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

Mars Moon Miners' Manifesto

www.MoonMinersManifesto.com

Mars Theme Articles – MMM Years 11–20

There is a reason that Moon Enthusiasts should be interested in Mars!

In fact there are many reasons!

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That is why opening the Mars Frontier is the 2nd focus for MMM!

In this 2nd compendium of articles and discussions focused on Mars, **we revisit many themes** touched on in the first collection of "Mars Articles" from MMM Years 1-10.

And we delve into **a number of new topics**.

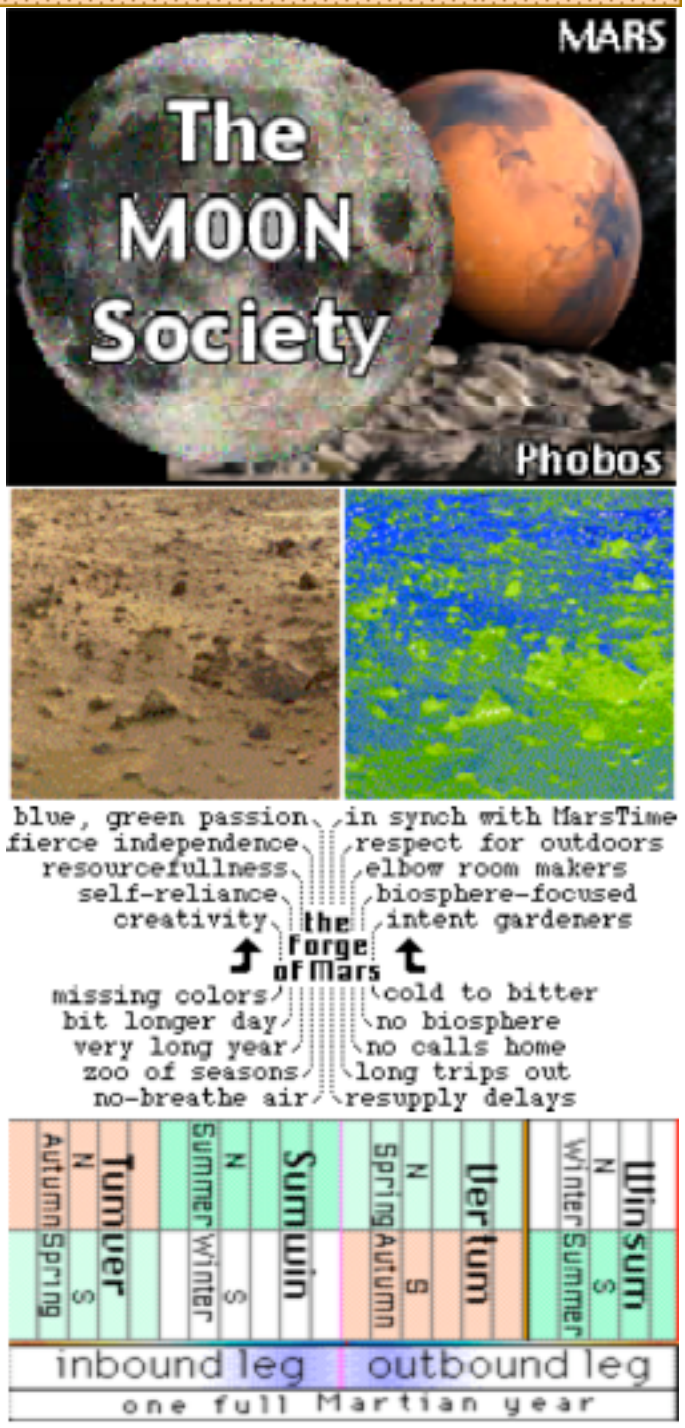
One of them is **how Mars itself will forge the characters and culture of its settlers**, looking at one salient feature of Mars after another: geology, climate, coloration, the length of its days, seasons, and year. The isolation in time lag, distance and launch windows, the need to be extremely self-reliant. 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?

As an appendix to this volume, we have included flyers prepared for The Mars Society Convention in Chicago, in August 2004, stressing **research of common interest**. We also include the gist of a presentation which seeks to unite Moon, Mars, and Asteroid Fans under one passionate banner: **Preservation of Mother Earth and of Humankind!**

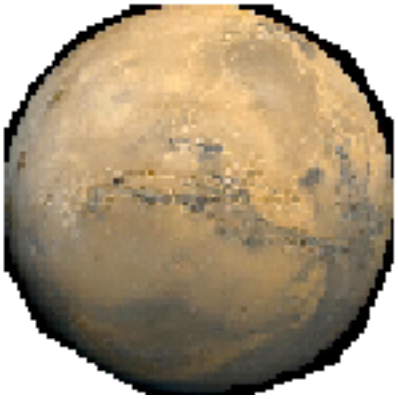


MMM #103 - March 1997

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



Outlining a Comprehensive Mars Fossil Discovery and 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 "man-hours" 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 refly 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 on 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 activatable 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 **G**enus of **L**ife" 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.

MMM

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 in advance of 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 impor-tant. 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.

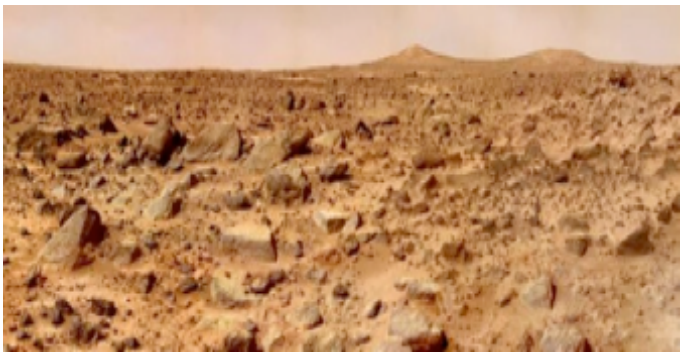
(3) The availability of Lunan industrial know-how and field-proven methods will prove invaluable. This kind of intellectual property export could include:

- ☐ MUS/cle design, manufacturing, & assembly techniques
- ☐ Lunan experience in creating variety & diversity for small markets.
- ☐ Manufacturing of local 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 were the slightest setback - equipment or systems failure - could well prove fatal to all. MMM



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

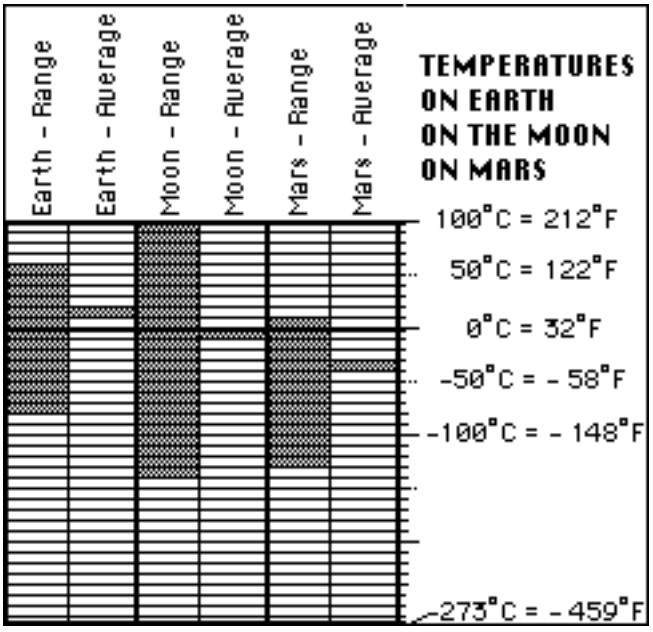
A cherished dream dies hard. We have known for a couple of decades now, that the real Mars is a much colder, drier, thinner-aired world than the one we used to dream of colonizing, than the Mars of Lowell and Clarke and Heinlein and Bradburry, the Barsoom of Burroughs.

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 snow-belters 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 politi-cians 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.



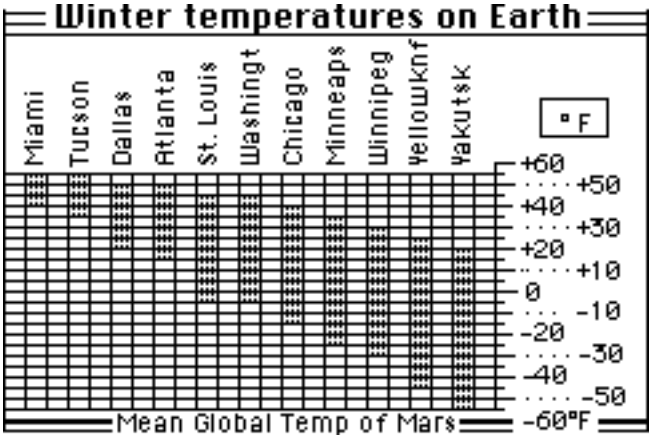
KEY: Absolute Zero at bottom.

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 hardiest 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, warm*er* and smooth*er* a nd friendli*er* 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 pioners, 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 many 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 civi-lization 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 think 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 recrea-tional 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 gap, 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 rmind 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 tradeoofs 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 long-time 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, what-ever 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

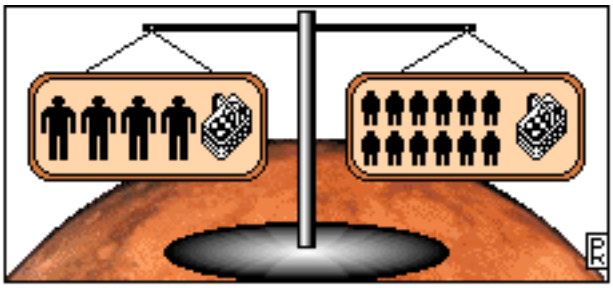
entice free market enterprise to open the Moon. Ultimately, only profits can open the frontier, and they are far, far likelier to come from, or via the Moon. *

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 – MAR 1998



Bold Tack in Casting 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 t*he same supplies* and thus accomplish much more mission for our precious bucks. See "**More to Mars**" page 13ff..

IN FOCUS In a word: Marsandback, No! Marstostay, Yes!

