, then this alternative process may be a practical one. We need to try!

Beyond basic hydrocarbons, nitrogen is available from the atmosphere as well. But taking a Mars' based chemicals industry any further (introducing chlorine, sulfur and other elements) must await development of a mining industry. The point is, that **the more organic substances and useful materials for which we can demonstrate the production from Mars' atmosphere, to stockpile in advance of crew arrival as a jump start to a basic level of self-sufficiency for the pioneers**, the more support and less opposition the idea of settling Mars will generate.

We may already know the basic chemical process pathways involved. What we really need to do is to develop the lightest weight equipment feasible for a given amount of production output.

We also need to develop lightweight storage systems so any atmospheric byproducts can be stockpiled on location. Inflatable containers with rigid bottoms would be our suggestion, lightweight and compacted for shipment. On Mars, the chance of micrometeorite puncture should be much less than on the Moon, where filled inflatable tanks could be placed under a prebuilt shelter to provide thermal stability as well. Inflatable bladders for gasses, liquids, solids and substances expected to change state with the seasons could be developed.

Now if these bladders could be produced on Mars that would be even more helpful. Providing a "produced on Mars" stockpile of as many consumables as possible is the name of the game: not just fuel for trips home!

## 2. Experimental Mars Agriculture in Marslike Air

That we can grow crops in a carbon dioxide atmosphere at 10% of Earth normal pressure, and in turn ten times the pressure on Mars, suggests an agriculture that meets Mars "halfway." These are experiments that are easy enough to do here on Earth in a project we have dubbed "redhousing." See MMM # 93 above.

The greater the number and the variety of food crops, and of plants useful in other ways (fiber, spices, pharmaceuticals, dyes, etc.) that we can demonstrate can be successfully raised in "redhouse" conditions, the lower we will have reduced the threshold for successful Mars settlement. More, the idea of meeting Mars "halfway" will begin to look like a doable long range plan for settlers to go beyond subsistence to actual thriving on Mars. This philosophy should appeal to environmentalists and eco-nomists alike. Widespread support for establishment of a Mars Frontier will make everything easier.

And if a semi-automated, partly teleoperated food growth system could be set up so that the first crops were ready to harvest when the first pioneers arrived, what a welcome omen that would be!

**We will get nowhere unless we dream what would seem at first to be absurd and impossible. It is not only the pioneers that need to have the right stuff. It is those who are preparing the way for them, maximizing the chances of success.**

## 3. Finding Minerals for Martian Industries

We cannot live on organic substances alone! If we want Mars frontier settlement to succeed, we have to mount a campaign to skew the choice of instruments aboard future Mars orbiters and landers to include those that will identify not just those elements useful for a geological understanding of Mars' physical evolution, but also of elements necessary for industry. Taking a page from orbital exploration of the Moon, we need not worry about identification of areas rich in iron, magnesium, titanium, and thorium. But we need to know where best to look for many other vital elements as well.

This will take some campaigning! NASA (we might assume the same for ESA, China, Japan, India, etc.) goes through proposals from principal investigators and decides on the basis of which proposals are the most advanced, and which the least costly. How they fit the needs of would-be frontier-settlers does not enter into these decisions at all. While all science has some practical implications, as a constituency pushing to open the Martian and Lunar frontiers, we need to make the case for prioritizing practical applications and needs.

- ✓ Instruments to map permafrost areas and to detect sub-surface ice and aquifers
- ✓ Instruments to detect and map subsurface voids such as lavatubes and trapped gas pockets
- ✓ Instruments to detect all industrially vital elements, such as copper, platinum, sulfur, phosphorous, potassium, and on and on.

The idea is to have data on which to base sound decisions on **where to set up industrial centers**. Not just anywhere will do, and certainly **basing site decisions on geological and exo-biological curiosity alone is begging failure, and failure sooner rather than later**. In the long term there will be immeasurably more geological and exo-biological exploration and research, if these activities are supported by a permanent and growing frontier population. Patience will pay off enormously!

#### **4. Mars transportation systems**

Mars is a big place, as big as all Earth's continents put together. We have already pointed out that the two most strategic places on Mars are half a world apart, some 7,000 miles or 11,000 km. Even if settlement of the northern part of the Hellas basin is postponed, we are unlikely to find everything we need for settlement self-sufficiency within short range of anywhere on Mars. And most certainly, monotonous appearances aside, one site is not as good as another!

There has been much talk about the feasibility of aviation on Mars. Enough talk! We need demonstrations and improvements and more demonstrations etc. We will need aircraft that can do reconnaissance but also carry passengers and some freight.

It would appear that ground-effects vehicles that could ignore the boulder-strewn fields of Mars and glide above the surface are unlikely. That doesn't mean we should not try to prove this assumption wrong. Railroads to haul cargoes and materials are a real possibility. How can we redesign them to suit the Martian climate and conditions?

The list of things we can do to demonstrate the feasibility of successful self-supporting Martian settlement is longer than we suspect. But we have to start making inroads if we are going to change opinions. There is a limit to self-sufficiency and the new Martians will need income-earning export options. Everything we can demonstrate that will give pioneers the edge, brings the day when we decide to open the Mars frontier closer.

#### **Thriving Together vs. Withering Alone**

How will future Martians pay for those things that cannot be produced (whether not yet or not ever) locally is the real question. It would seem that there is nothing Mars can produce that Earth cannot also make, except experiences. And very few will be able to afford the cost and the time for round trip tours of Mars!

We have seen science-fantasy suggestions such as life-saving pharmaceuticals (perfumes, aphrodisiacs, etc.) made from special Mars' soils that cannot be duplicated on Earth; or unique priceless gems made in the throats of Martian volcanoes. We have seen no suggestions that are realistic other than exporting things to the Moon at lower shipping costs than they can be shipped up (more quickly) from Earth.

On the other hand, building materials from the Moon, would be cheaper for building out LEO and GEO than equivalents rocketed up from Earth's surface. So helping make the lunar economy work is the key to making the Martian economy work.

Given its shallower gravity well, Mars will be a cheaper source of imports for the lunar frontier than Earth. Some items needed on Mars may be less expensive to import from the Moon. And this is our choice. Either prosper together, Moon and Mars, or face economic collapse apart. The Moon and Mars are logical trading partners. Those too proud to accept this will end up suffering the consequences.

In planning lunar industrialization priorities, it would pay then, to give some emphasis to those basic industries that could produce equipment and products of critical need on both Moon and Mars. Designing equipment for lunar and for Martian use may require some specific differences: but the two frontiers, in comparison to conditions on Earth, are similar in more respects than in which they are different. Equipment that proves out on the Moon may work on Mars with few adjustments, and if made on the Moon, for shipment to Mars, will cost less. And vice versa. It is only reasonable to expect one frontier to be ahead of the other in some respects, and the opposite in others. The most important thing in common is the need to become as self-sufficient as possible as soon as possible, should financial and other support from Earth decline or be interrupted.

There is much homework ahead of us. Leaving it to the government is not the answer. Working hand in hand (Moon and Mars supporters) should yield practical solutions and pathways for further investigation! If we spawn outposts on either or both worlds that could not survive collapse of civilization on Earth, or even an indefinite pause in support, then our effort to create additional baskets for Gaian and Human eggs will have failed. While such a level of survivability will be hard won at best, it is a goal that must be pursued in earnest from the outset. Dependency by design, intentional or not, is unacceptable. If we are going to expand the human world beyond Earth orbit, we need to do it right, and that means no half-measures.

In this respect, **neither** the Return to the Moon nor the push for a Mission to Mars, have been on the right track. We cannot assume that either NASA or any government bureaucracy, focused on exploration only, will understand these things. If it is our dream, we must take responsibility for getting it on the right track and keeping it there.

It is in the interests of Lunar Frontier enthusiasts to promote pre-development of any and all technologies that will help open the Martian frontier. Whether Mars frontier enthusiasts return the favor is immaterial. For us Lunans, this is a win-win situation. In time, "Mars only" advocates are bound to understand this. <PK>

## Without Lunar Settlements we have No Real Economic Case for Mars

By Thomas Heidel

### Introduction

At first look, Mars has enormous advantages over the Moon as a future human frontier. It has a thin but still considerable atmosphere rich in Carbon, Nitrogen, and Hydrogen, all elements present in barely minimal abundances on the Moon, and all necessary for life support. These elements can also be made into feedstocks for an organic chemicals industry: fuels, plastics and other synthetics upon which modern lifestyles are based.

There are also significant reservoirs of water ice both at the poles and below the surface. Mars is a place that could be terraformed, or better, to use Kokh's word, "rejuvenated", restored to its warmer, wetter self, as an authentic compromise between Martian and Terrestrial conditions, with humans also adapting to meet Mars "half way" so to speak.

Psychologically, Mars' bright sky is much easier to live with than the Moon's "black sky blues." But both worlds "as is" provide monotonous color schemes and without redress, significant visual color deprivation. On both, however, redressing this condition is easy enough.

Mars looks like our "Four Corners" areas where Colorado, Utah, New Mexico, and Arizona come together. That is deceptive, because the temperature range is much closer to that

in Antarctica, which only “looks colder.” Unlike Mars, Antarctica offers sweet fresh air, and abundant off-shore food. Yet no one seems to want to settle there. That suggests that many would-be Mars settlers are in denial about living conditions on Mars.

### **Mars Economics 101**

But this article is about building an economic case for Mars. The first, perhaps most salient fact is Mars much greater distance from the Earth-Moon system, and the infrequency of launch windows for Hohmann transfer trajectories between Earth and Mars: every 25.5 months.

That fact alone sets up a significant distinction between the Moon and Mars as potential human frontiers. A lunar frontier can grow at the end of an “**umbilical supply cord**.” If need be, flights between Earth and Moon can be managed daily.

Mars, in contrast, has to develop as does the chick from the egg, feeding on a “**yolk sac**” that will provide everything needed until the next “shipment window” if not twice as long for insurance against shipment delay to the next window.

### **Quid pro quo**

Regardless of how often shipments arrive to sustain growth, or at least to maintain the current state of development, benefactors on Earth, be they nation states, corporations, rich individuals, or more likely some ever changing mix of the above, without something coming back from these frontiers by way of at least partial payment, the outward flow of investment is likely to dry up, leaving the pioneers in a bad fix.

On the one hand, lunar pioneers are going to have the bigger challenge in becoming self-reliant. On the other hand lunar pioneers will have a significant advantage over their Martian counterparts in providing a mix of goods and services to the ever-expanding terrestrial ecosphere with which to make significant payments for investments made.

The reasons are simple. The Moon is two orders of magnitude closer to Earth in both distance and in ease and frequency of travel. This makes it possible to lunar source building materials needed for the inevitable very significant buildout of facilities and installations in Earth orbit, both LEO, but more especially in GEO - Geosynchronous Earth Orbit. Here will be built giant platforms at each location 2° apart (by international agreement) that will offer station-keeping, power, and communications, as well as robotic servicing to telecommunications satellites, GPS Systems, power beaming relays and solar power satellites. GEO will become an ever growing and significant part of the terrestrial “ecosphere”, and that will be in large part due to the availability of lunar building materials.

### **What can Mars sell to Earth?**

We can think of nothing Mars can produce that can't be made on Earth. Let's not hold out hope for some unobtainium exotic element or ore. Let's not hold out hope for enormously useful and valuable pharmaceuticals or perfumes derived from Martian microbes. That would be a bonus, yes, but there are currently no grounds to hold any reasonable expectation of this type.

### **Tourism?**

You can go from Earth to the Moon for a month, for a week, even for a weekend. Time is money! A round trip to Mars? Better set aside one to two years. Someday down the line, maybe we can get there in back in half a year with nuclear rockets? Yes, there will be tourists on Mars, but only a very tiny fraction of the volume of tourist business the Moon will enjoy.

However, the production of tourist travelogues and documentaries (3D, even holographics) for virtual tourism of Mars by Earthlubbers and Lunan pioneers alike should find a steadily growing market. The development of “Cycling Cruise Ships” may significantly increase the number of retired persons who will choose to make a once in a lifetime trip to Mars

Recorded telecasts of Martian exploratory expeditions, Martian sports events, performing arts, etc. will have a small dedicated market. But income from all tourist sources, actual or virtual stay-at-home, will be a very minor source of income for the pioneer economy.

Another difference from the Moon will result from the significantly longer time delay, a minimum of 6-40 minutes as opposed to a bit less than three seconds. This will make

interplanetary interviews difficult and awkward to say the best, and most likely canned edits that flow unnaturally.

### **The Moon, not Earth, will be Mars principal market**

- 1) **volatiles** – the Moon has barely enough hydrogen, carbon, and nitrogen (the latter in least abundance in proportion to need) to support tightly recycling mini-biospheres for its settlements. Mars atmosphere has plenty. But there may be another source in the Mars system: Phobos and Deimos were once commonly thought to be captured carbonaceous chondrite asteroids rich in these volatile elements. That expectation is no longer so confidently held. The Russian probe **Phobos-Grunt** [Russian word for “soil”] hopes to pick up where two previous Soviet Phobos missions failed: to reach Phobos, and do a chemical analysis of its composition. If it turns out that either or both Phobos and Deimos are volatile rich, that will become the initial cornerstone of the Mars trade economy. Volatiles can be shipped in the form of liquid methane (CH<sub>4</sub>) and liquid ammonia (NH<sub>3</sub>) to the Moon at much less expense than from Mars’ surface.
- 2) **alloys** – The Moon is as blessed in iron, aluminum, magnesium, and titanium – the four “engineering metals” – as is Mars. But the usual alloy ingredients (e.g. carbon for steel, copper and zinc for aluminum, etc.) are scarce on the Moon. Lunar metallurgists will no doubt develop second best workable alloys using the ingredients common on the Moon. But for uses where only the best will do, alloys produced on Mars and items made from them can be shipped to the Moon at lower fuel cost from Mars than from Earth. Of course, when time is of the essence, and the next launch window is far off, Earth contractors are going to get the order.
- 3) **settlers** – Lots of people sincerely believe that they would like to pioneer Mars. In our opinion, there numbers are as large as they are only because they are in severe delusion about conditions on Mars. As we pointed out, Antarctica is a much friendlier and less challenging place and there is no line of applicants for Antarctic openings.