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

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

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

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

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

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

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

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

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

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

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

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

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

Marstostay does not segue from Marsandback. Marstostay must be pursued *instead of* Marsandback.

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

There is a long list of hardware development, propulsion breakthroughs and all around general brainstorming home-work 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>**

Vision without action is just a dream
Action without vision is just activity
Vision and Action together
Can change the world

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>**

A reasonable man adapts himself to the conditions that surround him.
An unreasonable man adapts the surrounding conditions to himself.
All progress depends on the unreasonable man. - George Bernard Shaw

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

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"The Best Way to Predict the Future is to Invent It!"

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

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

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

Yolk Sac Basics

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

The nuclear thermal plant needed to power the fuel and volatiles production from the atmosphere should be gangable so that other units landed subsequently can be used in tandem to provide a scalable energy production plant. Excess power can be stored as chemical energy e.g. used to electrolyze water reserves that can later be combined in fuel cells to recover that energy as needed.

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

Amphibious Crew Cabins

The cabins of all landing vehicles could be designed with minor weight penalty, in amphibious fashion, fitted with wheeled chases so that they can serve as surface vehicles. There will never be enough of these, and every crew cabin that returns to Earth will be felt on the frontier as a mortal wound. This concept was first developed in our 1991 paper on Lunar Hostels1, 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 lighterweight metals and plastics would make the crew cabin lighter, requiring less transport fuel, at least part of the fare for "co-importing" these materials stow-away fashion would be paid by such a substitution. In this way such strategic metals can be added to the Yolk Sac.

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

The goal - and inevitable "leakage"

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

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

High Morale is Quintessential

Morale in a community obviously expanding, flouishing 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 atmos-pheric 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

1 Proceedings of the Tenth Annual International Space Development Conference, May 22-27, San Antonio, Texas. pp. 75-92 (specifically pp. 76-8 The Visiting Vehicle), "**The Lunar 'Hostel': an Alternate Concept for First Beachhead and Secondary Outposts**", P. Kokh, D. Armstrong, M. Kaehny, J. Suszynski.

Reprinted in MMM #s 48, 49-50.
Republished in MMMC #5 **<MMM>**

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

The Role of Creative Smuggling in the Building of Marsport

Peter Kokh

Relevant Reading from MMM past issues

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 twenty-five 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.

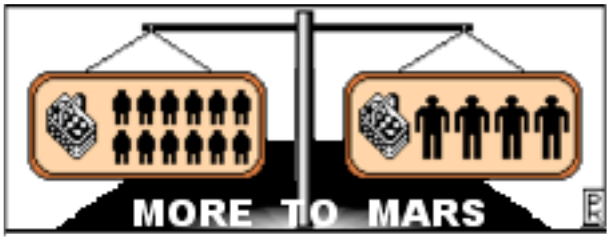
Or they can be made of materials otherwise hard to come by for the infant Martian industrial economy.

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>**



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 produc-tivity. 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 associ-ated 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 'unrepresenta-tive' 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 iden-tify now* dwarf and/or Pygmy individuals with the sufficient aptitude, and then to educate and train them *from early youth* to perform as outstandingly as any more advantaged candidates.

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

I am not suggesting here that Mars be *settled* 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*.

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

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

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

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

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

In the process, Little People and/or Pygmies could earn lasting and long overdue respect. Just as their outstanding participation in the performing arts and major sports has won Afro-Americans widespread and genuine, if limited respect in today's world, a successful mission to Mars crewed by more

diminutive persons will do much to erode the major cultural barriers that these populations now face.

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

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

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

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

Does it not seem poetically fitting that a "race" of little scouts turn the trick once again - this time on Mars? <PK>

Dwarfs & Pygmies

Just the facts, please!

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

Pygmies are members of two "races", the 150,000 Negrillos of central Africa, and approximately 35,000 Negritos of Southeast Asia and Oceania.

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

The Upshot for a "More to Mars" Mission

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

Its a win-win-win situation.

Sustained Sortie Exploration of Mars

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

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

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

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

cargo modules, then return to low Mars orbit with its payload for retrieval by a tug. They should be capable of landing at any latitude and during any season (except probably polar winter). Send two to Mars, aerobraking them into Mars orbit for retrieval by the tugs.

8. **Sustained sortie-exploration** of the entire martian surface will be possible, once the Mars Excursion Vehicles are available, limited by the
   - √ time needed to maintain and outfit the Excursion Vehicles and Orbital Tugs between missions
   - √ the propellant production rates. Addition of modules to the Orbital Base and Propellant Factory, plus additional Orbital Tugs and Excursion Vehicles can build up a robust exploration and operations capability at Mars without incurring the high recurring costs of building and discarding throwaway vehicles.
9. **After the initial landing on Mars**, additional sites can be visited once, retrieving samples and deploying fixed science stations and teleoperated/robotic rovers for traverses to later landing sites. Field camps can be established at certain sites and visited occasionally. Reusable shelters and supply depots can be set up at some field camps, then be mothballed between visits.
10. **After some years of sustained, low cost exploration of Mars from orbit**, a site can finally be picked for a permanent Mars Surface Base (probably a field camp), and a base can be progressively constructed and outfitted over a period of a few years until it becomes continuously habitable.

<JES III>

EDITOR'S COMMENT:

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

The problem with the orbital "home" approach is that it lays *no foundations* for global settlement.

The problem with the surface "home" approach is that the location picked for "home" *might* not be the best.

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

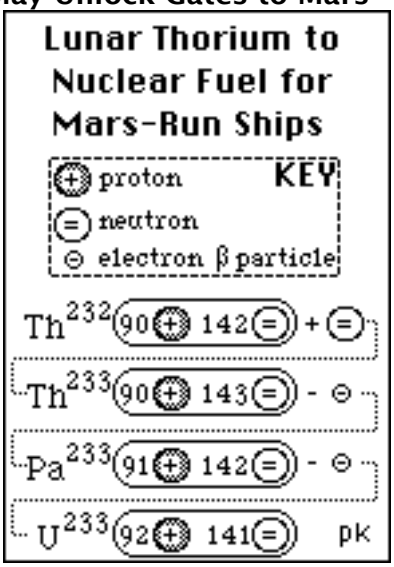
Thorough unmanned exploration of Mars can be done *more expeditiously by teleoperation of a fleet of landed probes from a manned forward base on Phobos of Deimos*.

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

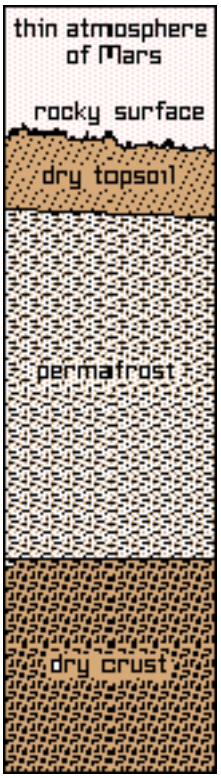
There is no "Try"
There is only "Do"

- Yoda to Luke Skywalker, in
- ***Star Wars: The Empire Strikes Back***

Moon's Thorium May Unlock Gates to Mars



The first human scouts may journey to Mars on chemical rockets. But settlers, developers, tourists, and traders won't be so willing to spend a chunk of their lives get-ting there, more much if they come back. Nuclear rockets can fix the time problem. But if shipping nuclear fuels through our atmosphere is banned, the only key to the Mars Frontier may lie on the Moon. *See below*.



In Focus First Step toward Mapping Martian Permafrost

By Peter Kokh

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 be 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.

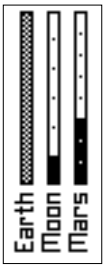
The target site is within the edge of the layered terrain near Mars's south pole. Finding (or not finding) subsurface ice in this location, within a meter of the surface, will neither prove or disprove the existence of globally extensive permafrost. It's a neat and adventurous science experiment. But 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 3/8ths 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 equip-ment 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!

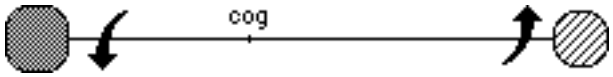
Further, NASA has wasted decades with lip service experimentation with tethers, and no more than paper study experiments with artificial gravity. The agency simply is not ready. It has no reason to feel confident it can pull off an artificial gravity mission. NASA *seems* to have a cultural mental block 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/despin 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 counter-weight, the greater must be 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 counter-weight 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 potion 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 were to 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 considera-tion is which items must be accessible during cruise mode, and which will not be needed until journey's end. If this prelimi-nary 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 consu-mables 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!

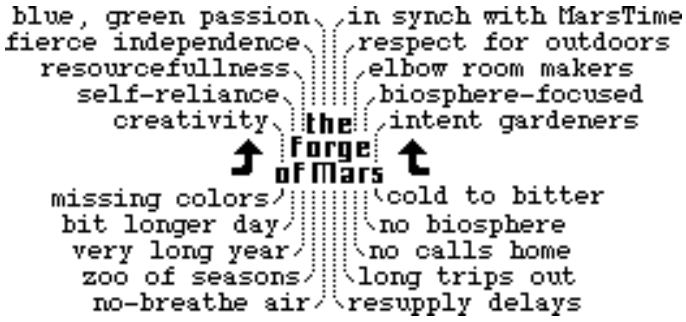
We think that a redesign is possible that would provide Mars level gravity for the trip to Mars.

As the return to Earth will be in a different vehicle, that posses 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>**

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." 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. A 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 ahs were audible as we saw that beautiful blue sky above those beautiful ocher sands! Yes. blue! But it was a teasing mis-calibration. 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.

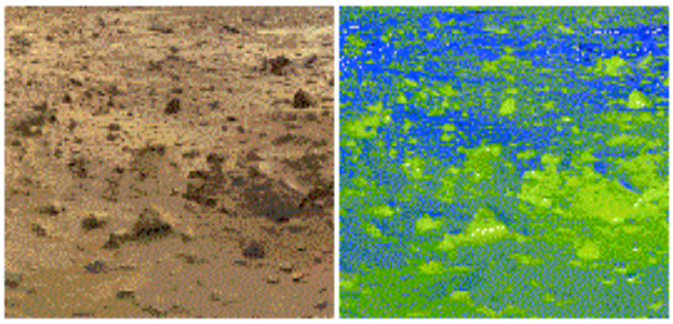
Now as much as we may miss those blue skies and as much as we may find ourselves hoping to catch sight of a green forest or prairie on the other side of the horizon, "Mars As Is" has a very real, otherworldly beauty all its own.