But for pioneers on the Moon, Mars might be a piece of cake, a walk in the park, a step up. Seasoned immigrants from the Moon will be already hardened to a life style that left behind on Earth many pleasures and opportunities and gratifications. A frontier is a place where you willingly give up an easy comfortable life for a chance to start over “at the bottom” where you can make a difference and have a better chance of living a truly rewarding life. Lunan pioneers will be tried and tested, and have a much easier time becoming adjusted.

It would seem then, that both for a seasoned core group of new immigrants and for opportunities to sell goods and services, that the Moon will be a much more promising economic partner for Mars than Earth. That does not necessarily mean that the Moon should be opened and developed first before we think of opening Mars. Mars could be opened at the same time or just slightly after the first outposts on the Moon, and both frontiers would grow apace, as trading partners with a much greater chance of both becoming economically viable than if either was to try it alone.

### **Why the hostility to the Moon by Mars advocates?**

It is clear that most Mars-firsters have not looked at the economics. Those few who have have forecast that we will find some kind of mineral unobtainium on Mars or some priceless microbe-mush extract. That’s pure “Sci-Fi” at this stage. It could happen, but counting on it is not a rational way to ground the opening of a Mars frontier.

**But we do need to open Mars** as a second basket for humankind and Gaia. But discounting the Moon’s key role in an Economic Case for Mars just shows plain old immaturity and pettiness, a willingness to cut off one’s nose to spite one’s face. We, future Lunans and future Martians, are going to be in this together or we will both separately fail.

### **Building the Economic Case for Mars tidbit by tidbit**

Mars seems to have a relatively abundant source of copper. Copper is useful for many things (other than being the metal I find most visually beautiful). Its conductivity makes it a superior medium for electrical current than second best aluminum, which will of economic

necessity be the electrical mainstay on the Moon. Copper is also the key alloy in making aircraft quality aluminum alloy. So for wiring needs for which aluminum cannot be made to serve, and for high-performance aluminum products, Martian copper will underpin one significant trade line from Lunar markets.

We are sure that we will find other similar cases, many of them metal alloy specialties, but also other products that can be made on Mars, but not on the Moon, for which there will be a strong lunar market. A corollary is that these same items may be cheaper to ship to LEO and GEO than terrestrial counterparts, at least when shipping time is not an issue. Again, it is difficult to see what Mars could export to Earth directly other than intellectual property including process licenses, entertainment products, and uniquely Martian arts & crafts for the extremely wealthy.

### End run around the Launch Window Infrequency

Solar sail cargoliners would take a long time to reach Mars. But that is irrelevant, as they can be launched at any time to arrive at any time. Sent out at regular intervals, monthly, weekly, even daily, in pipeline fashion, these craft would circumvent the Launch Window barrier. The pipeline would always be full with something always coming out the tap. It is absolutely essential that this technology be fully developed. Support the Planetary Society Cosmos-2 project!

### Concluding Advisory

Mars advocates would do their own cause better service to realize that the Lunar and Martian frontiers will both have a much greater chance “to survive and thrive” as trading partners than as bitter rivals seeking to kill each other. “Cooperate, or die trying to be stupid!”

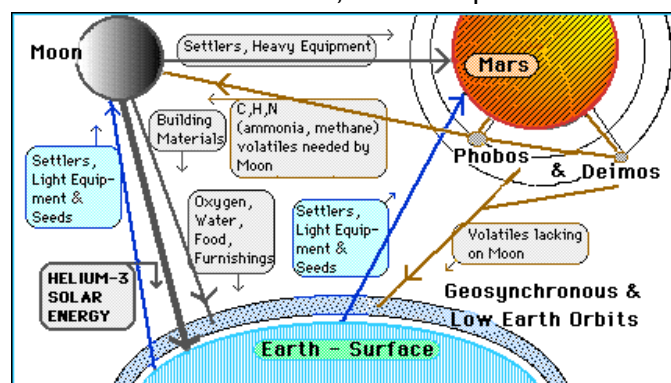
The author invites reader suggestions for more specific suggestions towards building a strong economic case for Mars. We need to build the case, not tear it down, and we don't build the case of Mars by attacking the case for the Moon, or vice versa.

The author can be reached indirectly at [comfyrock@aol.com](mailto:comfyrock@aol.com) subject line “For Tom Heidel”

### Appendix: Elements more common on Mars than Moon

**Volatiles:** Hydrogen, Carbon, Nitrogen; **Metals:** Copper, Zinc, Platinum, Silver, Gold, Lead, Mercury

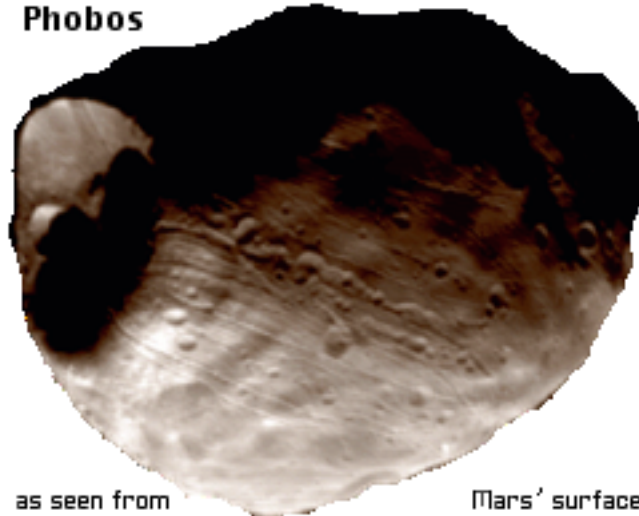
**Note:** There has been greater tectonic and volcanic concentration of elements into “ores” on Mars than on the Moon, though not nearly as much as on Earth. That will make some elements, equally abundant on both worlds, easier to produce on Mars than on the Moon.



Inner Solar System Trade Routes

<http://nsschapters.org/hub/pdf/SystemTradeRoutesTP.pdf>

## Phobos



as seen from

Mars' surface

MMM #233 - MAR 2010

### The Most Economic Way to Open Mars: Construction Equipment and Robonauts, Telepresence-operated in near real-time from Phobos directly, and via co-orbital relays

By Peter Kokh

In the previous issue of MMM, #242, we talked about how pre-human missions to the Moon, bringing teleoperable equipment and telepresence-operated "robonauts" could speed up realization of a first human outpost, and do so at greatly reduced expense. Human crews would arrive ready to do what they came to do. All the site preparation and construction chores would be done beforehand by robotic predecessors who do not tire, do not get bored, do not need rest or relaxation, do not need life-support, etc. And now, with the arrival of Robonaut 2 or "R2" at the International Space Station, to join the crew, the new Space Age 2.0 of human-robonaut synergy is upon us. This is an historic moment!

If robonauts can speed up the realization of a Mars outpost and get it ready for the first humans, at a similar savings, then we must rewrite our Manned Mars Mission scenarios accordingly. **But there is a significant difference between where we are at on the Moon and where we are at on Mars.** Our orbital mineralogical exploration of the Moon is much more advanced. But more to the point, rovers on the Moon can be teleoperated from Earth in near real-time. On Mars, which varies from 35 to 400 times as far from Earth as the Moon, time delays are measured not in single digit seconds but in minutes: from 6 minimum to 40 maximum, as Mars distance from Earth varies greatly. What has taken 7 years for **Opportunity** and **Spirit** to do on Mars, would have taken perhaps a month to accomplish on the Moon.

If we are going to really explore Mars - so that we know better where the resources are and where best to set up shop - a **Forward Teleoperations Base in orbit around Mars is absolutely necessary.** And not just anywhere in Mars orbit, on Phobos!

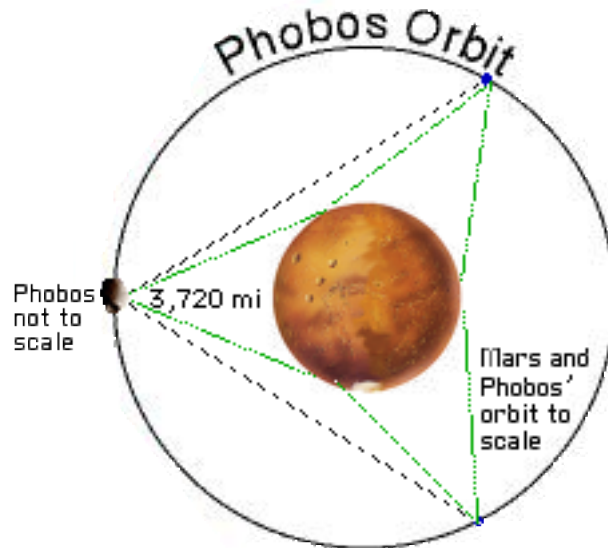
#### Why an Outpost on Phobos?

Wouldn't a small "Space Station" in some other orbit around Mars do just as well? Back around Earth, ISS gets significant shielding from cosmic radiation and solar flares from the Van Allen Belts. Mars lacks a magneto-sphere and hence lacks similar belts. Astronauts in a Mars orbit space station would be much more exposed.

An outpost "on" the surface of Phobos would be less exposed (to just one half of the celestial sky). But, given Phobos' mini-gravity, its "regolith" dust blanket has been much less compacted than that of the much more massive and significantly larger Moon. It should be

relatively easy to pile up a blanket of protective Phobos dust powder over the modules of any complex.

From Phobos a bit less than half of Mars is visible at any time, but a pair of unmanned relay satellites in Phobos orbit 120° ahead and behind Phobos respectively, would allow teleoperation of probes, rovers, and robo-nauts anywhere on Mars surface except at either pole.



The time delays involved are minimal, and even if relayed, would be much less than the time delay between an Earth-Moon L1 station and the Moon's surface. In fact, the perceived delay would be much less than that of global telecasts on Earth via Geosynchronous orbit. The near "real-time" control of rovers, construction equipment and telepresence-roboanauts would allow extensive global operations on Mars. In contrast, a manned outpost on Mars would (without satellite relays) be confined in its reach of operations to a very local area.

[http://en.wikipedia.org/wiki/Phobos\\_\(moon\)](http://en.wikipedia.org/wiki/Phobos_(moon))

**Phobos** is 7.24 times as massive as Deimos. It is named after the Greek god Phobos ("fear"), a son of Ares (Mars). Phobos orbits about 9,377 km = 5,827 mi from the center of Mars, 3,719.5 miles above Mars' surface, closer to its primary than any other known planetary moon. Its orbital period is 7h 39.2m. It orbits so close to the planet that it moves around Mars [more than three times] faster than Mars itself rotates. As a result, from the surface of Mars it appears to rise in the west, move rapidly across the sky (in 4 h 15 min or less) and set in the east.

[Because it orbits so close to the surface, at moonrise and moonset, from on the surface of Mars, one would peer a bit around one side of Phobos, then the other.]

**Clearly, a manned outpost on Phobos would immensely speed up global exploration of Mars, as well as pre-human-arrival site-preparation and construction of a first and any additional outposts so that when the first pioneers do arrive, they can get down to the real business of establishing a viable and enduring frontier presence. MMM**

## **Only 'Going to Mars To Stay' Makes Sense**

By Peter Kokh

**"Marstostay does not segue from Marsandback.  
Marstostay must be pursued instead of Marsandback."**



It is only to be expected that that people, even seasoned space advocates, would imagine “the first” manned mission to Mars to be a “souped-up version” of the first manned Moon-landing mission. But there is one critical difference. No matter how we do it, a “first” manned Mars mission will be an order of magnitude more expensive, even in 1969 dollars. In fact, the cost may be larger than the entire set of 6 manned Moon landing missions; and throw in the 2 non-landing missions, Apollo 8 (flyby) and Apollo 10 Snoopy (descent to within ten miles of the surface.

Humans are notorious for not learning the lessons of history. The Apollo program came to a not so glorious “Flags & Footprints” conclusion after the 6<sup>th</sup> successful landing. The lesson is that any expectation that there would ever be a 2<sup>nd</sup> Manned Mars landing, let alone an endless succession of landings, is an exercise in fairytale daydreaming. The odds are that the “been there, done that” shallowness of Aldrin and Obama will set in immediately after the first mission, or before work on a 2<sup>nd</sup> mission gets too far. “Flags & Footprints II “– this time on Mars, will be all the history books have to relate.

Unless ...

- **Unless** we pre-land equipment to produce (and keep producing) a nest egg of fuels, plastics, and other supplies from Mars’ atmosphere before the first crew arrives
- **Unless**, we pre-prepare the landing site, and pre-construct a modular outpost **not confined to the landing crew compartment** as the FMARS and MDRS Mars Society analog research stations presuppose. That complex should be livable long term, not something a crew can tolerate for a limited time.
- **Unless** we preland a greenhouse operation that has vegetables and salad stuffs ready to harvest when the first crew arrives
- **Unless** we design the first mission to leave crew members behind
- **Unless** the return crew capsule is large enough to return home with only a fraction of the crew
- **Unless** all crew members who volunteer for the mission are prepared to stay, free of personal and other ties to Earth, with the mindset of our forefather pioneers on the Mayflower

#### **A stay behind scenario**

If no one stays behind on Mars from the “first” manned mission, there is a strong possibility that there won’t be a follow-on mission, and if there is, the chances of no further follow-up increase each time. Witness Apollo. Those watching the public purse will cry “enough already” louder and louder each time. There is only one way to make a commitment, and that is for at least some of each crew, starting with the first, to stay behind.

Then, between departures and fresh arrivals, In order to accommodate fresh incoming crews, the outpost will have to grow and grow and keep growing. Again, per the previous article, equipment and robonauts operated from a forward base on Phobos would handle much of the expansion work, while remaining crew members handle things only humans can do.