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

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).



Left: Typical "marsscape" colors: "beautiful", but ...

Right: Computer Inverse or Opposite colors for maximum visual relief, which need to be emphasized in space suits, vehicle bodies, and interior decor.

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 ice-caps 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, beat - 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 their 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 their 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 estab-lishment of a ten day week met with victorious public resistance. After the Bolshevik Revolution in Russia, commu-nist 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 all the same. They will learn.

The best all-around approach is t**pick all new names** *not based on heavenly bodies* (Tiw, Woden, Thor, and Fria being Nordic Mars, Mercury, Jupiter, and Venus, respec-tively). 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 immedi-ately 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. Or, going back to our suggestion that the Martian day be called by the Barsoom-ian term ***padan****, dopadan, repadan, mipadan, fapadan, solpadan, lapadan, tipadan, dopadan etc.*

In practice, these names would soon be shortened to ***dopad, repad, mipad, fapad, solpad, lapad, tipad, 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 signify-cance. 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 as a point of "dogma" just discredits one and all 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 their 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 24x3=96 weeks. Out of every five years, in two years there would have to be one week with only four says, 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".

But 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 South Pole in Antarctic was dependent on the temperature affecting the hydraulic systems on the rescue plane. On Mars, such seasonal temperature differences will be extremely crucial for outdoor activities. There can be a critical life-or-death survival difference between cold, colder, and colder yet!

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!

It is not only seasonal activities that 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:

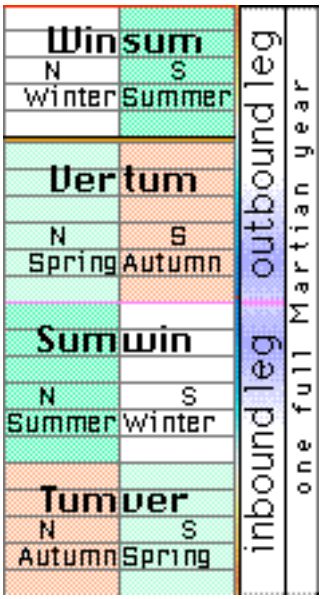
154 Northern Winter = Southern Summer = **Winsum**

193 Northern Spring = Southern Autumn = **Vertum** *

179 Northern Summer = Southern Winter = **Sumwin**

143 Northern Autumn = Southern Spring = **Tumver** *

[* taking "ver" from "vernal" (Latin vernis = Spring)]



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 discuss-list at <time-sig@lists.marssociety.org> 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.***

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've 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. You can find the details of Zubrin's calendar along with our friendly amendments online at:

http://members.aol.com/Tanstaaflz/petesmars_calendar.htm

Note: When AOL stopped hosting websites, this page disappeared - Please try the following:

http://pweb.jps.net/~gangale3/other/zubrin_critique_frm.htm

http://pweb.jps.net/~gangale3/other/thomas_frm.htm

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.lunar-reclamation.org/mars/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!

Outdoor Mars

Mars' Thin Unbreathable Atmosphere

Mars' atmosphere does some attractive things for those interested in making this planet a second human home world. If 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 breath 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-Forest Parks**!

All of which would also support an increased amount and variety of outdoor surface recreational activities. But you still won't be able to breath 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. And 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 anther 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 condi-

tions 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, whereever 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. And 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 beeches 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, may 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 be 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

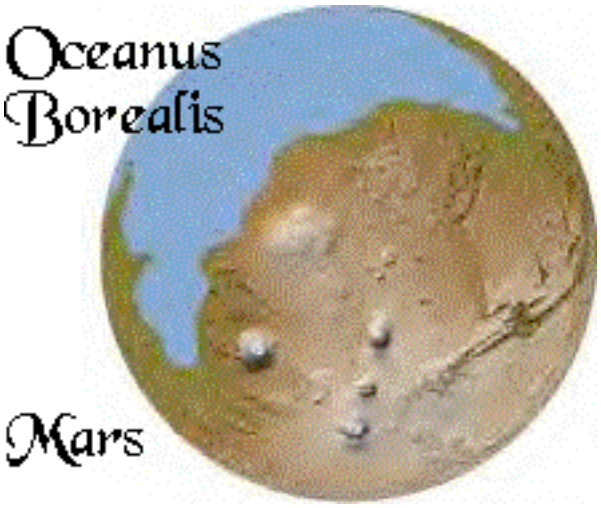
The 25 month wait for the next Earth-Mars launch window to open will "separate the men from the boys. the women from the girls." The pioneers on Mars will have to operate sans "umbilical cord." A "Yolk Sac" strategy that stockpiles all likely needed items and replacement parts will be the way to go.

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>**

Evidence Found of Ancient Mars Ocean

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 University 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>**

In the end, Mars will tolerate only "its own kind of people." Mars will make them "the best."

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 littel 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.

How it would all work => below

In Focus: Mars' Moonlets Phobos & Deimos Ripe for NEAR Clone Sequels

The **NEAR-Shoemaker** mission to Eros has concluded as a resounding success, returning vastly more information than planners had expected. As a Discovery Mission, the first approved, it was all accomplished on a shoestring budget.

We cannot but wonder if this successful survey of a small low-gravity world could be replicated, for even less money, this time targeted at the two small moons of Mars, Phobos and Deimos. Even less money, we say, because the engineering is already done. Al we have to do is put two more NEAR-clone craft together and send them on their way, hopefully at the 2003 mission opportunity. The Russians sent two probes that way in 1988-89,

Fobos 1 was sent astray by a controller's human error.

Fobos 2 was mysteriously lost after arriving on the scene and taking a distant picture or two. The only "PhD" mission proposed since has been **Aladdin**, which was not approved for a Discovery slot. *See box at right.*

Given the unqualified success of a mission to a similar lightweight destination (Eros), the time is ripe to demand that those planning the robotic investigatory attack on Mars over the next decade or so, integrate such a mission to Phobos and Deimos into their plans.

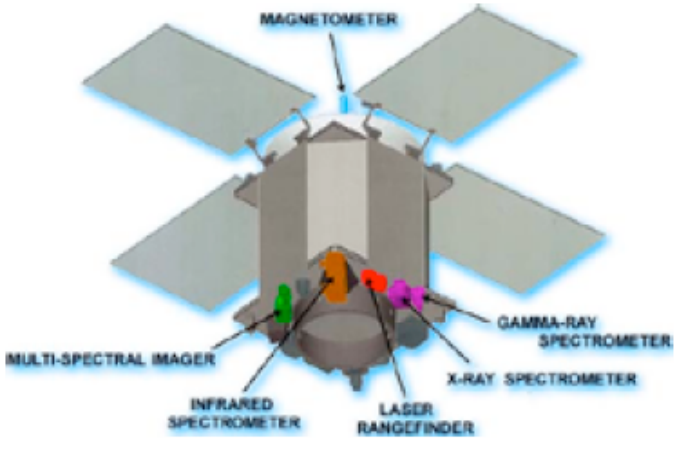
Aladdin pegged at $248 M including launch vehicle, was a Discovery mission proposal to gather samples from Phobos and Deimos in early 2003 by firing 4 projectiles into their surfaces, then collecting the ejecta during slow flybys, returning the samples to Earth for study.

Aladdin was one of 5 semifinalists in the round won by **Messenger** (to Mercury) and **Deep Impact**.

The same repertoire of instruments carried to NEAR (see box below) would provide a wealth of desperately needed information about Mars' two moons. Adding or switching instruments would only add cost and delay with questionable reward. We have a winner. Just send in the Clones!

NEAR–Eros Mapper Instrument Package

- X-Ray/Gamma-Ray Spectrometer [XGRS] The X-Ray Spectrometer detects X-ray fluorescence from surface elements excited by solar X-rays. The Gamma-Ray Spectrometer detects gamma rays from specific elements on the surface, excited by cosmic rays or by natural radioactive decay.
- Magnetometer [MAG] Searches for and maps any intrinsic magnetic field.
- Coherent X-band transponder measures radial velocities of the spacecraft relative to Earth, helping to map the gravitational field of the visited body(ies).
- Multi-Spectral Imager [MSI] images target in multiple spectral bands to determine its shape, surface features, and mineral distributions.
- Infrared Spectrometer [NIS] Measures the near-infrared spectrum to determine distribution and abundance of surface minerals olivine and pyroxene.
- Laser Rangefinder [NLR] A laser altimeter that measures the range to the surface to build up high resolution topographic profiles. This data will give a global shape model of the target.



For more on NEAR, visit:
http://near.jhuapl.edu/

NOTE: The Deimos Base Proposal in the following pages, bears some similarities to that of Dr. Fred R. Singer (See the References that follow our proposal) but has essential differences and was developed independently by the author. – ***PK***

Deimos Now vs. Mars Someday

The "Case for" a Forward Staging Base

By Peter Kokh

When it comes to on-the-surface exploration, there can be no question that it is much less expensive to mount a robotic mission to Mars than a human one. But a problem both approaches have in common is that the surface area covered is very small, even with rover-supported sorties into the "neighborhood" within reach from the touchdown point.

Now imagine how big a land mass we'd have if all seven of Earth's continents were recombined into one super-continent, as there is evidence was once the case some 600 million years ago. Mars is that vast! The pathetic futility of trying to explore the surface with one or even a few touchdown missions should be obvious.

All we can do is select a site that we hope offers a well-chosen sample of terrain. Imagine yourself an alien captain having to pick just one small area of Earth to explore.

Which site would you choose? How representative would it be. - I'd be tempted to go with New Zealand as far and away the single most variegated compact area on Earth, but even there you'd miss so much.

"any kind of serial mission approach to the exploration of Mars will span many decades.

A whole series of missions would certainly be needed to provide a reasonably complete picture. But the problem with serial missions is twofold:

(1) The **synodic period between Earth and Mars** orbital lineups is 780 Earth days long -- 25 5/8 months, 759 Mars days -- That is the average time between launch windows, either going or returning, the average wait for *any kind of follow-up*. Even if the time to prepare a new mission were minimized, we'd still have to wait for a launch date. That puts enormous pressure on planners to design a follow-up mission that will address as many of the analyzed shortfalls of the current mission as possible. In effect, any kind of serial approach to the exploration of Mars, whether manned or unmanned robotic precursor missions such as those we have been conducting, becomes an effort that spans decades. *"the serial approach is a throwaway one"*

(2) There are **repetitive costs** to the serial mission approach:

- Transportation out from Earth to Mars (and in the case of human crews, transportation back home.)
- No part of a lander or orbiter, even if it still works, is retrievable for reuse, however reusable.

The serial approach is a throwaway approach.

The serial approach to either unmanned or human-crewed exploration of Mars has the solitary advantage of requiring no commitment. Committing to any one mission does not require commitment to follow-on missions, however desirable they should be. In the absence of more than temporary political consensus, that seems to be the only way to do things.

Each mission is designed and launched as a stand alone project out of political expediency. Each new class of leaders with short-term vision confined to reelection effort advantages, demands the right to veto or confirm all programs supported by the previous set of leaders afraid to lead.

Inefficiency and mediocrity are two of the tradeoffs we habitually pay for democracy. Consensus and long-term commitment require full national discussion, an effort unlikely to ever be made. Indifference and short-term vision along with attention to innumerable vested interests conspire to make productive consensus and long term commitment unlikely.

A Manned Forward Base Meta-Mission Strategy

Perhaps it is fantasy to believe that we could do things in a more sensible manner. We won't try to touch that one. Our purpose here is not to propose a better way to "do politics," but to identify a better way to "do Mars," with a "meta-mission" strategy that:

- Telescopes the time involved
- Fractionalizes the total cost

What makes serial missions "necessary" is simply the unexamined assumption that Earth must continue to be our staging base. That mind set locks us into the stretched out timetable that the Earth-Mars synodic period between similar orbital lineups demands. And, it locks us into "throwaway" cost multiplication.

Recall the fable of "the Tortoise and the Hare." We are an impatient species. Taking the tortoise approach does not come easy. It demands an act of faith. Moving the Mars mission staging base off Earth will require such a leap of faith.

At first glance, the delay of setting up such a forward base will seem to be a detour. And humans have been impatient with detours from time-immemorial. I have a plaque on my bedroom wall that says: "the contented man is one who enjoys the scenery along the detours." That is a virtue that does not come easily. Faith that the detour will get us to our ultimate goal *more quickly in the end,* is hard to assent to. We are anxious to see early milestones. Impatience comes pretty close to identifying the all-crippling "original sin."

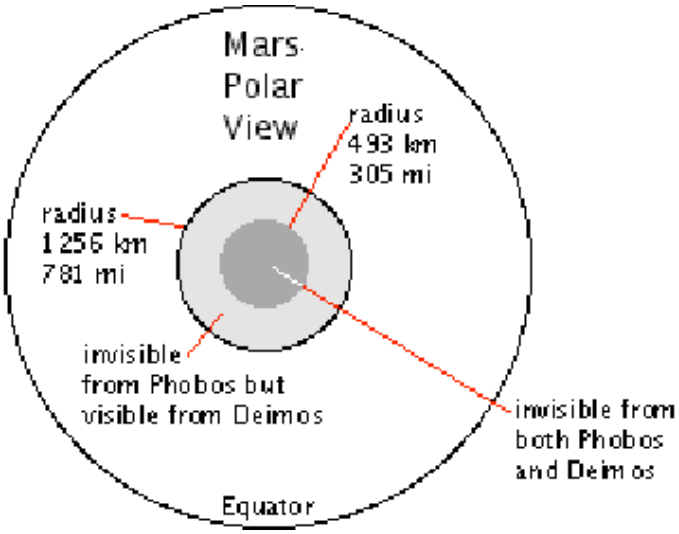
Most Mars buffs are thus naturally suspicious of any proposal to use the Moon as a staging base for the opening of Mars. But that is not at all what we have in mind. Whether the Moon should be developed before, or in synch with Mars is not the question.

Rather, we are suggesting -- and this idea is hardly new! -- that in the long run it makes much more sense to make our number one Mars Program priority *a manned forward base* on the outer of the two Martian moonlets, Deimos.

Why Deimos?

Though Deimos is smaller than Phobos (less than a third the surface area and only half the feeble gravity) and 2.5 times as far from (the center of) Mars, it would seem to provide the better perch for teleoperations on Mars.

- Deimos revolves about Mars more slowly, in 30.3 hours, but as the surface of Mars is rotating a bit faster underneath in 24.7 hours, any point on Mars is in sight from Deimos continuously for 40 hours at a time. That would allow, for example, a telescope on Deimos to produce continuous video records of individual intriguing objects on Mars through the whole range of lighting conditions from dawn to dusk so that they can be better interpreted.



- At that greater distance, Deimos overlooks much more of Mars' near polar areas than does Phobos, some 4 million square. kilometers or 1.5 M square miles total in the two polar areas, north and south.
- Important both for using solar energy to maintain a base and for minimizing periods in which the base is out of communications with Earth, the seasonal periods in which Deimos traverses Mars' shadow cone and is in solar eclipse are proportionately shorter in length and fewer in number than is the case for Phobos.
- As tiny as it would seem to be, Deimos is sizable enough to host a base with considerable expansion potential.

  Diameter: 15x12.2X11 km (9.3x7.6x6.8 miles)
  Circumference: 42 km (26 miles)
  Surface Area: 542 km2 (210 sq. miles)
- The pulverized rock powder blanket (regolith) on Deimos seems to be substantially thicker, an estimated 5-10 meters (16-32 ft.) than that on Phobos, judging from the way crater rims on Deimos are "muted" or softened. This will make burrowing into the surface relatively easy.
- Deimos is more richly endowed with hydrates and other volatiles, an invaluable resource. These can be used for air and water, fuel production, food production, agricultural byproducts, synthetics and other essential needs. This would make for a more self-sufficient base than Phobos could support, as well as potential trade items.

Why not just a Mars Orbiting Space Station?

Okay, so Deimos has advantages over larger and closer-in Phobos as a perch. Why not just put a Space Station in orbit around Mars? Why not in synchronous orbit where it can overlook an entire hemisphere permanently? Well, we could do that. Three such stations would give u s permanent full-time global coverage. But using either Deimos or Phobos has these advantages:

- Shielding mass, from the local regolith or blanket of impact pulverized rock, would be available on Deimos or Phobos. The base could even be built in a tunnel. Shielding is very important, for there is no Martian equivalent of Earth's Van Allen belts to protect personnel in Mars orbit from solar flares and cosmic rays.

- Probes, orbital and lander, might be designed so that less sophisticated replacement parts could be fabricated on Deimos in base shops.
- We expect that rocket fuels could be processed from Deimos' regolith as well as outpost atmosphere and water needs.
- Using regolith, the base could be expanded more liberally by local fabrication of big dumb shelter units (of steel and other alloy, concrete, or glass composites) than by expensive and infrequent shipment of additional space station type modules from Earth. Imports would be reduced to compact work stations, etc.

Major Synergies with lunar Development

Regolith-based technologies needed to develop a Deimos forward staging base will be broadly analogous to those we need to open and develop the Moon. If both these frontiers developed simultaneously, the cost of the needed R&D could be charged to, or born by both frontiers. If one preceded the other, sale of technology and equipment to the other could be a source of supporting revenue. If these technologies were field-tested and became operational first on the Moon, then the Moon could possibly support the forward Deimos Mars Staging Base by providing some of the *initial* equipment and supplies:

- Regolith-handling , processing, and manufacturing equipment; crude but workable solar panels
- Regolith-based replacement parts and nonvolatile regolithbased fuels for Mars orbiters and landers and on site generators, equipment, and vehicles
- Regolith-based outpost expansion modules Deimos is comparatively will endowed in the volatiles the Moon lacks. A "pipeline" shipment plan for supplying lunar settlements with liquid methane and liquid ammonia in trade for manufactures listed above at a fuel-cost advantage for both locations over Earth-sourcing will create a natural two-way trade to the benefit of both Moon and "Mars PhD."

Advantages over Earth staging for Manned Mars Crews

We can go for a quick, cheap, and dirty human expedition to the surface. Far and away the most popular course, it has these major disadvantages:

- Even if the technologies for a human landing mission were online, the mission would be politically "postponable" until "further information" is gleaned from a stretched out series of robotic missions mounted every 26 months.
- Follow up crewed missions would be subject to the inconstant vagaries of political illogic, and could easily be delayed beyond "next" opportunities
- Deimos is easier to reach, fuel-wise, than Mars with more cargo throwweight (no aerobrake shields needed, etc.)
- It takes less fuel and less preparation and equipment to return to Earth from Deimos than from any other location in the Mars system.
- New surface missions can be flown as soon as the equipment is ready, and teleoperated in real time instead of by limited intelligence robotic AI programs.

In contrast, as the first order of business of a forward of Mars in a greatly shortened time, the forward staging base strategy would see a permanent human encampment on the threshold of Mars years before the common wisdom strategy could hope to result in a first *temporary* visit to Mars' surface.

What it will Take

For a Deimos Forward Base we'll need the same basic equipment as for a Mars surface b ase with these differences:

- Equipment to produce volatiles (carbon, oxygen, nitrogen, hydrogen) from the regolith instead of the ISRU sabatier reactor intend for Mars surface use.
- The crew quarters should be designed as a low profile horizontal than vertical cylinder for ease of covering with regolith shielding
- Shop facilities for integrating instruments shipped from Earth into new orbiter, lander, rover, and penetrator packages for Mars.
- Capacity to retrieve orbiters at the end of their mission and salvage reusable parts
- Mission control facilities ot deploy orbiters and surface probes and to take over final guidance of incoming flights of cargo from Earth.
- Phase II: regolith processing, building materials, production, and some manufacturing facilities to enable self-expansion of pressurized volume.