#### **Inflationary Expansion**

The larger the percentage of crew members of each successive crew who stay behind, the faster the permanent population will grow. Here is the population growth chart for 5 incoming crews of 12 (over 11 years):

##### **If half of each crew go home each trip**

- 1<sup>st</sup> crew: 12 arrive (6 return) perm pop 6
2. 12 arrive (6 return) perm pop 12
3. 12 arrive (6 return) perm pop 18
4. 12 arrive (6 return) perm pop 24
- 5<sup>th</sup> crew: 12 arrive (6 return) perm pop **30**

##### **If only a quarter go home, then**

- 1<sup>st</sup> crew: 12 arrive (3 return) perm pop 9
2. 12 arrive (3 return) perm pop 18

- 3. 12 arrive (3 return) perm pop 27
- 4. 12 arrive (3 return) perm pop 36
- 5<sup>th</sup> crew: 12 arrive (3 return) perm pop 45

**If more ships arrived each window, growth would be exponential. So if only a quarter return each time:**

- 1<sup>st</sup> mission: 12 arrive (3 return) perm pop 9
- 2. 24 arrive 8 return) perm pop 25
- 3. 36 arrive 12 return) perm pop 49
- 4. 48 arrive 16 return) perm pop 81
- 5<sup>th</sup> mission: 60 arrive (20 return) perm pop **121**

**not counting children born on Mars!**

Plymouth, MA was settled in 1620 by 101 pilgrims on the Mayflower

### **Recommendations**

- Pioneers with an increasing genetic
- New recruits bring increasing diversity of occupational talents, educational backgrounds, and aptitudes.
- The physical complex of the outpost-becoming-settlement grows to support development of indigenous arts & crafts, sports and recreational activities
- The Right Mix – Men and women, single, unengaged, without dependents, and with diverse talents

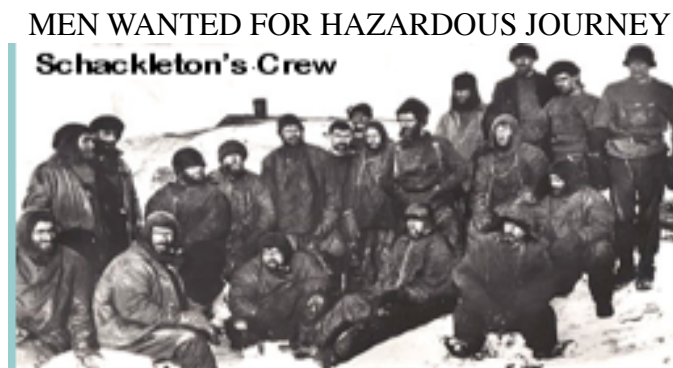
### **Perks for those committing to**

- Security benefits for anyone left behind on Earth
- Weight and volume import allowance on next flight for personal items (furnishings, hobby supplies, etc)
- Pick of better quarters, furnishings, hobby supplies

This plan prioritizes build-up of recreational, hobby, and other facilities, continued diversification of food, entertainment options, personal vehicles on Mars, getaway retreats and changes of scenery options, etc.

Outlying Outposts are needed

A settlement effort must be broad-based, access different resources, provide cultural, architectural and horticultural diversity, for insurance against catastrophes, and to begin appropriating the planet at large. If you think this scheme is unworkable or outrageous, don't volunteer! Consider the siren call Ernest Shackleton placed in the London Times in 1905:



Small wages, bitter cold, long months of complete darkness, safe return doubtful.

Honor and recognition in case of success.”—Ernest Shackleton

Five thousand eager men answered that ad! Are those with such “right stuff” a vanishing breed? Has our society become so risk averse that no one will answer a no-punches-pulled call to pioneer the frontier? We think not. Forget the Earth-lullabied majority. Blessed are “the second best” – those of us who are restless despite everything life in these times can offer us, who sense we don't quite fit in, who yearn for a chance to start fresh, those of us willing to

make space a place. That is the history of human expansion, first within Africa, then “out of Africa.” As always, pioneering is the work of those who accept the considerable risks, the large chance of failure, and the hardships sure to come. – There will be plenty of volunteers, even after vigorous vetting.

### “Mars to Stay” gains support

Robert Zubrin’s “Mars Direct” steers clear on this issue, but his rhetoric and passion make it clear, that establishing a new frontier, not mere exploration of an intriguing planet, is the passionate dream that drives him. His novel, First Landing, makes that clear. A woman astronaut discovers that she is pregnant and refuses to return home; then the astronaut involved, owns up to his responsibility and insists on staying behind with her.

That said, Zubrin has not adjusted his “Mars Direct” scheme to provide for the possibility that some crewmembers may make such a decision. To get to Mars in the first place, requires support from those too timid to wrap their minds around such options.

Type “Mars to Stay” in your Google search box



72,500,000! MTS advocates are a minority, yes, but are becoming ever less shy about their conviction. And we need to return to the Moon in the same fashion, with the same preparation, and with the same determination.

Now government space agencies, which must proceed with the approval of the majority who will surely ridicule such ideas, will not plan for such scenarios. That is why any outpost plans which freeze out corporations and the private sector must necessarily fail. Constellation was such a sterile program, and “sterile” is the apt word. We need a program for both Moon and Mars, that in its design is “pregnant” with open-ended possibilities and preparations. Space is for the bold, not the timid! PK

## ACCESS TO MARS:

### A Fully Re-usable Mars Ferry – Logistics and Transport for Crew and Cargo

John K. Strickland, Jr. ([jkstrick@io.com](mailto:jkstrick@io.com)) 2-28-2011

Engineering analysis and support by Engineer Raghavan Gopalaswami, Hyderabad, India

This article is a **preview** of a fully detailed presentation and paper for the 2011 ISDC in Huntsville. It will focus on the Mars Ferries themselves. These ideas originated about 20 years ago during the NASA Outreach 1990 and after the advent of Mars Direct. Since 2005, the full extent of the Mars EDL (Entry, Descent and Landing) problem has become very apparent. Much of the credit for the work to identify and focus attention on it must go to Dr. Robert Braun and his colleagues at Georgia Tech. Dr. Braun is now Chief Technologist for NASA.

### Human Mars Exploration Concepts

When Robert Zubrin’s Mars Direct concept burst on to the scene over 20 years ago, it was clear he had made a very major advance in thinking about Mars Missions, with the concepts of using local materials like CO<sub>2</sub> to produce propellant and pre-positioning of equipment for redundancy. Zubrin intended his concept to be used for permanent occupation of Mars. However, his original design maintained no active operational base in Mars orbit and is based on all-expendable launchers and vehicles, which virtually forces any human Mars program based on them to be an unsustainable flags and footprints type program as conducted by a government, no matter the sincere intent of the designer.

Rationale for a Low Mars Orbit (LMO) Base to support Mars surface base Logistics

A space-faring civilization needs to be able to operate both on planetary surfaces and in orbit for maximum effectiveness, such as increasing payloads to Mars per ton delivered from Earth. The Ferry concept assumes the creation of a LMO Base to support the crew and continuing orbit to surface base logistics operations. It would also maintain a redundant cryogenic propellant supply in the LMO Depot for the departure from Mars orbit to Earth. A special transit vehicle would carry each Depot from Earth Orbit to LMO while full of propellants, using aerocapture and an orbit trim maneuver. The Depot allows the continuing storage of cryogenic propellants in LMO without loss to boil-off using a combination of sun-shields, super-insulation, and active cryo-coolers.

#### Why We Cannot Land Humans on Mars Right Now

Right now, in 2011, we **cannot** land anything larger than the ~1 ton Mars Science Laboratory rover on the surface of Mars. This is called the Mars EDL problem (Entry, Descent and Landing).

**No** combination of available parachutes, reentry shields and terminal descent rockets can land even a 10 ton payload on Mars. This problem first got serious attention in 2005, so the field is only about 5 years old. Things decelerate differently in a thin atmosphere. (On the Moon, we just decelerated and landed with pure rocket power since there was **no** atmosphere). Earth's dense atmosphere slows reentering spacecraft to about Mach 1 at about 25 miles high. The atmosphere density of Mars at the surface is like that of Earth at 36 miles up. It slows objects from orbital velocity to about **local** Mach 5 – assumed to be about 543 mph). Below that speed, it is too thin to continue to slow a spacecraft enough all by itself. You could use expendable parachutes, ballutes or hypercones to slow down, but the object here is to produce a fully re-usable vehicle.

It is really hard to slow down after entry, since we would be about to hit the surface at supersonic speed. We are glad that Mars has an atmosphere, but if Mars had no atmosphere, it would be easy to land on; it just would take a lot more fuel. With an atmosphere, the descent engines probably cannot fire during the peak period of reentry. However, they may be able to fire during or at the end of reentry (starting at about 3200 mph or about local Mach 6.)

Supersonic Retro Propulsion (SRP) requires rocket engine thrust firing directly through the heat shield and against the supersonic flow of air pressing against the base of the vehicle as it decelerates. The rocket engines must be fixed in position with the nozzle ends flush with and sealed to the heat shield and thus they cannot gimble for steering. Instead this is done by varying the thrust of individual engines or by using small side-mounted vernier engines. SRP appears to be crucial to future access to Mars. No rocket vehicle has ever flown backwards at high speed in the same direction as its thrust. SRP's viability could be proven with a few inexpensive sub-orbital tests.

#### Think Re-Usable: The Case for Re-usable Mars Ferries

The debate over re-usable launch vehicles has been going on for decades while the debate over re-usable spacecraft or IN-space vehicles is just starting. Current scenarios for Manned Lunar or Mars landings envision a large lander which has, inside it (Mars) or on top of it (Moon), another **entire** vehicle for the ascent with its own engines, tanks, controls, structure, etc. I call this a Matryoshka-style architecture, after the traditional sets of Russian Nested Dolls, (Matryoshka) which are a metaphor for an object with another similar object inside.

Thus every new trip to the surface requires an entire additional pair of vehicles with all of the descent propellant, all of which has to be brought from Earth. It wastes all of the perfectly good descent equipment, leaving the crew dependent on the ascent vehicle. This exposes them to a loss of crew risk caused by a single vehicle failure, since there is no practical escape system, especially during ascent. Apollo astronauts were exposed to this risk on liftoff from the lunar surface 6 times. This architecture leads to the extremely marginal "one-way" Mars trips currently being proposed by some of those desperate to see any kind of Manned Mars Mission occur during their lifetime.

With a **fully re-usable vehicle**, nothing is thrown away. The descent engines, fuel tanks, and vehicle structure can also be used for the ascent. Fewer ferries would need to be built and shipped from Earth to Low Mars Orbit. It increases reliability & safety after the **first** use of each vehicle (which is the riskiest use). Having the vehicles after the first use provides additional backup vehicles for rescue. It allows replacement of failed internal equipment modules (which would all be designed for rapid swapping) from older (retired) vehicles. It does require an integral (to the vehicle) aero-shell for reentry, since the entire exterior of the vehicle would be exposed to some entry heating during descent. Cargo items would be inside the ferry, fully protected from entry.

New information about Mars affects the ferry design

20 years ago, we had no knowledge of the widespread existence of water on Mars in the form of relatively pure subsurface ice deposits and ice regolith, some fairly close to the equator. Mars Direct (1989) and related concepts assumed we would bring hydrogen to make methane fuel from all the way from Earth. Now we know that hydrogen can be obtained from Mars ice in large enough quantities to use as a fuel directly.

Producing liquid oxygen and hydrogen propellants at a Mars surface base would **not** be an exotic zero-gravity technology that still needs to be developed. Since we will have the ability to maintain the cryogenic (LOX-H<sub>2</sub>) propellant supplies both in orbit and on the surface, we should use them, due to the huge advantage in allowing a surplus of Mars-derived propellant to be delivered to and used in orbit.

### **The SSTOAB Fully Re-Useable Mars Ferry – Transport and Logistics System**

The Mars Ferry is essentially a Single Stage to Orbit And Back (SSTOAB) vehicle for Mars. Mars has about 1/10th of Earth's mass, and is about 8 times the lunar mass. Mars gravity is 38% of Earth's, so achieving low orbit is much easier than on Earth – about 2.1 miles per second (4.1 km/sec) instead of over 5 miles per second. This means reaching LMO it takes only about ¼ of the energy needed to reach LEO. (On Earth, an SSTO can barely reach orbit even with zero payload). If there is no staging, then there is no first stage to recover – the entire vehicle goes to the orbital “base” and back to the surface base – intact. Much less fuel is needed to land than to return to orbit since reentry sheds up to about 2.4 km/sec of speed (out of the initial 3.36 km velocity).

What would the Ferry look like? Since the air on the surface is so thin, air resistance and “Max Q” (maximum dynamic pressure) on ascent are not significant issues. This means we do not need to make the vehicle narrow like the pencil-shaped boosters used on Earth. During descent, propellant tanks would be only 16% full, reducing vehicle density. Wide base vehicles with more cross section exposed to friction, and with lower density slow down more during reentry, and thus need less propellant to land than a narrow base vehicle. During entry, a conical, capsule like shape is known to be stable, and would require less internal structure and less external shell surface than a long, narrow vehicle. The current design has the ferry shaped somewhat like a giant Apollo capsule, slightly taller (18 meters) than wide (14) meters if the crew capsule is included. It would have a cargo hold capable of carrying a 25 ton payload to the surface. The hold is a horizontal box-shaped area which would be located just above the engine compartment and extending through the middle of the vehicle to accommodate cargo or containers about 4.5 by 4.5 by 8 meters long.

Two types of fully reusable Ferry vehicles are proposed: a Cargo Ferry and a Crew Ferry. They would be identical, except that the Crew ferry would carry a 5 ton combination crew cabin and escape capsule for abort to surface or abort to orbit self-rescue during in-flight emergencies, so it can only carry 20 tons of cargo down. The crew would never be exposed to a single failure leading to a fatal crash. In case of a vehicle failure or loss of control in flight, the crew cabin would separate from the ferry and the crew would descend to the surface or return to orbit under power. This capability could be used during both descents and ascents.

Payload to orbit for both vehicles is 20 tons, including the crew capsule for the crew version. The cargo hold for both versions would normally be empty during ascent. A ferry can

carry either 15 or 20 tons of LOX–Hydrogen back into to orbit for use on the next trip down, because there is little or no cargo other than propellant to go up. Rock samples for return to Earth would amount to a few hundred pounds at most. About 5 tons of extra propellant would be loaded into the orbiting Depot for use by other vehicles by the cargo ferry only. Each vehicle would be retired after about 10 flights depending on engineering calculations of overall system reliability compared to safety on the very first flight.

The Ferry’s main rocket engines would be mounted in a unique way: fixed in position, not gimbled. The nozzles would be flush with the base heat shield and integrally attached to it, to prevent entry of hot air flow and rocket exhaust gases into ferry’s interior. Steering would be done by varying the thrust of individual engines. With 8 main engines, there would still be three pairs left to power and steer the vehicle, in the case of a single engine failure providing an engine–out capability. The engines would be mounted in a ring close to the outer rim of the base heat shield and would probably be canted out at an angle of about 20 degrees.

**Approximate Mass Mars Cargo Ferry Configuration**

(The **Crew** Ferry carries a 5 ton crew capsule and thus carries only 20 tons of payload Down and 15 tons of propellant Up)

| CONFIGURATION    | DESCENT        |             | ASCENT       |             | Rounded Values in <u>Metric</u> Tons |
|------------------|----------------|-------------|--------------|-------------|--------------------------------------|
|                  | Mass           | %           | Mass         | %           |                                      |
| <b>Payload</b>   | - 25 tons      | 36          | 20           | 16          |                                      |
| <b>Structure</b> | 30 tons        | 43          | 30           | 24          |                                      |
| <b>Fuel</b>      | 15 tons        | 21          | 75           | 60          |                                      |
| <b>TOTAL:</b>    | <b>70 tons</b> | <b>100%</b> | <b>125 t</b> | <b>100%</b> |                                      |

A trip to the surface would start with a loaded ferry with 15 tons of propellants in the 400 mile LMO. It would perform a small de–orbit burn about 180 degrees around Mars from the surface base site. The resulting elliptical Hohmann transfer orbit would intersect the atmosphere and have an “aim point” (deliberately inside the atmosphere) of about 60 km or less, depending on the exact trajectory design. The following table shows the descent sequence. NOTE the difference between absolute and relative (to the surface) velocities! [see table p. 8]

After landing and unloading its cargo at a fully operational base, a Ferry would be re–fueled with 75 tons of LOX and LH2, along with 15 or 20 more tons of fuel as payload and begin its ascent back into Low Mars Orbit at 400 km high. This requires a delta–V of 4.2 km/second with a circular orbital speed reached of 3.36 km/second using an ascent mass ratio of 2.52.

**Mars Entry Descent & Landing Sequence**  
(DETAILED DECELERATION BUDGET FOR EDL)

Descent Delta–V Requirements met with mass ratio 1.39

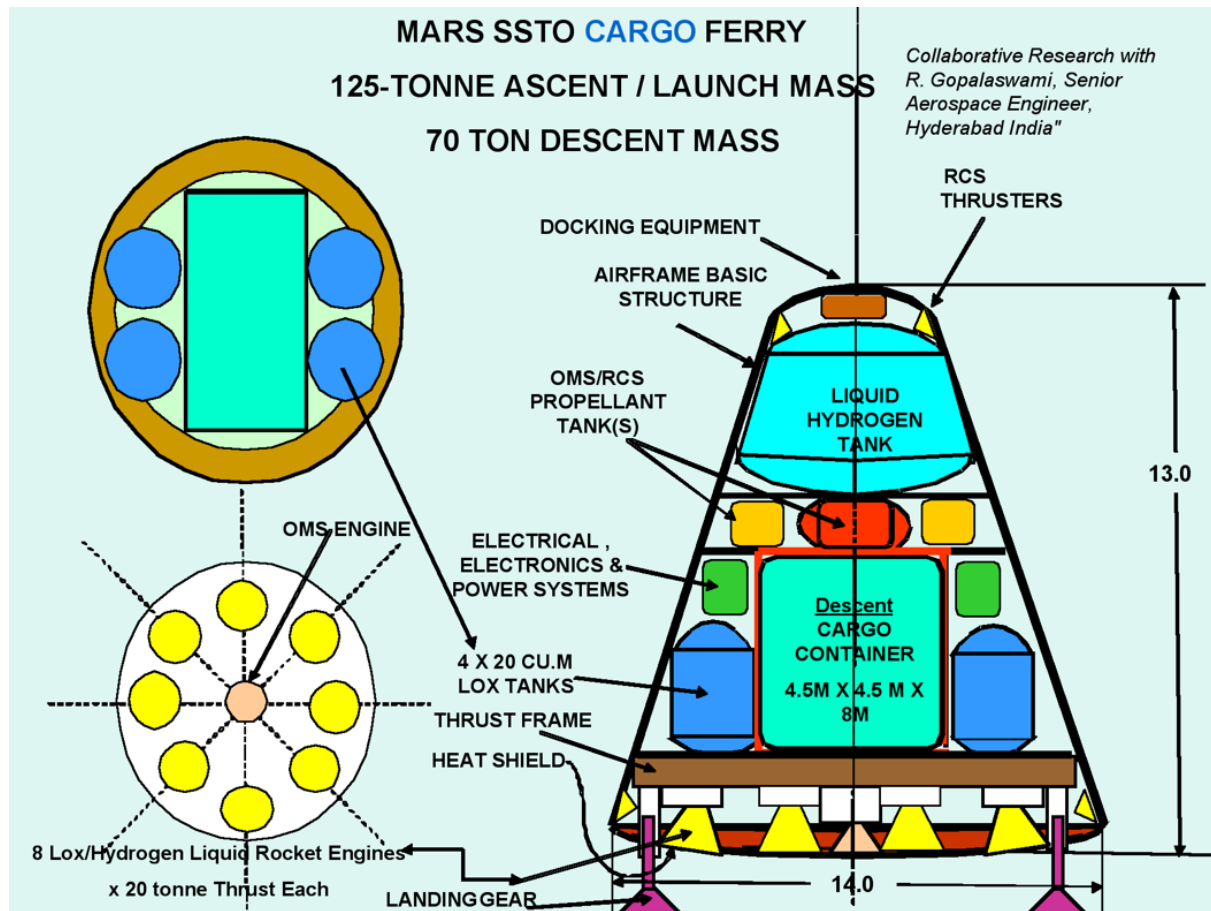
NOTE the difference between absolute and relative (to the surface) velocities!

| Velocities at each stage of EDL                              | Delta–V Remain. | Velocity |
|--------------------------------------------------------------|-----------------|----------|
| Starting V. 400 mi circular orbit ( <b>absolute</b> )        |                 | 360 m/s  |
| $\Delta V$ de–orbit burn fr Low Mars Orbit                   | - 82 m/sec      | 3282 m/s |
| Approx entry V. at <b>118</b> km (absolute)+ 260 (gravity)   |                 | 3542 m/s |
| Subtract Mars rotational velocity ( <b>not</b> $\Delta V$ )  | -               | 240 m/s  |
| Relative Vel. to shed to Mars surface at Entry – Total       |                 | 3302 m/s |
| Approximate Total Velocity shed from passive entry drag      | - 2406 m/sec    | 896 m/s  |
| Delta–V to perform <b>S.R.P.</b> from ~Mach 4 to < Mach 1    | 606 m/sec       | 290 m/s  |
| Entry Drag <b>simultaneous with</b> SRP Phase (1/4 of total) | 202 m/sec       | 88 m/s   |
| Remaining V. removed during final Landing Phase              | <b>88</b> m/sec | 0 m/s    |
| Total passive drag deceleration:                             |                 | 2608 m/s |

|                                                            |          |
|------------------------------------------------------------|----------|
| Total Propulsive Descent $\Delta V$ (H <sub>2</sub> -LOX): | 776 m/s  |
| Reserve $\Delta V$ (for hover and translate margin):       | 328 m/s  |
| Total $\Delta V$ Capacity of descent configuration:        | 1104 m/s |

### Surface Base Integration and “Bootstrapping”

It is important to realize that the LMO base, the surface base, propellant production equipment and transport vehicles are an integrated system, which is **not** complete until fuel production begins and ferry vehicles can return to LMO. To support continued construction of the surface base, you need the source and store of LOX and liquid hydrogen on the surface (ISRU) and a large propellant supply in orbit (stored in the Propellant Depot) to operate the Ferries repeatedly, once fuel production begins. This means the base site must be where ice exists underground. Once a base site was picked, fuel producing equipment would be the first payloads sent down to the surface by cargo ferries. The equipment could be offloaded and set up via tele-operations by crew in LMO.



### Mars Ferries compared to expendable landers

Without reusable vehicles, you have to bring to LMO from Earth an expendable cargo lander and all of its propellant for every 20–25 ton cargo you want to use on the surface.

With reusable vehicles, you can make repeated trips, saving 1.8 tons brought from Earth for every 1 ton delivered to the surface. Duplicate crew Ferries would also be available for emergency flights back to orbit. They would also allow a larger crew (a minimum size of 12), with a greater range of skills such as medical, for improved safety.

This also means more exploration and science will get done. The ability to bring fuel back to Mars orbit means the Earth return vehicle can use cryogenic fuel for its departure from Mars. Most importantly, reusability tips the balance of mass brought from Earth away from vehicles and fuel and towards usable payloads landed at the surface base.

Permanent orbital and surface bases can thus be established with the very first human mission, bypassing the “Flags and Footprints” architecture phase. The bases can then be counted on as existing refuges for the next mission, with equipment health monitored from Earth or Mars surface (or Phobos).

#### **What do we need to support such a plan?**

- Define and accept clear, supportable goals for the Mars expeditions, such as deep drilling for life.
- Agree on a clear, politically and financially sustainable budget commitment for the program.
- Agree that the **initial** architecture fielded to access a new destination (Mars or the Moon), **needs to be reusable from the very beginning.**
- Agree on an internationally supported Mars program effort, with each participating country getting to build major segments of the equipment depending on their commitment level.
- Create an HLV manifest to clarify the demand for large payload launchers.
- Develop fully re-usable private HLV boosters capable of launching payloads with a wide diameter to get the large mass of equipment and propellants into LEO and keep the launch costs down.
- Create an integrated IN-space transport and logistics system consisting of standardized vehicles, equipment, modules and stationary nodes, such as propellant depots to support the LEO zone effort.
- Continue a multi-arena basic Technology Development program including flight tests of Supersonic Retro-propulsion using sub-orbital vehicles in Earths atmosphere.
- Design and Integrate the Mars mission vehicles and bases.

#### **Lets Keep Going to Mars**

Our objective is to create a capability for continuing Manned Mars exploration. Let us use the time until the First Mars Expedition to make sure that once we go there, we can afford to keep going there. Assuming the first expedition would take place after 2030, we have over 20 years to create Re-usable space vehicles. Surely that is time enough to do it.

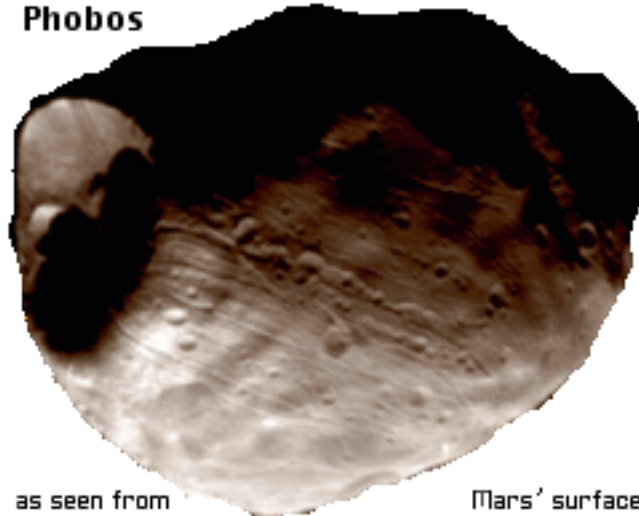
#### **Major SRP Papers:**

<http://soliton.ae.gatech.edu/labs/ssdl/> (Go to SSDL papers / Conference Papers)

MMM #243 - MAR 2011



Phobos



as seen from

Mars' surface

## The Most Economic Way to Open Mars: Construction Equipment and Robonauts, Telepresence-operated in near real-time from Phobos directly, and via co-orbital relays

By Peter Kokh

In the previous issue of MMM, #242, we talked about how pre-human missions to the Moon, bringing teleoperable equipment and telepresence-operated "robonauts" could speed up realization of a first human outpost, and do so at greatly reduced expense. Human crews would arrive ready to do what they came to do. All the site preparation and construction chores would be done beforehand by robotic predecessors who do not tire, do not get bored, do not need rest or relaxation, do not need life-support, etc. And now, with the arrival of Robonaut 2 or "R2" at the International Space Station, to join the crew, the new Space Age 2.0 of human-robonaut synergy is upon us. This is an historic moment!

If robonauts can speed up the realization of a Mars outpost and get it ready for the first humans, at a similar savings, then we must rewrite our Manned Mars Mission scenarios accordingly. **But there is a significant difference between where we are at on the Moon and where we are at on Mars.** Our orbital mineralogical exploration of the Moon is much more advanced. But more to the point, rovers on the Moon can be teleoperated from Earth in near real-time. On Mars, which varies from 35 to 400 times as far from Earth as the Moon, time delays are measured not in single digit seconds but in minutes: from 6 minimum to 40 maximum, as Mars distance from Earth varies greatly. What has taken 7 years for **Opportunity** and **Spirit** to do on Mars, would have taken perhaps a month to accomplish on the Moon.