The Thoroughness Argument *Our goal should be nothing less than the uncancelable opening of the Mars Frontier*.

We now are forced to make painful choices in selecting landing sites for rover probes. If a more promising site is found, we have no choice but to wait for another launch opportunity window. A Deimos base with a supply of programmable landers, would be able to dispatch them to fresh target areas in relatively quick succession.

Further, surface probes and rovers could be teleoperated from Deimos in almost "real time." The 1/6th to 1/7th second Deimos-to-Mars-surface-and-back radio signal delay is only half as much as we routinely accept in terrestrial newscast interviews via geosynchronous communications satellites.

Consider the case for Mars Sample Return. Not only would Deimos provide ideal biological and chemical isolation, and, if need be, quarantine, but we would not be stuck with sampling just one site chosen as a political compromise between geologists and Mars exobiologists. Not having to send samples all the way back to Earth,a whole series of sample return-to-Deimos-lab missions could be flown for the same cost as a single return-to-Earth mission. In a relatively short time we could do fairly representative sampling of many heterogeneous areas of Mars. As frosting on the cake, in the unlikely (as it seems to us) event that the samples contain biological agents that could prove harmful to Earth life, a quarantine lab on Deimos would be infinitely safer than on on Earth, or even in Earth orbit.

And that would mean a much better "economic geography of Mars, a much better idea of where the starter settlement should be -- not just for science purposes -- but to support industries needed for settlement self-sufficiency. After

all, just ot concern ourselves with getting there is rather shortsighted. Our goal should be nothing less than the uncancelable opening of the Mars frontier.

In short, the time of preparation for a manned Mars landing, the wait before we can say the time for a manned landing is truly "ripe," will be shortened. The present "Hare" mentality promises a shorter wait but will instead either result in indefinite postponement or in a premature "flags and footprints" Apollo type "Kilroy was here" (and gone) one time program of pride and achievement, followed by ... er, nothing!

A political commitment to even a one time manned Mars landing sortie may prove out of reach. But a commitment to a long-term manned forward base on sterile Deimos can be made now. Will Mars advocates find the wisdom to switch gears? We must take the Tortoise Faith step first. **<MMM>**

Phobos – Deimos Trivia

Both of these mini-moons were discovered after a prolonged search by Asaph Hall in 1877, who was encouraged not to give up by his wife Angeline, née Stickney. Her role has been recognized by naming Phobos' largest crater after her. Phobos (Greek φοβοσ Fear) and Deimos (δειμοσ Terror) were the attendants of the Greek god of war, Ares (Αρεσ), identified with the Roman god of war, Mars. Deimos is Cluros in Barsoomian (Edgar Rice Burroughs' John Carter on Mars series of novels.)

Mars looms huge in Phobos' sky, spanning 42°, 21 times the apparent diameter of the Earth seen from the Moon and covering 400 times as much of the sky. Mars spans 16° of arc in Deimos' sky, still an awesome sight.

Full Mars to Full Mars, 30.3 hours on Deimos, may dominate practical scheduling, if not timekeeping, for a manned base (35 Demos Full Mars to Full Mars periods very nearly equal 43 Mars days.) Personnel may experiment with special clocks and calendars and work schedules. Phobos laps Deimos in a synodic period of 10.24 hours, about 3 times per Deimos day.

As late as 1960, it was possible to suggest that these might be hollow artificial worlds. Iosif Shkovskii's intriguing suggestion has since been ruled out by Viking measurements of the two moons' masses and densities. (as well as by their irregular shapes.)

How Mars came to have or acquire these moonlets is still a puzzle as the mechanics of capture (of approaching asteroids) into their present orbits seem unlikely. The surfaces of both moonlets date from the last period of heavy impacting from solar system debris 3 billion years ago.

Both are dark (low albedo or light reflectivity) and seem similar to carbonaceous chondrite asteroids, denser than ice, less dense than rock debris. Phobos is the denser, having lost much of its original water ice or hydrates in the heat of the impact that created Stickney crater.

Tethers have been proposed to capture incoming freight and dispatch outgoing cargoes from Deimos, to further reduce Delta V needed for imports and exports.

Unmanned solar sail freighters could be used to keep shipments between Deimos and the Earth-Moon system "in the pipeline. ---

Life at a Deimos Forward Staging Base

Minimal Gravity or "Mini-G"

It takes ta speed of 25,000 mph to escape the grip of Earth's gravity; 5,300 mph to escape from the Moon; and only 18 mph to escape from the "gravity dimple" of little Deimos. Popular assertions to the contrary, human muscle power would not be up to the task. No one can jump with that much force (without a series of accelerating bounces of a trampoline), and with near zero traction, it would seem impossible to build up enough speed by "running."

Feeble as it is, Deimos' gravity is enough to hold undisturbed items in place. "Undisturbed." That means furniture and furnishings must be securely fastened to floors and walls less a casual touch or brush send them flying. People will need velcro soles to "walk" or maintain position within the habitats, handrails attached to walls and ceiling will be useful in pulling oneself along, feet tending to drift towards the floor and drag a bit. Out-vac, on the surface, a railing system will allow personnel to zip along regular traffic routes. Pogo sticks with landing pads may, with practice, become popular, but a bounce off uneven terrain could be dangerously uncontrollable. Pogo sticks could help in reconnoitering unfamiliar terrain or getting one's bearings when "lost." They might also lead to out-vac sports activities: races and rallies, even slaloms.

Those who wanted to maintain muscle tone for eligibility for a hoped for trip to Mars' surface or a return home to Earth, could exercise in a centrifuge.

Other Free-time Recreation

Watching the gradually changing phases of the slowly rotating globe of Mars above will be especially interesting when dust clouds are astir. Mars viewing will be more comfortable, but also more distracting, if the Base is located so that Mars hovers over the horizon. Live surface videocams could feed electronic Marsscape photo murals in the lounge.

Getting Away From it All

To get away from thing from time to time for relief from the stress of work and interpersonal irritations, there could be a pressurized retreat "cottage" on the "farside" of Deimos where Mars will be "out-of-sight-out-of-mind; there, the Earth-Moon bi-planet, Jupiter, and the Milky Way will rule the heavens.

Tours of Duty

The Forward Base strategy will work best if crew replacement frequencies can be minimized. One perk for tour extension may be earning points for selection to the crew that will make the first Mars landing. Will it be better to pick married couples? free swingles? or monastic types? One shouldn't discount the power of faith, ideals, and dedication in allowing one to cope with extreme assignments. **<MMM>**

Phase II: A Quarantine Facility on Deimos

The initial task of a Deimos Forward base will be to deploy and teleoperate a growing fleet of rovers, landers, penetrators, balloon-borne and flying Mars probes. But long term, its ultimate *raison d'etre* or flagship capacity will be to serve as a Quarantine Facility for Mars sample returns. The

Quarantine Facility will be equipped for physical, chemical, biochemical, and biological analysis of sampled materials. A Terrarium with a wide variety of Earth life forms will be needed to test the interactivity of any discovered life forms or remains.

It is only with such a facility, and only if it is situated on Deimos or elsewhere in orbit around Mars, that a convincingly thorough bioanalysis of Mars life forms or remains can be made.

It is nothing less than mass self-deception for Mars advocates to think that a tabloid-reading public, led by rabblerousing fringe scientists, could ever settle for anything else. Mainstream thought, which has been wrong before, is that we will not find surviving lifeforms on Mars. And if we do, the odds are that *they will not find us nutritious or tasty, and vice versa*. But say the worst case scenario holds true. The public would demand that an infected Quarantine Facility in Earth orbit [as called for in NASA's Antaeus Report] be destroyed, along with all its occupants, including human ones.

A facility in the Mars system would be sufficiently remote. We just wouldn't ever send any replacement crew personnel. The inability to "rescue" "infected" persons on Deimos in any timely fashion, thanks to the long period between launch windows and the long travel times en route, would ease consciences. Analysis of any Mars life forms or remains on remote Deimos would "threaten" no one.

Putting the Mars Sample Return Quarantine Facility on Deimos is our only option if we want to our money's worth.

While discovery of surviving life forms on Mars may be exciting, it could very well doom all public support for human Mars exploration and settlement. One must never underestimate the capacity of the public to be irrational. A Mars sample return facility on the Moon might be just as safe, but could not economically support a thorough series of sample returns. A lunar location, though "safer" than Earth orbit, makes no sense. To analyze one sample return or many, the cost of the facilities will be the same.

Phase III: Support for Mars Surface Operations

The Forward Staging Base on Deimos would not become obsolete with the start of manned Mars surface operations. Most importantly, it might enable rescue and recovery from potential disasters where the only other assistance was many months, or years, and millions of miles away on Earth.

- The ISRU Sabatier reactor automated fuel production plant to be landed on Mars two years before the first crew arrives could fall short in its production quota or fail entirely. The forward Base could send some of its own locally produced fuel (methane) reserves to the surface on very short notice.
- The Deimos Base fabrication facilities would be a source of some (not all) critical replacement parts for surface missions
- Its "Mission Control" could guide unmanned freight and cargo pods to on-target landings.
- Deimos Mission Control could also assist and guide manned exploratory surface rover excursions.
- The Deimos Base could provide rescue personnel (medical, systems, engineering, etc.) in short order (assuming a personnel shuttle craft was at their disposal)
- Given such a shuttle, Deimos could provide R&R (Rest and Recreation) for surface crews along with the possibility of trading crew members if needed.