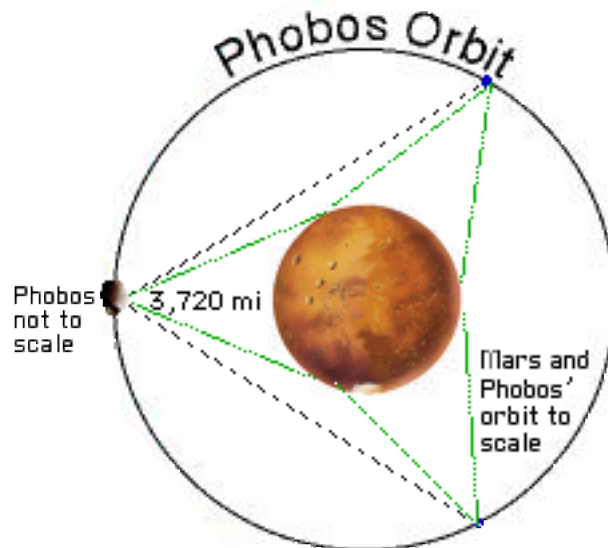
If we are going to really explore Mars – so that we know better where the resources are and where best to set up shop – a **Forward Teleoperations Base in orbit around Mars is absolutely necessary.** And not just anywhere in Mars orbit, on Phobos!

### Why an Outpost on Phobos?

Wouldn't a small "Space Station" in some other orbit around Mars do just as well? Back around Earth, ISS gets significant shielding from cosmic radiation and solar flares from the Van Allen Belts. Mars lacks a magneto-sphere and hence lacks similar belts. Astronauts in a Mars orbit space station would be much more exposed.

An outpost "on" the surface of Phobos would be less exposed (to just one half of the celestial sky). But, given Phobos' mini-gravity, its "regolith" dust blanket has been much less compacted than that of the much more massive and significantly larger Moon. It should be relatively easy to pile up a blanket of protective Phobos dust powder over the modules of any complex.

From Phobos a bit less than half of Mars is visible at any time, but a pair of unmanned relay satellites in Phobos orbit 120° ahead and behind Phobos respectively, would allow teleoperation of probes, rovers, and robonauts anywhere on Mars surface except at either pole.



The time delays involved are minimal, and even if relayed, would be much less than the time delay between an Earth–Moon L1 station and the Moon’s surface. In fact, the perceived delay would be much less than that of global telecasts on Earth via Geosynchronous orbit. The near “real–time” control of rovers, construction equipment and telepresence–roboanauts would allow extensive global operations on Mars. In contrast, a manned outpost on Mars would (without satellite relays) be confined in its reach of operations to a very local area.

**Phobos** is 7.24 times as massive as Deimos. It is named after the Greek god Phobos (“fear”), a son of Ares (Mars). Phobos orbits about 9,377 km = 5,827 mi from the center of Mars, 3,719.5 miles above Mars’ surface, closer to its primary than any other known planetary moon. Its orbital period is 7h 39.2m. It orbits so close to the planet that it moves around Mars [more than three times] faster than Mars itself rotates. As a result, from the surface of Mars it appears to rise in the west, move rapidly across the sky (in 4 h 15 min or less) and set in the east.

[Because it orbits so close to the surface, at moonrise and moonset, from on the surface of Mars, one would peer a bit around one side of Phobos, then the other.]

**Clearly, a manned outpost on Phobos would immensely speed up global exploration of Mars, as well as pre–human–arrival site–preparation and construction of a first and any additional outposts so that when the first pioneers do arrive, they can get down to the real business of establishing a viable and enduring frontier presence. MMM**

- Define and accept clear, supportable goals for the Mars expeditions, such as deep drilling for life.
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- Agree that the **initial** architecture fielded to access a new destination (Mars or the Moon), **needs to be re–usable from the very beginning.**
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<http://soliton.ae.gatech.edu/labs/ssdl/> (Go to SSDL papers / Conference Papers)

Note the city lights of settlements.

Mars will look very large from Phobos, many times the apparent size of the Moon from Earth. [We've had this painting in our files for years, but have never been able to determine the identity of the artist. If you know, contact [kokhmmm@aol.com](mailto:kokhmmm@aol.com)

MMM #253 - MAR 2012

## The Challenges Of Mars

By Peter Kokh, onetime Martian "wannabe"

Many people are understandably more enthusiastic about the prospects of human exploration and eventual settlement of Mars than they are about further human missions to the Moon. The Moon is enormously more visible in our skies, even at times in the daytime, than Mars, and we are bored with its unchanging gray tone appearance. "Familiarity breeds contempt," as the proverb goes.

Mars, while less frequently, and much less revealingly present in our skies, has become legendary through science fiction as well as by early misunderstandings of the planet's current climate, similarities to Earth, and of the challenges of thus who would transform Mars into a more Earth-like human frontier by "terraforming."

Make no mistake, Mars will play an enormous role in humanity's future. But we will be in a better position to move in that direction, if we better understand the challenges the Red Planet poses for us.

**Mars temperature range is much lower than Earth's or that of the Moon**

[http://en.wikipedia.org/wiki/Climate\\_of\\_Mars](http://en.wikipedia.org/wiki/Climate_of_Mars)

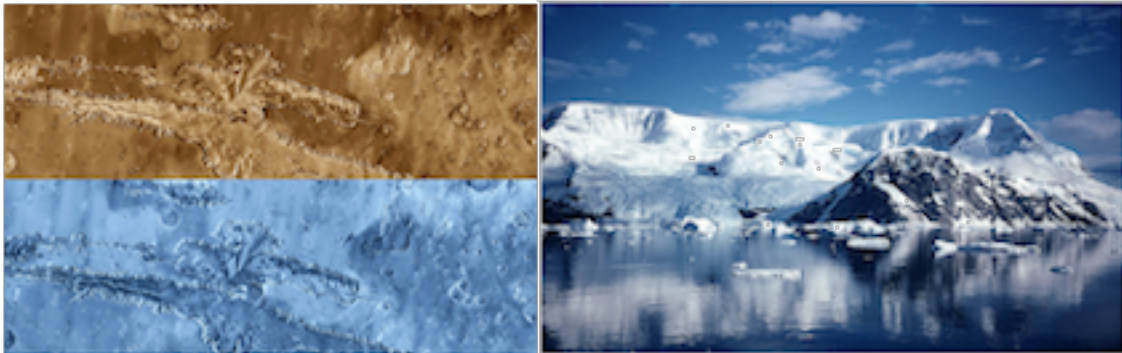
"Surface temperatures have been estimated from the Viking Orbiter Infrared Thermal Mapper data; this gives extremes from a warmest of 27 °C (81 °F) to -143 °C (-225 °F) at the winter polar caps.[17] Actual temperature measurements from the Viking landers range from -17.2 °C (1.0 °F) to -107 °C (-161 °F)."

[http://en.wikipedia.org/wiki/Climate\\_of\\_Mars#Temperature](http://en.wikipedia.org/wiki/Climate_of_Mars#Temperature)

In fact, these figures are very similar to the temperature range on Antarctica, which few people seem anxious to settle despite the continent's fresh breathable air and surrounding fish-teaming waters, and its improving accessibility from other, populated, regions of Earth.

[http://en.wikipedia.org/wiki/Climate\\_of\\_Antarctica](http://en.wikipedia.org/wiki/Climate_of_Antarctica)

[http://en.wikipedia.org/wiki/Climate\\_of\\_Antarctica#Temperature](http://en.wikipedia.org/wiki/Climate_of_Antarctica#Temperature)



Mars may look amazingly like Arizona, but we must not fool ourselves. It will feel much more like Antarctica!

<http://www.moonsociety.org/home-page/center-column/changing-images/showimage.php?image=112>

It is puzzling many would-be Mars pioneers have made “life-style” decisions to relocate from the “snow-belt” to the “sun-belt.”

Given that Mars has thin atmosphere and lack of a protective magnetic field provides little protection from cosmic rays and solar flares, we will have to shield ourselves under a blanket of “Mars dust” or loose soil (within lava tubes is another option) at any rate, and this will greatly moderate temperature swings. But make no mistake. The average temperature on Mars at a depth of 2–5 meters is 50° C lower than on the Moon. That means, that whereas Lunan pioneers can store excess dayspan heat for nightspan heating and nightspan cold for dayspan cooling, on Mars, no such easy way to moderate interior temperatures exists. Martian pioneers will need to be tapping various sorts of energy to warm themselves year-around.

For many would-be pioneers, this constant “war” with Mars climate will be too demoralizing. Pioneers from Earth’s cold desert regions will fare much better than those who enjoy sun-bathing on Earth! We do not want to discourage anyone. Humans will meet the challenge. But many Mars enthusiasts need to remove their sunglasses. Even if they realize that Mars is not for them, we encourage them to keep supporting human missions to Mars!

### **Mars’ Long Irregular Seasons**

[http://en.wikipedia.org/wiki/Climate\\_of\\_Mars#Seasons](http://en.wikipedia.org/wiki/Climate_of_Mars#Seasons)

One of the characteristics of Mars that has long endeared this “future homeland” to would-be pioneers is that Mars has a climate pattern very much like Earth’s Winter, Spring, Summer, Fall, with the seasons in the Southern Hemisphere in inverse sequence from those in the Northern Hemisphere, again as on Earth. But there are two significant differences,

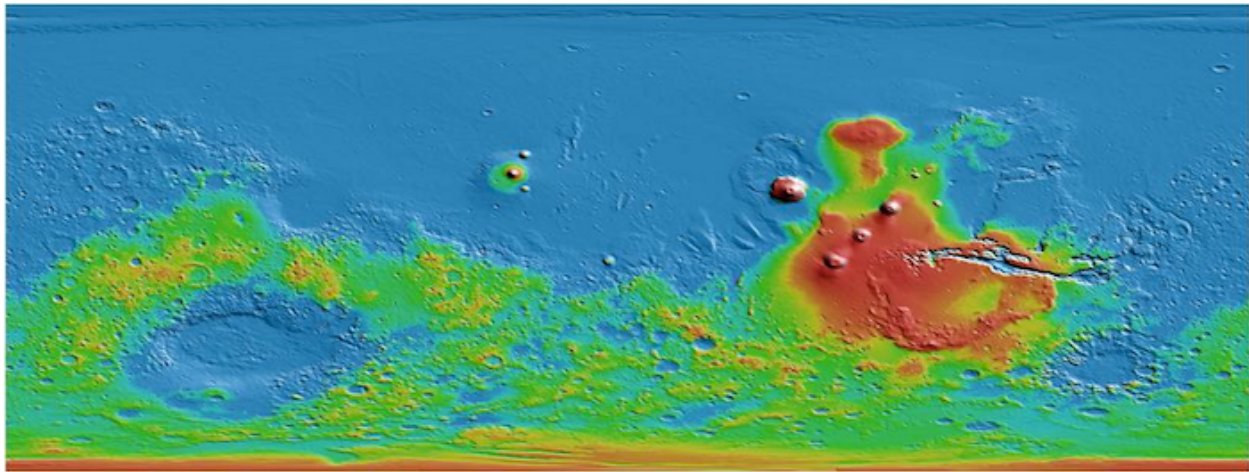
- The sequence is not “cold” – “moderate” – “warm” – “moderate” but rather “very very cold” – “cold” – “moderate” – “cold”
- As Mars orbit is significantly more eccentric, bringing the planet much closer to the Sun during Southern Hemisphere Summer and much further from the sun during Northern Hemisphere Summer as attractive as some northern sites may seem for settlements, the Northern Climate will be the more challenging. To make it worse, since Mars slows down in its orbit when as it gets further from the Sun, colder Northern Spring (=Southern Autumn) and Northern Summer (= Southern Winter) will be longer than their warmer Southern counterparts. “Daddy why can’t we move to the South? Please!”

Again, since the pioneer habitats will be under the surface at a level where the year-around temperature will be a constant “cold”, future Martians will only notice these climactic differences when they are out on the surface. Now many look forward to the eventual terraforming of Mars: “Red Mars -> Green Mars -> Blue Mars “(but Kim Stanley Robinson

forgot a color/stage between Red Mars and Green Mars – Muddy Mars! “Terraforming” (making Mars more Earth-like) vs. “Rejuvenescence” (meeting Mars halfway) is a whole separate topic in which there is a dire need for realism and respect for Mars. We will bring this up in another issue, perhaps # 263, next year.

<http://www.moonsociety.org/home-page/center-column/changing-images/showimage.php?image=115>

Meanwhile, in choosing sites for a first outpost (hopefully located where it can grow into a viable permanent settlement rather than be doomed to become a historic preserve or the first “ghost town on Mars”) the implications of Mars’ irregular seasons will be taken into account along with other, economic advantages. We have previously written about the unique and superior advantages of a location on the western slopes of Mars Pavonis astride the equator (riddled with lava tubes; ideal site for a launch track up the western very gradual slope, from which spacecraft and payloads could be launched directly into an Earth-Moon rendezvous orbit.) Another site which has unequalled characteristics is Hellas Planitia in the southern hemisphere, the lowest basin on Mars, in which atmospheric pressure will always be the highest, giving it marginally the best climate on Mars.



The mercator map above has been vertically compressed to 75%. The blue areas are below “sea level” and do not indicate ocean beds, but they are where oceans could have been located, “if.” The large blue basin at left is Hellas. On the right we see three volcanoes in a slanting row. Pavonis Mons is the middle one, smack on the equator. This whole “red” area is one lava sheet on top of the other and probably riddled with lava tubes with a “world” of pre-sheltered volume, and could hold the bulk of settler population in the future. Pavonis was the site of a space elevator in Arthur C. Clarke’s “Fountains of Paradise.”

Can future pioneers adjust to Mars’ long and irregular seasons? Of that, I have no doubt! There have been many attempts to create a Mars Calendar. All of them respect the length of Mars’ year, but only one reflects Mars actual seasonal patterns while minimizing cultural implications of the length of Mars year. You are invited to check out my “Mars Pulse” calendar.