In Summary

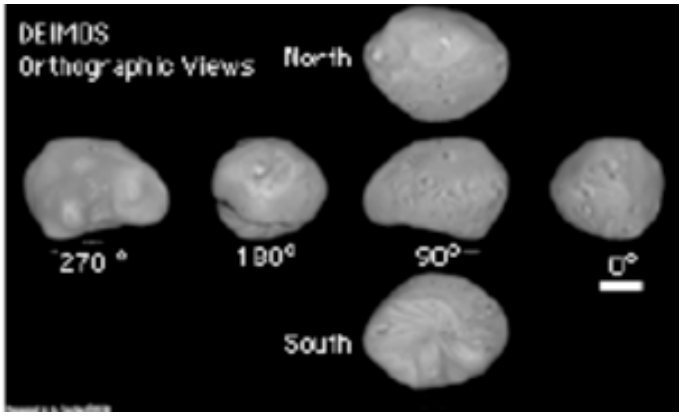
A Deimos Forward Base has " **the potential to reduce costs, accelerate schedules, and reduce risks**" for a combined robotic-human program of *comprehensive* Mars Exploration. **<MMM>**

Relevant Reading from Back Issues of MMM

- MMM #6, JUN '87, "Mars, as I see it"; "Mars, PHOBOS, Deimos"; "M is for Methane & 'Momonia" *republished in MMM Classic #1*
- MMM #18, SEP '88, "The M.U.S./c.l.e. Plan for Lunar Industrialization: ¶ The Contribution of a Phobos-Deimos M.U.S./c.l.e. Plan to Mars"
- MMM #19, OCT '88, "Mars Option to Stay: Scenario 1: Timeline 2010: A Complete Phobos Base" both #18 & #19 articles republished in MMM Classic #2
- MMM #25 MAY -89, "Podokinetics" *republished in MMM Classic #3*
- MMM #42 FEB '91 "Locomotion: Mobility in Very Low Gravity Environments," Michael Thomas
- MMM #45 MAY '91 "VLG Regolith Tractors, Michael Thomas
- MMM #46 JUN '91 "Footloose Among the Asteroids" *#42, #45, #46 articles republished in MMM Classic #5*
- MMM #110 NOV '97 "Lunar Quarantine Facility for Mars Sample Returns, Bob Bialecki, P. Kokh *republished in MMM Classic #11*

Other Readings

- "An Orbital Quarantine Facility for Analysis of Returned Samples" [abstract only. John R. Bagby, AAS 84-194 p. 701, The Case for Mars II (proceedings), Ed., Christopher P. McKay, Vol 62 Science & Technology Series, American Astronautical Society, 1985.]
- <http://www.scientificamerican.com/2000/0300issue/0300singer.html> "To Mars by Way of its Moons: Phobos and Deimos would make ideal staging areas," by S. Fred Singer



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. =>> *below*

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 form 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 siting 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 Coloeado 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 settlement's, La Paz is as close to "Marslike" 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:

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

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

And Peter Kokh kokhmmm@aol.com

Segue form the piece above -- Peter Kokh

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. (Cf page 32 top left, above)

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 openended 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 – By 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 a ground 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 toy 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 he 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/MarsAviation

MarsAviation-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 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 Can Fly 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 (CH4) + 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 feed-stocks 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, "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 petro-chemicals 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"

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 (been 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 (NH3) via the Haber Process and from this we can make nitrate fertilizers. Ammonia can also serve as a refrigerant.

Other logical feedstock products are NH4OH ammonium hydroxide, and reacted with sulfur and chlorine, ammonium sulfate and ammonium chloride.

More Nitrogen products

N2O Laughing gas is used as a mild anesthetic but can also be combusted with carbon to revert back to pure Mars Air (CO2 + N2) providing another fuel combination option for specialized uses.

NO Nitric Oxide can be used to make HNO3 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.

N2O5 Dinitrogen Pentoxide:

An inconvenient attribute

According to Jeffrey Landis, a respected NASA researcher and writer, N2O5 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 P2O5 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 CH4 is the first in a series followed by Ethane C2H6 and Propane C3H8. If we could synthesize ethane and propane, we'd have additional fuels as well as the building blocks of ethylene C2H4 (> polyethylene) & propylene C3H6 (> polypropylene -- trade names: Olefin, Herculon, etc.)

The Alcohol family begins with Methyl Alcohol CH3OH derived from Methane and Ethyl Alcohol C2H5OH 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**, NH2CONH2, from human urine
- Organic **dyes**
- Organic **oils and lubricants** from Oliferous (oil-bearing) plants
- Organic **solvents**
- Organic **adhesives**

The list of useful plant and animal byproducts that can be used as chemical feed-stocks 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>**

Water "on Location" for Drinking, Bathing, Growing Food, and Industrial Purposes

By Peter Kokh

Up until Mars Odyssey arrived in Mars orbit, schemes for supplying water to an outpost/settlement had 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:

Main Salts in Earth Seawater			
Cations	g/kg	Anions	g/kg
Sodium	10.76	**Chloride**	19.35
Magnesium	1.30	**Sulfate**	2.71
Calcium	0.41	**Carbonate**	0.14
Potassium	0.40	**Bromide**	0.07
Strontium	0.01	**Boric acid**	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>**

"3/8ths G
It's not just a good idea,
It's the law."
— Marsport local ordinance

There is Daylight on Mars!

By Peter Kokh

That may seem to be a strange declaration. But 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 shinning 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.

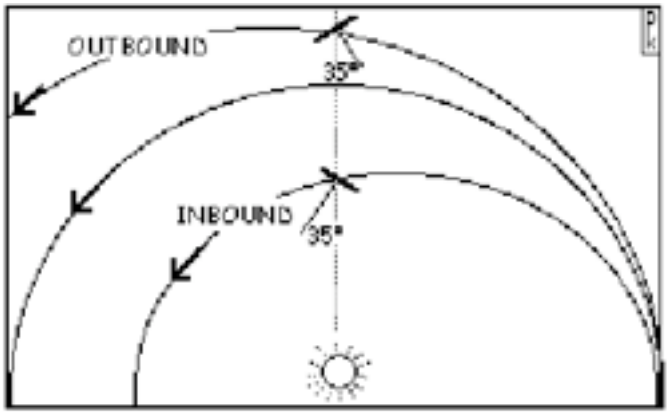
The submarine launch planned for **mid 2003,** will be from the Barents Sea north of Murmansk. The space-craft will be operated from the Babakin Space Center near Moscow. Telemetry data will be received in Russia and in the United States.

Inflatable tubes keep the sail rigid. The solar sail will use the pressure of sunlight to increase it orbital energy and raise its orbital altitude. The sail I 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 the 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 a lot of 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 U.S. government decided not to pay for launch costs for three of the entrants of the race.

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 form 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

www.kp.dlr.de/solarsail/

www.spacetransportation.com/ast/abstracts/3C_Frisb.html

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 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" to survive in our air-filled living rooms. "Strangers 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 better, 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:

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 envelopes 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. The 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 sports-minded, 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 foresaker 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.

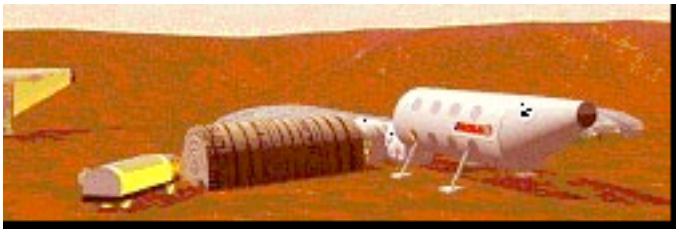
It is our efforts, spearheaded by MS Australia, and eventually championed by commercial outfitters of frontier sportsmen, that will make it possible. <MMM>

Need for More, Diverse M.A.R.S. Habs

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.

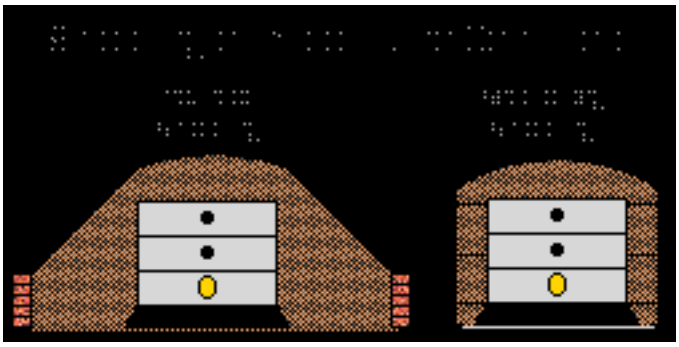
The 4th M.A.R.S. Hab will part company with its predecessors in using a pre-Mars-Direct design, the so-called Biconic shape for a habitat '"flying in" for a landing rather than lowered to the surface vertically by parachute.



http://www.marssociety.org.au/technical/tech_images/MarsOz_cover.jpg

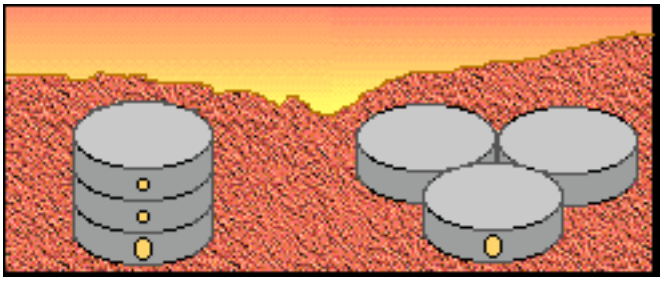
While the pros and cons of landing the two basic designs cannot be tested in Australia, the relative effect tiveness of the two designs in supporting operations can. The biconic design has the advantage of a lower profile, which will make it easier to shield with loose Mars regolith soil. In fact, it 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.