[http://www.moonsociety.org/publications/mmm\\_papers/marspulse\\_cal.html](http://www.moonsociety.org/publications/mmm_papers/marspulse_cal.html)

### **The Challenges of Shielding Habitats on Mars**

On the Moon, thanks to Apollo on location measurements, we have a good feel for how deep the moondust “regolith” blanket is, and how that depth varies. In the more recently formed lava flows that feel many of the Moon’s impact basins and other lowlands, as these areas have not been subject to as much bombardment as have the much older “highlands” the blanket is generally 2–5 meters, whereas in the highlands it can be as thick as 10 meters. In both cases, this is more than adequate for the purpose of “tucking our habitats under a blanket” to shield not only from cosmic rays and solar flares, but also for moderating interior temperatures through the dayspan-nightspan-dayspan cycle.

On Mars, we have much less feel for the depth of the Marsdust “regolith” blanket. But clearly, as Mars does have a thin atmosphere, the winds have concentrated dust to great depths in “dunes” areas, and scraped the surface nearly clean in other areas where patches of bedrock were quite visible to the passing through cameras on the Mars Exploration Rovers **Spirit** and **Opportunity**, witness the image on the cover page.

In the “dunes” areas, which are quite extensive, we could place a habitat complex in between dunes and pull down the marsdust on top. These dunes do move, as do their counterparts on Earth, but given the greatly reduced power of Martian winds, these changes will be tolerably slow. Another suggestion is to burrow into a mountain side. Sounds easy, but that could be quite a project!

Yet another idea, and a good one, is to use what soil is available to make mars bricks or blocks and build a sheltering structure with them. At the least, a perimeter of Mars blocks or bricks could be used to tightly contain marsdust so that we need less of it.

But where the surface dust is not very deep, shielding may require import of marsdust from elsewhere, hopefully nearby. It is quite clear that the availability of shielding material must be a consideration in choosing a site to locate any outpost that we intend to be the seed of a permanent settlement. It is not at all clear that anyone had considered this.

The way pioneers shield themselves in various areas on Mars, will create a characteristic “architectural style” that will encourage visiting tourists from Earth, as well as from any settlement on Mars, to travel to other areas for one of the reasons tourists on Earth to visit “different” and “distinctive” regions on our home planet. And that will be a plus for the infant Mars’ economy.

The challenge of keeping habitat spaces at “room temperature” will be greater at distances north and south of the equator, as it is here on Earth. Our prediction is that Mars pioneers, if carefully selected or self-selected, will be up to the challenge. The results will add to the tourism-worthy differences between different settlement clusters on Mars.

### **Mars has as much land area as all Earth’s continents combined**

That’s a challenge? Well, that’s a lot of land to settle. Settlements could be antipodes apart. There could be clusters of settlements here and there with great stretches in between providing transportation challenges. It may be quite a while before there is any sort of circum-global road network. The implications are that unless the original settlements are “clustered” in a way that makes mutual access (trade, collaboration, sports, rescue, etc.) easy, it will be that much more difficult to build a “Mars economy.” Yet there are in fact areas that will not be soon mutually accessible but yet are each attractive for settlement. My choice would be the lava-flow-built Tharsis Ridge which gives access to the Valles Marineris area, the most scenic tourist-tempting area on Mars. Other areas can come later. If NASA or an international collaborative effort are tasked with setting up just one location, not looking at the options for growth, they will pick a site fated to be that “first ruin” on Mars; \ (regolith depth varies much lava tubes (Pavonis, Olympus, etc.

### **The Import/Export Challenge of Mars**

Mars is a long way from Earth, or rather from the Earth-Moon “economy” – in terms of the speed of light, a 6-40 minutes conversation gap vs. less than 3 seconds. In terms of one-way travel with present rocket technology, 6-9 months vs. 3 days. But that is the least of it. The Moon is in an orbit around Earth at a distance that does not vary greatly. Travel between the two is possible at virtually any time. Earth and Mars are in two different orbits around the Sun. Mars has a longer trip to make at lower speeds. They “line-up” every 25 plus months. So travel “windows” are brief (a month or so) and infrequent. And we must not overlook that some of these launch windows, as many as 2 or 3 in a row, may be in “Active Sun” periods in which the possibility of Coronal Mass Ejection solar flares could erupt with not enough notice, endangering those caught in space en route.

Someday, Vasimir-type rockets (“technologically infeasible” say some, “not” say others) and nuclear-thermal rockets could shorten the travel time and widen the departure-arrival windows. That will ease things greatly for travelers.

[http://en.wikipedia.org/wiki/Variable\\_Specific\\_Impulse\\_Magnetoplasma\\_Rocket](http://en.wikipedia.org/wiki/Variable_Specific_Impulse_Magnetoplasma_Rocket) (Vasimir)  
[http://en.wikipedia.org/wiki/Nuclear\\_thermal\\_rocket](http://en.wikipedia.org/wiki/Nuclear_thermal_rocket)

It is clear that import and export supply runs will have to be planned well in advance. It will be vital to stockpile needed supplies – enough to last perhaps two cycles c. 51 months, over 4 years! Whereas lunar settlements can live and thrive at the end of an “**umbilical cord**,” for **Mars**, a “yolk-sac” situation is the only one viable under travel conditions currently feasible.

For both Moon and Mars, the principle export markets will be installations in Low Earth Orbit (LEO) and Geosynchronous Earth Orbit (GEO) where, when timing is not the number one issue, shipments from Mars will require less fuel cost, and from the Moon much lower fuel costs yet, than sourcing equivalent products up from Earth’s surface, simply because of the differing depth and intensity of the three gravity wells. Installations in any of the Earth–Moon Lagrange Points will also be markets for goods from Mars and the Moon.

Yet imports from the Moon will be more attractive than those from Mars, all else (type etc.) being equal, as the Moon’s gravity well “dimple” is much shallower than that of Mars. If cargos can be launched directly into an Earth–Moon orbit using only electric power and no fuel (the Mons Pavonis launch track) and needing no engine except to ease into orbit at the chosen Earth–Moon system location, that could go a long way towards diminishing the Lunar launch advantage – EXCEPT that one can launch from the Moon, in an emergency, at virtually any time.

That Mars is volatile-rich in comparison with the Moon, gives it an edge in products composed largely of such elements: natural organic material products and plastics.

Finally, Mars and the Moon will make natural trading partners.

<http://www.moonsociety.org/home-page/center-column/changing-images/showimage.php?image=45> PK

## The Red Planet “Blues”

By Peter Kokh, onetime Martian “wannabe”

Mars would seem to offer both viewers from afar and future visitors and pioneers, a monotonous pallet of orange–salmon–beige coloration. Now the Moon’s pallet is perhaps just as monotonous, but at least Mars’ hues do have noticeable color from afar.

Up close, the situation is a little different. The Moon, is transformed into a mini–Mars during eclipses when the Sun’s light reaches the surface only after being refracted by the orange–hued dust in Earth’s atmosphere. That may seem a curiosity for those of us on Earth, but for future lunar settlements, that will mean big bucks from tourists timing their visits to the Moon to experience this awesome temporary and infrequent transformation, as well as for lunan pioneers themselves. We stray off topic.

<http://www.moonsociety.org/home-page/center-column/changing-images/showimage.php?image=91>

Mars pioneers will “compensate” in several ways. Inside their living and working spaces, there will be abundant greenery. Plants will be an integral part of the Life–Support System as well as an integral part of the “morale system” if you will. Of all systems, the human one is the most fragile, and thus maintenance of high morale has top priority, after just “keeping alive.” Foliage itself comes in many shades of green as well as other colors. Flowers will be highly appreciated. You can expect that the “green thumb” culture on Mars will be much more cultivated than here on Earth, where nature provides so much “outdoors.”

<http://www.moonsociety.org/home-page/center-column/changing-images/showimage.php?image=63>

Clothing on Mars will be as colorful or more so than on Earth, for the same reason. Ceramics and stained glass will add. How about glass windows which “translate” Mars’ “salmon-colored skies” into blue ones? The ruddy skies could give one the blues after a while.

Out on the surface, brightly colored vehicles and signage will be easier to pick out against the landscape, a matter of safety. Although, a test at the Mars Desert Research Station

showed that regular shapes with set colors can be picked out from the background fairly easily. Roadway signs will have to stand out, both in daylight and headlight conditions  
<http://www.moonsociety.org/home-page/center-column/changing-images/showimage.php?image=60>

But what about those distinctly “blue” rocks that show up on **Spirit** and **Opportunity** photos of Mars surface, such as the photo on the cover page of this issue? If you get MMM as black and white paper hardcopy, you can see another such image at: [http://www.astrobio.net/images/galleryimages\\_images/Gallery\\_Image\\_7054.jpg](http://www.astrobio.net/images/galleryimages_images/Gallery_Image_7054.jpg)

While NASA says it does not doctor the colors on this or similar photos, one wonders if we can be certain that a human eye will see the same shades and tones? We might have to wait until we have “people on the ground.” But who can argue with some welcome coloration outside the range of the usual Mars hues pallet?

Would chemical treatment of rock surfaces to alter the color be something the Martian “Green” Movement would embrace or want to ban? It would be better if we found areas where the coloration of rocks and/or soil was different, as such places would become tourist destinations, boosting at least the local economy. But surely sculpture gardens at “take a break and rest” road waysides would be universally welcome, and here the coloration could come from metal tones, ceramics, stained glass – a treat for the eye that gives the tired body a break as well.

For the Moon Society’s “Artemis Moonbase Sim 1” exercise at the Mars Desert Research Station in Utah in early 2006, of which I was the commander, on a hunch when I happened to see them at a hardware store in Iron Mountain, Michigan (my summer cottage is nearby), I picked up six pair of sunglasses with very large wraparound green lenses. Sure enough, they transformed the decidedly Martian coloration of the MDRS landscapes from orange family hues to whitish tones with a very faint orange tint. The transformation was remarkable.

Most of us have seen photos of Martian sunsets, and these leave a lot to be desired, as the gradation of hues is very coarse. Again, we’ll have to wait until humans are there. Perhaps **Curiosity**’s camera(s) will be much improved and can stun us with more believable photos. Curiosity, aka The **Mars Science Laboratory**, is due to arrive on Mars August 6, 2012.

[http://mars.jpl.nasa.gov/MPF/ops/best\\_sunset.gif](http://mars.jpl.nasa.gov/MPF/ops/best_sunset.gif)

[http://www.jpl.nasa.gov/images/mer/2004-02-26/mars\\_sunset-640.jpg](http://www.jpl.nasa.gov/images/mer/2004-02-26/mars_sunset-640.jpg)

[http://en.wikipedia.org/wiki/Mars\\_Science\\_Laboratory](http://en.wikipedia.org/wiki/Mars_Science_Laboratory)

How would fireworks look against the Martian sky? (do they need oxygen to ignite?)

Mars narrow color pallet is a challenge. One could get bored with it all too quickly. But I have a hunch that the pioneers will be inventive enough and challenged enough to be able to insert all sorts of treats for the eye. PK

**For More on Mars in MMM’s past, and on Mars vs. Moon see the following:**

<http://www.moonsociety.org/mars/>

[http://www.moonsociety.org/publications/mmm\\_themes/mmmc\\_Mars1.pdf](http://www.moonsociety.org/publications/mmm_themes/mmmc_Mars1.pdf)

[http://www.moonsociety.org/publications/mmm\\_themes/mmmc\\_Mars2.pdf](http://www.moonsociety.org/publications/mmm_themes/mmmc_Mars2.pdf)

## **Artificial Gravity enroute to Mars and back strongly advised**

By Peter Kokh, onetime Martian “wannabe”

### **Why there is a need**

While some brainstorm designs for Mars-bound craft have included provisions for simulating gravity, most writers and designers dismiss the need. Admittedly, such a design requirement would make the craft heavier, more expensive, and because of the added weight, such a craft would require a more robust and more expensive propulsion system – all conditions to be avoided. But hold on a minute! Compare that extra expense to the cost of minutes wasted on Mars by crew members taking time to get their legs back so that they can



use their priceless hours on Mars to accomplish the goals they came to do! Most of us are aware how helpless persons find themselves on returning to Earth after a year in “zero-g.”

There is no comparison of the cost of wasted time on Mars to the cost of avoiding the problem by providing shipboard artificial gravity – at the 3/8ths G level they will experience on Mars, and which would allow them to “hit the ground running.” The tipping of the scale is so very self-apparent that it makes one wonder what universe its proponents are living in. Zubrin’s “Mars Direct”, NASA adaptations thereof, and Elon Musk’s Falcon Heavy Mars trip scenarios do not address this problem, despite its obviousness (when you think about it in the terms stated above.

Now if the pennies need to be pinched, the crew could return to Earth in “free fall” as there would be no such urgency to get back on their feet on arrival. Like the MIR and ISS astronauts returning to Earth after very long stays in space, they would eventually recover for the most part. Permanent vision problems reported are hardly disabling. Most people lose some visual acuity as they age anyway. (This writer gets to see 2 or 3 stars where everyone else sees but one. But I can still type and do all I need to do. It’s not fatal!)

If we do provide artificial gravity on the return trip, it could start at Mars-normal 3/8ths G and gradually ramp up to full Earth-normal gravity by arrival, so that the returnees could hit the lecture circuit right away!

### **How we can provide artificial gravity en route**

We do not intend to go into design options in this article. To help you visualize the options, consider the artificial G rotating circular running track in the classic film 2001: a Space Odyssey. There are a number of other films where set designers have gone where no NASA designer dared to go.

Rotating cylinders are the common answer. They do create a problem as their rotation would induce a counter rotation in the rest of the vehicle and that is to be avoided. A pair of mutually counter-rotating sections is one answer. A simple flywheel turning in the opposite direction would be much simpler.

Most of the illustrations show a very short radius which might induce coriolis problems. The simple trick of colored directional cues, with experience, would keep crew members from turning too fast in certain directions.

Another solution that has been advanced, is to divide the ship into two sections, crew quarters and everything else, pay them out and apart on a tether (a twist-resistant beam or truss would work much better if it were collapsable) then induce rotation about a common center of gravity.