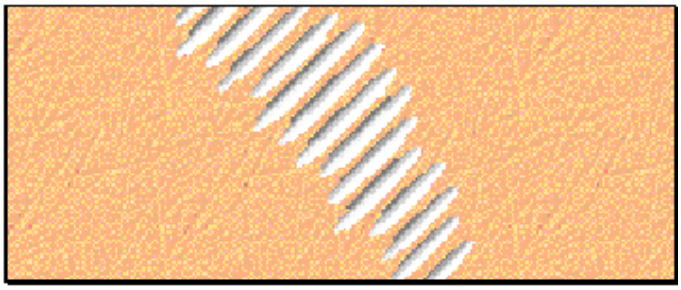
As shown in the illustration above, using fabric "saddle bag" held in place by straps to the habitat hull, and folded in pleats against the hull for the transit from Earth would reduce the total volume of soil needed as well as the footprint area of the shielded habitat. Both methods could be tested, 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. And 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. Hab** project with enthusiasm. <**MMM**>



The Sand Dune Fields of Mars

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

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

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

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

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

This is not to say that it will not be a difficult, dangerous, and expensive endeavor. It will be. However, at this point, we are far better prepared to send humans to Mars than we were to send humans to the Moon when John

Kennedy made the decision to do so in 1961. At the time that Kennedy issued his stirring challenge to the nation, America had only 15 minutes of experience in human spaceflight--none of it actually in orbit around the Earth -- yet eight years later humans walked on the Moon. In 1961, we had not sent a single successful robotic mission to the Moon--much less to any planet--yet eight years later humans walked on the Moon. In 1961, we had launch vehicles capable of putting only a couple of thousand pounds into orbit around the Earth--yet eight years later humans walked on the Moon.

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

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

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

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

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

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

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

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

How we go to Mars is as important as whether we go. In the 20th century, a single nation went to the Moon on a Cold War double dare. In the 21st century, let it be united Earth that goes to Mars. Going to Mars, the pushing outward to the stars, will be a parallel process with other human developments in a push-pull relationship. Going to Mars together will go hand in hand with coming together here on Earth. Bringing life to Mars will go hand in hand with assuming responsibility for the competent stewardship

of life on Earth. Bridging the gulf of space to meet and understand the Alien will go hand in hand with tearing down the obstacles of greed and prejudice that are the source of alienation on Earth.

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

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

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

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The Sundial – First Artwork on Mars?

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

Roadblocks to an Open Mars Frontier

By Peter Kokh

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

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

How do we tackle this?

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

exports. This will create a model for the Mars Initiative to follow. - PK

Moon – Mars Project Commonalities

By Peter Kokh

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

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

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

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

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

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

Martian Sand Dune Rows

May make ideal Settlement Sites

By Peter Kokh

A different situation than on the Moon:

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

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

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

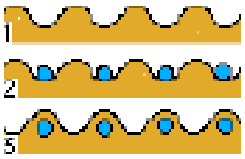
In MMM # 42 FEB '91, p4 Atmosphere Derived Shielding for Lo-REM Martian Shelters, we explored the idea of "mining" Mars' atmosphere for shielding materials. In the article, we suggested dinitrogen pentoxide, which is a powder through out the entire thermal range to be found on Mars. It would extract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

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

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

The dune fields of Mars: a unique structual opportunity:

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



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

Questions of stability and preservation:

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

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

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

Being Playful on Mars

Arizonesque Burlesques on Mars?

by Peter Kokh

Where comparisons end

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

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

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

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

Why not do something about that?

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

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

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

Using Made–on–Mars Art/craft materials.

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

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

Clues from Mars on Earth

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

Enter the wind

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

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

Wind and Sound

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

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

Mars of Yore, and Lore

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

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

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

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

Tourist attractions

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

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

Earthside Deserts will continue to inspire

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

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

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

A Barsoom Glossary – Illustrated

People - Places - Things - Culture - Technology

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

Do maps of Barsoom and Mars line up?

1440x721 pixel map of Edgar Rice Burrough's Barsoom

http://www.geocities.com/area51/dreamworld/6532/barsoom/maps/barsoom_large.gif

Jetan – Barsoomian Chess

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

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Tourist Attractions, Marsport

A Piece of Old Barsoom

E.R. Burroughs Outdoor Museum

The real Mars is not the Barsoom of novelist Edgar Rice Burroughs. But what can it hurt to pretend! Transport yourself back to that fictional yesteryear on ancient Mars, to a time of survival and chivalry and heroism. Visit the **Avenue of the Quays** in ancient **Aaanthor** as well as the **Avenue of the Ancestors** in **Greater Helium**. Behold our recreations of **apts**, **thoats**, **calots**, and other creatures encountered by that first visitor from Earth, John Carter, related in Burroughs novels. published way back in 1911-1941 common Earth era.

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

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The Mars Desert Research Station (MDRS) in Utah

The MMM editor spent two weeks in February at this remarkable facility in Utah. On pages 3-8 and elsewhere in this issue, 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, Editor of Moon Miners' Manifesto
Life Member, the National Space Society
President, the Moon Society, Member, the Mars Society,
and 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 ATVsμ"pressurized 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, a lot of 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 tearing down the present hab and building 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.

And 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 unnecessarily 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 photographer 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 gener-ator 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 multi-function 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 undersoil. 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 impor-tant 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 can not 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 expan-sion. 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 insula-tion, 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 involv-ment 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 hardware 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 de done elsewhere, *in any type of host terrain* (even verdant farm-scapes 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, inclu-ding 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 Innuit villages might do, although most are *too easily accessible,* these days, by airplane or helicopter.

MDRS is both blessed and handicapped by its remoteness. But 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 & 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 multi-site, 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.

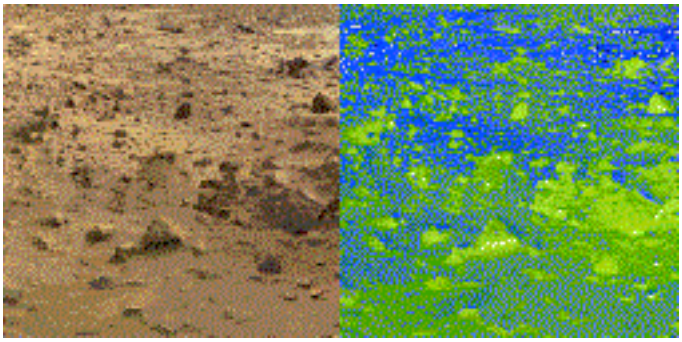
There are already strong dedicated concentrations of volunteers in the form of focused chapters within the Mars Society, the National Space Society, and the Moon Society that could undertake some useful bite-size project, however humble, in support of the broader effort. SEDS (Students for the Exploration & 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>**.

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." PDF file readers can see this below.



http://members.aol.com/tanstaaflz/petesmars_projects.htm

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 crafts-man talent are used to working will be in short supply, exor-bitantly 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 craftsperson.

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›**

Our 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 to 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 m2 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 situa-tion 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 is 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.

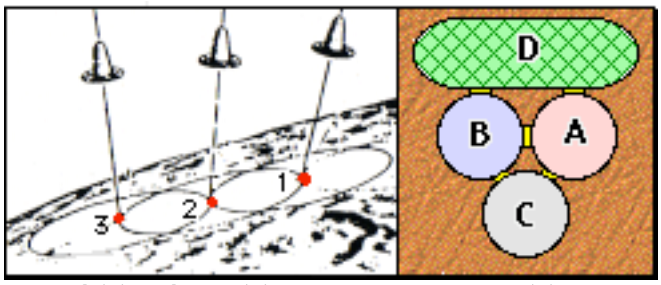
Crew Life Styles: We need prior commitment from our volunteers to participate wholeheartedly in experimental pioneer vegetarian food preparation and menu development. It's a matter of getting into the spirit and will generate good publicity. But we should also incorporate time, space, supplies and tools 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 improve-ment, 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 brain-storming and planning. Let's start now. **<PK>**



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) Green-house. 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 *looong* 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 instru-ment first flown over Mars could be reflown over the Moon.

[* MMM # 133, Nov. 1999, In Focus Editorial, pp 1-3] – **PK**

From the Arctic & Desert Analog Stations to a Real 1st Human 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 made 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 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*. The 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 chose 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^2 = 128 mi^2 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 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-identidal 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.

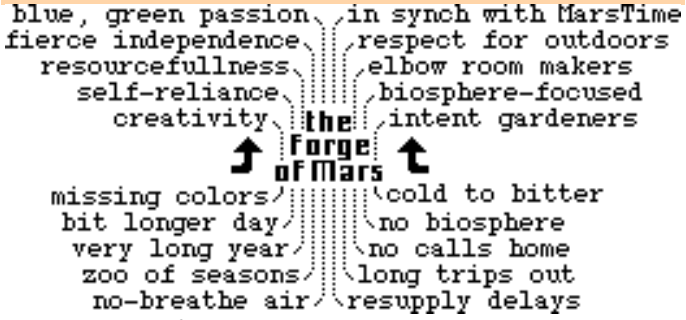
Currently, the separate Mars Foundation works on its own to find pathways to settlement. The Mars Society needs to collaborate with the Foundation to vastly improve its analog program., which is currently aimed only at the exploration of Mars, not settlement.

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 some-how? If so, how do we get back on the path to our dreams?"]

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 contri-buted 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 futily 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 furni-ture 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 form 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 exteriorscapes 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!

Marsspeak, 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, p.1

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 are 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 U.S. 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>**

Flyers Prepared for the 2004 Mars Convention

By Peter Kokh

The Moon Society is focused on the Moon, obviously. But for lunar settlement to be truly viable, the Moon will need to tap resources it lacks in economically accessible abundance: industrially strategic metals such as copper, zinc, silver, platinum, and gold; and perhaps carbon and nitrogen-rich volatiles. The Moon also needs markets for its products.

Mars first fans are quick to point out the resource-challenged poverty of the Moon. That established fact turns out to be irrele-vant. Japan too, lacked many industrially strategic resources: coal, oil, iron ore, and more. So it *went out* and developed "markets" in the resource-rich areas of the Pacific Rim, becoming rich and prosperous in the process. Japan is the model for the Moon. Our satellite does, however, start with the three most important resources of all -- "location, location, location" -- the Moon has it and Mars does not.

The story does not end here. Greater Mars (with its moonlets, Phobos and Deimos) is a potential market for goods manufactured on the Moon, but more importantly, a potential source of volatiles and strategic metals that can be shipped to the Moon for far less fuel cost than up out of Earth's deep gravity well. It is in the Moon's interest to promote the opening of "Mars PhD", *not even-tually, but without delay,* apace with the opening of the Moon.