Now there is an ideally perfect option: thrust at 1 G halfway to Mars, flip directions and decelerate at 3/8th G until you arrive. Unfortunately, we know of no engineerable way to do this, or of no propellants with this much oomph for the same mass. With such a system, one could get to Pluto in a week, if I remember correctly (I did the math for all Earth to planet destinations 3 decades ago, on paper, and have no idea if that sheet of paper still exists. Oh yes, to Alpha Centauri in 3 years and we know that isn’t going to work! Jerry Pournelle did the math as well I believe and it may be in one of his paperbacks. Back to the real early 21st Century!

Our purpose here is not to pick the ideal engineering solution, but to help ostrich-minded designers to take a peek at the real world and abandon and start from scratch. Look at all the options and their variables and weigh the plusses and minuses of each, compare the nickels and dimes, determine what needed technology and engineering items are not yet on the shelf, and in general, get to work and give us some real designs.

And Oh by the way, if you can give us some shielding while you are at it, enough shielding so that we can make the Earth-Mars run and Mars-Earth run in Active Sun periods as well as in Quiet Sun years, that would be marvelous. It would be a pity to send out a crew on a very expensive mission only to have them fried on the way by some unexpected Coronal Mass Ejection solar flare event. Now to be honest, these events are directional, and by luck none will

expand in the vector our Mars-bound or Earthbound ships are traveling. The gambler needs to know when to fold the cards, however.

If we are only going to send a ship or two to Mars just to say “Kilroy was here” on an expensive remake of “Flags and Footprints I” perhaps we can take the gamble. But if we are going to stay, the only option that makes any sense at all, including economic sense, we need to gamble intelligently.

**Calling all readers** If you find any designs of Mars-run ships that provide artificial G - online - please email MMM the URL (web address) to [kokhMMM@aol.com](mailto:kokhMMM@aol.com)

MMM #263 - MAR 2013

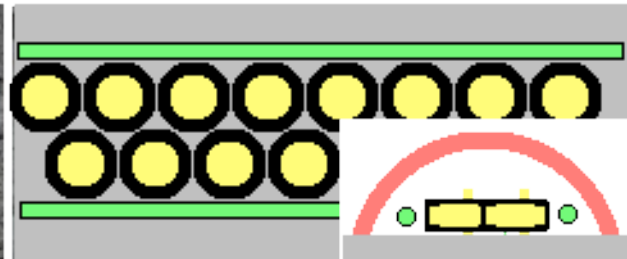
**A Better Idea for MarsOne** - <http://mars-one.com/en/>

By Peter Kokh

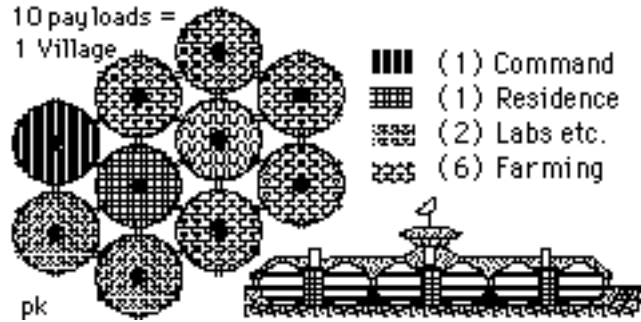
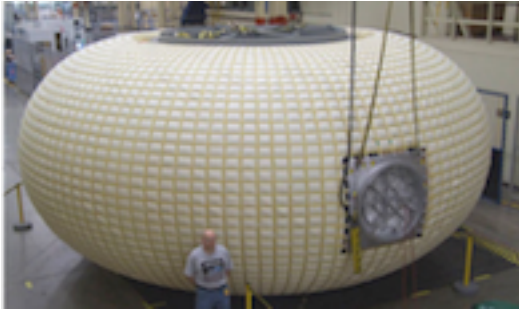


**MarsOne would ship identical modules to Mars to be ganged together.** Connecting hallway runs **through** the units, eating up valuable floor space. **No thought is given to shielding**, condemning settlers to a high incidence of cancer and short lives. We give MarsOne an A for good intentions, an F for ignoring known risks and poor design.

**Below:** Inflatable torus units from LDC Dover (now under contract to NASA) provide more volume, and much more floor space for the same structural weight, leaving room for more furnishings, for the same shipping weight allowance from Earth to Mars. Putting these units under a robotically pre-built contour-crafted extendable Quonset like hangar allows that structure to bear the weight of several meters of Marsdust shielding, allowing maintenance access to the exterior surfaces of both the toroid units and of the connecting pressurized corridors to either side.



Passage between units is via flanking corridors (so as not to eat into torus unit floor space) with corridors are lined on one side with living wall units producing food and cleaning air, realizing the “middoors” concept. Other side can have storage lockers, art made on Mars, etc. This design provides safety, easy expansion, abundant vegetation, and intermittent observation towers. <http://www.ilcdover.com/Toroidal-Lunar-Habitat/>



L: ILC Dover–built unit inflated at NASA JSC with hardware integrated

R: These units can be ganged together.

We had proposed something very similar in our presentation at the 1991 ISDC in San Antonio.  
**The Lunar Hostel: An Alternate Concept for First Beachhead and Secondary Outposts** © '91  
[http://www.moonsociety.org/publications/mmm\\_papers/hostels\\_paper2.htm](http://www.moonsociety.org/publications/mmm_papers/hostels_paper2.htm)

Major advantages are (1) a **stable footprint**, (in comparison to a sphere or cylinder laid on its side), (2) **very low height per volume**, (3) an **outfitting–works–packed central core**. The central core was a feature of the discontinued TransHab technology for which Bigelow does not seem to have realized the advantages. The remaining design/architectural/engineering challenge is to design the core with pull–out features that will structure the interior: flooring supports for one or more floors, toilet/sink, kitchen core, lighting, etc. features. If the “donut” inflatable is to have more than one floor, it should contain a ladder to provide inter–floor and surface access. Toroid units are also ideal for automated agriculture, see: [http://www.moonsociety.org/images/changing/torus\\_greenhouse.gif](http://www.moonsociety.org/images/changing/torus_greenhouse.gif) PK

## MAROONED ON MARS

### Could the first Martians be Marooners?

By Peter Kokh

Most humans to Mars scenarios envision a number of exploratory missions, followed, if all goes well, by planned settlement. But the chances of something going wrong are real and should not be ignored in “defining” a first or following “exploratory” missions. The number one risk is that exploration for exploration sake will not be followed by settlement.

Yet that it could happen that the first human crew to visit Mars would be marooned for whatever reason, however unlikely and unintended, is reason enough to prepare for the eventuality by the choice of

- **Crew male/female mix, age mix, gene mix, expertise mix, talent mix, personality mix, hobby mix**
- **Amount and variety of supplies and tools and equipment\*** etc. to send with them.

\* See ‘Yolk Sac Logistics’ article, MMM #113, March 1998, reprinted in

[http://www.moonsociety.org/publications/mmm\\_themes/mmmt\\_Mars.pdf](http://www.moonsociety.org/publications/mmm_themes/mmmt_Mars.pdf)

If we do this, and get them back safely, this “just in case preparation” will shape and enrich Martian culture, lore, and history. **That it makes sense to prepare for the eventuality of marooning and forced settlement, makes it all the more logical to plan for settlement in the first place. In that light, any plan to explore only, makes no sense. Only “Mars to Stay” plans deserve our support.**

That is a big leap, but as we all know, “anything that is worth doing is worth doing well.” **And to thoroughly explore a planet as old, as large, and as varied as Mars, is a task for endless generations.**

### Just the facts:

The Moon is only **3 travel days** away, so we can build our presence there at the end of an “umbilical cord.” Mars, in contrast, is **6–9 months** plus “remaining window time” before the next return opportunity or for resupply and rescue. And any emergency response could easily be delayed if a cosmic ray outburst or solar flare intervenes. But these are not the only eventualities which could force such a situation. Political or economic collapse or military conflict could result in postponement of resupplies and/or rescue. And a rescue mission could fail on the launch pad or en route. Once you take off from Earth, there is no guarantee you will ever return. It will be a gamble.

There are simply too many things that could go wrong given the interval between rescue and resupply windows and the many months–long travel times involved. But things could also go wrong on Earth with economic or natural catastrophes interfering with “timely” rescue, “timely” meaning not “soon,” but as soon as possible, which could be from half a year to a couple of years, more if a solar outburst intervened during the next rescue window.

If the first crew does come back safely, their “just-in-case lode” will be of great use for the next crew. And that is all the more reason to send a new crew to the same location. (Contrary to the suggestion in Robert Zubrin’s “Mars Direct” proposal.) That in turn is a significant reason to pick a site with all the plusses appropriate for the first major settlement. **That means not picking a site solely for its scientific interest.** In the end, we will do far more exploration of Mars if we go there to settle, than if we go only to satisfy our scientific curiosity.

Did Mars once harbor life? Are primitive life forms still present? Did Mars once have an ocean?...., and on and on. Exploration and Science are human activities of all societies. If we settle Mars there will be far more explorers and scientists doing far more research, than if we only send one, two, or a few sortie parties.

Thus, paradoxically, **science is best served if the primary reason for humans to go to Mars is not science but settlement.** The corollary is that the first crew must be prepared for the eventuality of being marooned. It is most likely that **“being marooned in new territory” is one of the ways humans spread across this planet.**

### Marooned on Mars in Science Fiction

Being marooned, or almost marooned on Mars has been a frequent theme in movies (e.g. “Mission to Mars,” “Red Planet”) and novels about humans on Mars, and not just because it makes for a great story with drama and suspense, but also because there is a very real chance, that despite precautions, it could happen. The more complex something is, the more ways something can go wrong. And human Mars missions will be very complex, much more so than past or future Moon Missions, because of the very much greater (and ever changing) distance and time factors that make “timely” rescue or resupply all but impossible.

Only those volunteers should be selected who are emotionally and personally prepared for such an eventuality. We don’t need a crew of bitter, angry, and depressed persons stranded on Mars. **We need to pick people who will be okay with such an eventuality.** Given all this, would **you** still volunteer? If all volunteers answer this up front question truthfully, any marooners will do okay. And we’ll bet, some will choose to remain behind even if their flight home is assured. **These are the kind of volunteers we need in the first place. PK**

## Hellas: a glimpse of the past, a tease of Basoomian Mythology, and an Cornerstone of the Future of Mars

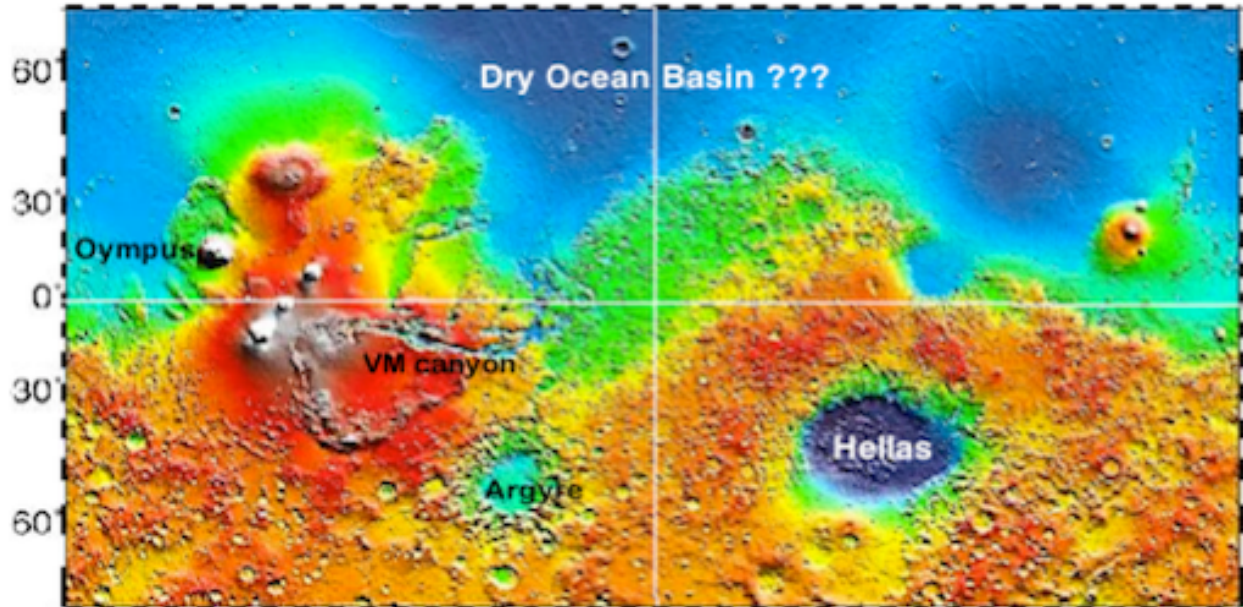
By Peter Kokh

<http://www.marsdaily.com/reports/>

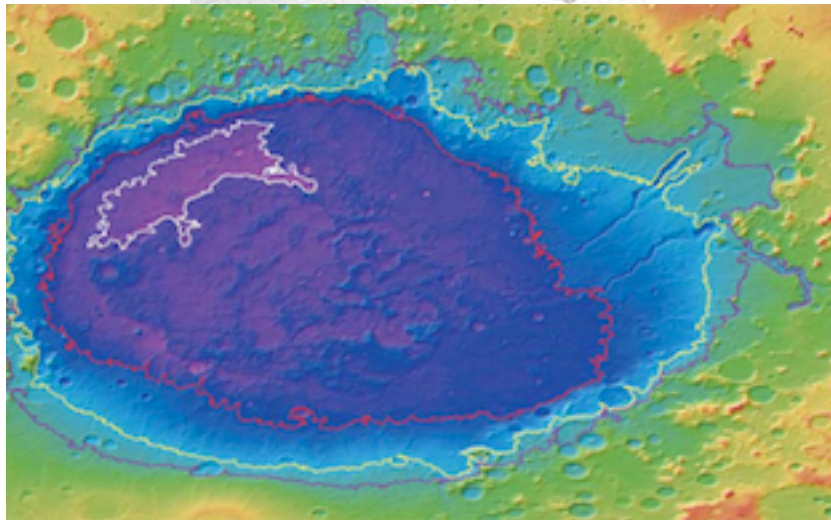
[Mapping Project Consistent With Huge Historic Seas On Mars 999.html](http://www.marsdaily.com/reports/Mapping%20Project%20Consistent%20With%20Huge%20Historic%20Seas%20On%20Mars%20999.html)

The Hellas basin, more than 1,250 mi across and 26,000 feet deep, is the largest recognized impact structure on Mars, and once may have held a sea. “Fine–layered outcrops

around the eastern rim of Hellas have been interpreted as a series of sedimentary deposits resulting from erosion and transport of highland rim materials into a basin-wide standing body of water.” [see link above] The **circum-Hellas highlands** represent a significant percentage of the southern hemisphere of Mars and have served as a locus for volcanic and sedimentary activity throughout Martian geologic time. **Hellas Planitia** preserves the materials shed from these highlands and holds the key to further unraveling some of Mars' long held secrets.



Pavonis Mons is the white mountain on the equator SE of Olympus



**Right:** The size of Hellas basin in comparison to the US Western States

**Left:** Circular basin distorted by the angle of image (to see this image in false colors denoting elevation differences, purple deepest, see images at [http://news.bbcimg.co.uk/media/images/48020000/jpg/\\_48020986\\_hellas.jpg](http://news.bbcimg.co.uk/media/images/48020000/jpg/_48020986_hellas.jpg))

"This mapping [snip] constrains the timing of these putative lakes to the early-middle Noachian period on Mars, between 4.5 and 3.5 billion years ago." Link above.

**In the Hellas basin, where Mars' atmosphere is the most dense, early Mars aircraft will first be able to fly! That could make it a primary tourist mecca.**

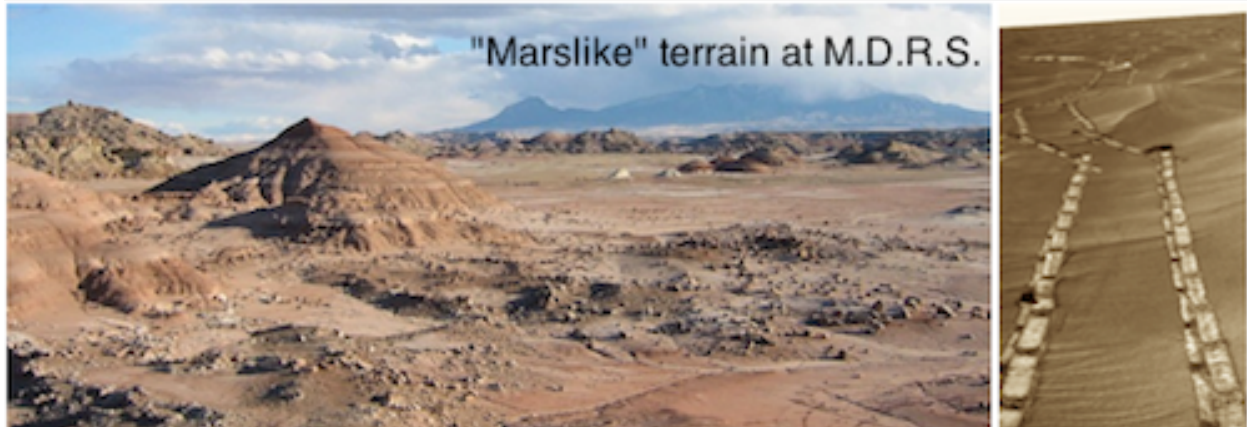
Even if Hellas Basin has always been dry, that does not diminish its capacity to hold water in the future. Surely in any Mars "terraforming" or "rejuvenation" program, Hellas will play **the starring role**. It is significantly lower in elevation than any other locale on Mars and as such will always be the area in which atmospheric pressure is the highest. Hellas will be the first place on Mars able to hold liquid water. It will be the first place where watered land can support vegetation. And this is so whether this "plain" as "Hellas Planitia" has been so inaptly and unimaginatively named, ever held water and life in the past. Its depth is everything.

Hellas north shore will be the warmest part of the basin, being closest to Mars equator. Surely this shore or beach, as you like it, deserves to be picked as one of the earliest settlement sites. Pavonis Mons, smack on the equator (think launch track, think space elevator) and, being a "shield volcano" laced with many cubic miles of lava tubes, surely should be picked as a major settlement site as well.

In Edgar Rice Burroughs map of Barsoom, as his fictional Mars inhabitants called their planet, it so happens on his map that roughly the same coordinates are those of the major Barsoomian cities of Greater and Lesser Helium. Helium and Hellas, what a coincidence. The word Helium is a derivative of the Greek word for the Sun, Helios, helium being an element first discovered in the Sun, long before it was found on Earth. Hellas is the Greek word for Greece. An interesting coincidence nonetheless. Also nearby was the Barsoomian seaport of Aanthor – an apt name for the first settlement along the north “shore” of Hellas basin.

[\* For more colorful Edgar Rice Burroughs/Barsoomian tidbits, see John Flint Roy’s 1976 **A Guide to Barsoom: The Mars of Edgar Rice Burroughs** – Ballantine, ISBN 0-345-24722-1-175]

## Building Fictional “Ruins” on Mars as a “Culture Booster”



By Peter Kokh

Mars has both monotonous plains and “scenic” areas – all untouched by intelligent beings – save for the wheel tracks of **Pathfinder**, **Spirit**, **Opportunity**, and **Curiosity** Mars Rovers. In contrast, science fiction writers have populated the Mars of our imagination with ancient forts, castles, cities and other relics of intelligence now in ruins, plus now dry canals that “once” brought life-giving water from the polar caps to temperate and tropical areas.

Could we blame future human Martian settlers if they chose to “recreate” some of these fictional-mythical structures here and there along future Martian highways? The excuse would be to reduce boredom for travelers, create attractions for domestic tourists as well as for visitors from Earth or the Moon, all with monetary advantages.

Forts and castles, bridges and canals, statues of mythical Barsoomian wildlife, abandoned vehicles, crashed planes, ruins of ancient castles and more. Consider our Dinosaur gardens in South Dakota and Alberta!

On Earth, we have an abundance of actual ruins to provide this interest from Stonehenge to Mesa Verde to Teotihuacan to the Pyramids, and on and on. Our history is long and diverse. Mars, in contrast, will be a brand new untouched frontier. We will make its “history” over time. There are/ were no “natives” or “ancient ones.” Mars is a tabula rasa, a blank slate, except for the imagination of fiction writers and movie producers.

The problem, however, is that while many a Mars novel has given us intellectual images of such things, actual illustrations come from artists who do the jacket covers, not from the fiction writers themselves. As a result, a novel that has been republished many times will have a diversity of illustrations, none of them blessed by the author. You can get a feel for the “cacophany” of images by doing a Google Image Search for

✓ Barsoom    ✓ John Carter on Mars    ✓ fictional cities on Mars    ✓ canals on Mars    ✓  
 etc.

Nonetheless, this is an interesting idea, and a far better way to add interest on long monotonous highway stretches on Mars, as vast as all 7 of our continents than, heaven forbid, billboards advertising consumer products.

Mars is without a real history, human or ancient Martian, and a bit of “borrowed creative mythology” might be welcome. Over time, Martians of human descent will create their own history, and forge their own culture(s), but who can blame the early settlers to want to “accelerate” the process with images from the diverse fictional mythologies of popular Mars/Barsoom novels of old? Here are some links:

[http://en.wikipedia.org/wiki/Mars\\_in\\_fiction](http://en.wikipedia.org/wiki/Mars_in_fiction)

[http://en.wikipedia.org/wiki/Mars\\_trilogy](http://en.wikipedia.org/wiki/Mars_trilogy)

<http://www.irosf.com/q/zine/article/10021> – Mars sci-fi

Yet there are other more rational ways to introduce scenic interruptions. Waysides can have a variety of architectures and layouts. They can also host rock and sculpture gardens. Bridges over valleys can have a variety of architectural designs. Even a landlocked version of “lighthouses” of as varied designs as ours would help.

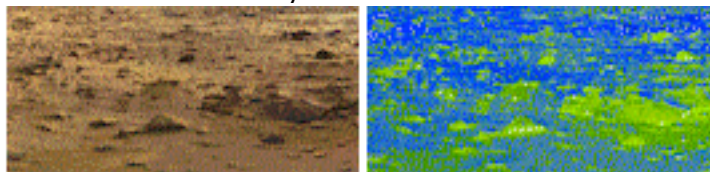
In time, with a policy of encouragement of creative designs and architectures for the purpose of “maintaining alertness and interest,” this is a need that will take care of itself especially on more traveled routes. Commercial and government dollars will both play a part.

The result is that not just towns and urban areas, but the vast stretches in between, over time will proclaim ever more effectively, that Mars is becoming a human world. Meanwhile, we are always happy to get artwork and illustrations from readers that attempt to illustrate any of the many concepts and ideas brought up in various MMM issues through the years (now into year #27!)

PK

## Dealing with the Color Monotony of Mars' Terrain

By Peter Kokh



Missing

Colors

**Above:** a typical Marsscape (L) in natural color and (R) in a color inversion

The scattered “blue” rocks and “blueberry” nodules found here and there on Mars notwithstanding, marscapes seem to have as narrow a color range as the gray tones of the Moon. And just how “blue” those rocks and “berries” are is yet to be validated. Mars is not all monotonous plains of sand, gravel, and rocks. There are scenic craters, mountains and valleys to be sure. But shapes to the side, the color range appears to be restricted. To those who do not appreciate geological variation, the narrow range of coloration on Mars could be depressing.

It would appear from the above simple color inversion test that the biggest psychological boost would come from introducing blues and greens. Of course yellows, oranges, reds, purples would also help as accents, along with whites, blacks, and grays, but perhaps not as much as blues and greens. But here, our purpose is not to dictate but rather to suggest ways colors opposite or complementary to Marstones might be introduced.

### #1 Interior decor & outfitting of habitat and activity modules brought from Earth

The interior surfaces and various outfitting items (including fabrics) can be in a wide range of colors, picked by the crew, and when it comes to individual quarters, by individual crew members, all at zero additional cost. Color has no weight! Electronic wide screens (TVs, monitors, etc.) could offer a wide selection of scenic colorful electronic wallpapers pre-selected by crew members. (Additional ones could be added at any time via the interplanetary internet.)



All of these things, at no cost or extra import weight, can help counter the color monotony of the Martian outdoors, however beautiful.

If there are multiple modules, and interconnecting pressurized corridors, these can all provide a reassuring refuge of a full color palette. So could vehicles, such as Martian ATVs. Each having its own color scheme would be an aid in identification and location against the otherwise semi-monochromatic background. Road markers and signs could test various colors and then be standardized for maximum visibility against the background. Our personal experiments at the Mars Desert Research Station in 2005 showed that astrobright™ colors on items of regular shape best make a manmade object stand out against the narrower range of pixelated Mars tone hues.

## **#2 Projected colors**

Assuming that we are going to have some peripheral lighting around the outpost from dusk through the night into dawn, some of bulbs (or LEDs) brought from Earth could be colored, spreading assorted color overlays on the landscape, perhaps more effective at dusk, night, and dawn.

Here on Earth, in urban areas, partially cloudy nighttime skies take on a fantasy coloration from street sulfur lamps – which can be beautiful even if at the penalty of rendering all but the very brightest stars invisible. Only experiment will tell if nighttime clouds on Mars would reflect lighting in such a way.

## **#3 Vegetation: greens and more**

Assuming that the outpost is growing most of its food, at least salad stuffs and vegetables, herbs and spices; the greens and other colors of living plants should be a welcome boost. Herbs and spices and other useful plants can do double duty as decor. Homes, offices, workplaces, hallways etc. could be green with live vegetation.

## **#4 Simple manufactures – ceramics, glass, cast basalt**

It should be at least a secondary priority to experiment with simple early manufactures. Ceramics (tiles, dishes, planters, statues) may not at first add much in the way of complementary colors until we are able to experiment with glazes. The same may be true of early glassware and cast basalt items. But even if they do not help diversify the color pallet, they will be a humble start on the road to self-reliance, along with production of bricks and blocks, and concrete. Without sample returns to more fully analyze in a laboratory, we cannot be as confident about what we can make on Mars as we are with respect to the Moon. But we will definitely find a variety of azoic soils from which we can produce a variety of glass colorants and ceramic glazes. Cast basalt will always be very dark gray to bluish black. But that too will be welcome.

## **# Experimenting here on Earth at M.D.R.S. and elsewhere**

I suggest that future crew members at MDRS expand on the line of experimentation that I did on crew 34 (although I reported it as an activity on crew 45) See MMM #184 “Testing Colors for Survival on Mars” [http://www.moonsociety.org/publications/mmm\\_themes/mmmt\\_Mars.pdf](http://www.moonsociety.org/publications/mmm_themes/mmmt_Mars.pdf)

PK

**NEWS FLASH:** Mars red color is only skin deep:

[www.space.com/19932-mars-color-gray-curiosity-rover.html](http://www.space.com/19932-mars-color-gray-curiosity-rover.html)

Alas, gray is a neutral color, as are white and black of which gray is composed. It offers “some” relief.



## “Someday!”

**Artist rendering of Mars seen from Deimos:**

**Note the nighttime city lights of settlements on Mars**

Mars will look very large from Deimos, many times the apparent size of the Moon from Earth, and far larger yet from Phobos.

[We’ve had this painting in our files for years, but have never been able to determine the identity of the artist.

If you know, contact [kokhmmm@aol.com](mailto:kokhmmm@aol.com)



Read our brochure: “Mars is in our Field of View”

[http://www.moonsociety.org/reports/mars\\_conv2004/mars\\_in\\_view.html](http://www.moonsociety.org/reports/mars_conv2004/mars_in_view.html)