But it is also in the best interests of the future Martian frontier to have the lunar frontier develop side by side. Why? It is difficult to conceive of an export product that Mars could market to customers on Earth: Mars has no resources in abundance that are scarce on Earth. Tourism? Who will be willing to take two to three years out of there life for a round trip jaunt to Mars, when most of that time will be spent coming and going? But Mars does have poten-tial exports it can market to the Lunar Frontier. In fact, without the Moon in the picture, it is exceedingly difficult to establish any believable "Econo-mic Case for Mars."

An Earth-Moon-Mars economy can work. The Moon has three potential product areas that might be developed for direct sale to customers on Earth: micro-waved-power, helium-3, and tourism. But beyond that, any item that lunar industries develop for local, lunar, consumption, should be marketable to in-space markets such as LEO industrial parks and tourist facilities, at a cost advantage over equivalent products produced on Earth, given the 20:1 fuel savings advantage. Again, what the lunar economy will be able to produce, and the extent to which it will be able to diversify, will be limited without cheaper sources of lunar-deficient materials than Earth.

Mars too will benefit from immigration of Moon-seasoned pioneers. For Lunans, Mars will be a walk-in-the-park. A Lunan recruit will be worth as much on Mars as many recruits direct from Earth.

Simply because of distance and frequency of launch windows, the lunar frontier will initially develop faster than the Martian one. Made-on-Luna equipment and supplies will be shipped to Mars at considerable fuel cost savings, allowing Martian hard currency credits to go farther, helping to insulate the Martian frontier from a cut off or cut back of support by benefactor governments and corporations on Earth.

Whichever world you person-ally would rather pioneer, it remains all but certain that the Lunar and Martian Frontiers will have an immensely better chance of successful development, each more quickly reaching via-bility should support from Earth be interrupted, *together* than separately. The Moon and Mars then are more fruitfully seen as natural partners, not as "us or them" competitors.

Well-intentioned enthusiasts who buy into the "Moon or Mars" debate, not only deceive themselves, but unwittingly work for the fail-ure of both. Can we afford both? Let's rephrase the question: Can we afford to pick just one if it entails certain failure? The Moon Society calls for the opening of both frontiers simultaneously, with new equipment (e.g. mining, processing, and manu-facturing; transport) and systems (pocket hospitals, air, and for use on both worlds, tested on the Moon first, where rescue, resupply, repair are easy.

This will be provide a triple benefit for Mars. New equipment will arrive on Mars with a much higher confi-dence and assured reliability level for use in a location where rescue and or resupply can be months or years away. Development of such equipment and systems can be charged to the cost of opening the Moon, *greatly reducing the incremental cost of opening Mars.* With the new, debugged equip-ment from the Moon will come personnel familiar with its use, proven pioneers rather than untested romantics from Earth.

Yes there are differences between the Moon and Mars, differences that do *matter.* Some equipment and systems will be unique and special to one frontier or the other. But that should not keep us from working to iden-tify and maximize equipment and systems that can be standardized, at least in part, for use in both locations, saving precious money and funds for other vital expen-ditures.

The Moon Society sees the Mars Society not as a rival, but as *a logical partner in working to realize this vision.* If some things get tested on the Moon first, that initial delay will greatly speed-up the pace at which the Martian Frontier successfully develops *over the long run.* But we have to work at it, to guarantee that both frontiers open and develop apace.

Patience? Not exactly. *Aggressively industrious patience,* yes! Impatience gets quicker results, to be sure, but far more often than not, those results are flawed and soon lead to failure.

So let us both, the Moon Society and the Mars Society, work together, cooperating and collaborating, helping each other achieve a shared, brighter, open-ended future. Yes, the Moon Society is focused on the opening of the Lunar Frontier. *But Mars loom large in our Field of View.* It is in this spirit, and with this hope, that the Moon Society is cosponsoring Mars Convention 2004.

This vision is just the beginning. In time man-kind will call all the Solar System home, and have begun to reach for the Stars!

www.moonsociety.org

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. And the Moon can probably supply the Martian frontier with some items at a lower expense than they can be shipped from Earth. In short, the Economic Case for Mars, presently mostly wishful thinking, gains a boost from the Moon being a customer. The reverse is also true.

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

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

√ The ability to go outdoors without a spacesuit and enjoy the sunshine under an open blue sky.
√ Many outdoor forms of recreation that attempting to do in a spacesuit would have comic results.
√ An endless 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 mush 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 pallets, 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 "flash-bulb" impactor** with two parts which 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 air-lock 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 non-functional 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 adavntage.

> **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.***

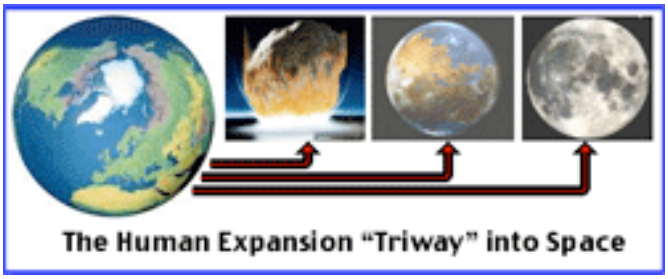
Suggestions and *constructive criticism* are invited.

Peter Kokh - kokhmmm@aol.com

MARS Articles Since Year #20

For your convenience, the March issue of each year, usually dedicated to Mars, is freely available for download on the Editor's Pick List at:

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



The Human Expansion "Triway" into Space

Moon and Mars Supporters Are strongly united in a Passion to *Preserve Mother Earth and Humanity*

Read the following

Moon, Mars, or Asteroids: Which path to pick?

By Peter Kokh

There are three principal human space expansion pathways, each focused on one of three principal imperatives in which space is the key to the ultimate challenge facing humanity. ***Survival!***

1. **Planetary Defense of our home world from potential impactors (Near Earth ASTEROIDS)**
2. **Establishing a viable exclave of human civilization on another world (MARS)** to guarantee human survival should civilization on Earth be wiped out by an impact or other natural disaster, or implode through human-caused environmental degradation.
3. **Using Space Resources to halt, and ultimately reverse environmental degradation on Earth** through overuse of fossil fuels, and to create a more equitable global economy **(THE MOON)**

Path #1 The Danger of Asteroid Impacts

Before we can design a suite of astrochunck orbit adjustment method, we need to

1. **Identify all the possible impactors** out there, and then
2. **Tag them with transponders** so that we can keep ultra-accurate track of them and
3. **Characterize each** as to internal cohesiveness and structure, then
4. **O**n the basis of which population group poses the greatest threat, **prioritize development and testing of methods of deflection**

Given the relative likelihood of different size impacts over time, the **first things first, one step at a time** plan sketched at right offers the best cost-benefit ratio. We have to keep in mind that the **odds of disaster from impact are less than the odds of a super-volcano eruption, or of a super-tsunami event, or of a next ice age,** any of which could devastate Earth on a continental scale. Asteroids are not the only natural threat we face. But they are the threat that we can do the most about.

I. Changing Orbits of Threatening Astrochunks

We are learning that asteroids come not only in many sizes and with serveral kinds of mineralogy, but that they have several kinds of complex rotations and several degrees of internal cohesiveness.

- Punch a bean bag, and it doesn't fly away from you, it just rearranges itself around the impact point
- Giving an asteroid with a complex wobble a push in the desired direction can be very tricky.
- No one strategy fits every case

2. Other benefits of Asteroid identification & tracking

Near Earth Asteroids & Comets are not only possible threats, they **are reserves of raw materials** that may be essential to our growing material needs:

√ iron, nickel, and other "engineering **metals**

√ **precious metals:** gold, silver, platinum - Platinum is now involved in over 25% of all modern industrial processes. It is most needed for the fuel cells that could usher in the "Hydrogen Economy

√ **volatiles:** water-ice, hydrocarbons, carbon and nitrogen ices - these may be vital imports for a lunar economy. Water-ice rich comets, comet hulks, and carbonaceous chondrite asteroids may be of use in the terraforming (or "rejuvenation") of Mars

Path #2. A Viable Human Colony on Mars

Mars is in many ways the most "Earth-like" planet in our solar system.

1. **Total land surface** of Mars is equal to total land surface of Earth
2. **Mars day** is just a bit longer than ours. Mars has four seasons.
3. Mars has **a thin atmosphere** and apparently **a lot of water** locked up in underground aquifers

4. A Mars colony **could someday survive cutoff** of support from Earth
5. We may be able to **restore the warmer, wetter climate of early Mars**

Stephen Hawking has warned,
"The survival of the human race is at risk as long as it is confined to a single planet. Sooner or later, disasters such as an asteroid collision or nuclear war could wipe us all out."

Synergies between Highways 1 & 2

- Mars could provide a valuable **vantage point for identifying and tracking Earth approaching astrochunks** that also approach MarsSome of these asteroids are sure to contain **resources that will be of value on Mars** and contribute to faster and more diversified industrialization
- Early civilization on **Mars could also be threatened** by asteroid impacts
- Some of the **techniques developed to redirct Earth-approaching asteroids** might also be used to direct comets into collision course with Mars if this would prove useful in adding to Mars water reserves

Path # 3. Using the Moon to Save Earth from Ourselves:

Moving Away From Fossil Fuel Dependency

OPTION 1. SOLAR POWER SATELLITES made from Lunar Materials

- Solar Power Satellites **receive more intense sunlight "24/7"** and can beam the power to rectennas on Earth by microwaves or lasers
- A lot of material will be needed to build them, and it will cost **1/20th of the fuel to source the needed materials from the Moon as from Earth** because of the Moon's lighter gravity
- A solar satellite can be **built of 92% lunar materials at only an 8% weight penalty**
- Solar Power Satellites are an **ideal solution for** coal-burning China and India and other quickly industrializing **Nations**

OPTION 2. SOLAR POWER ARRAYS on the Moon

- **Extensive farms of solar panels along the east and west limbs of the Moon** would beam power direct to Earth or via orbiting relays
- **When one limb is in darkness, the other will be in sunlight**, guaranteeing around the month coverage
- **Solar arrays would be far cheaper to build on the Moon itself**, but the challenge for beaming power over a distance 10 times as great may be a problem.

OPTION 3, LUNAR HELIUM-3 is the ideal Fusion Fuel

- Had we the fusion plants to burn it, **one Shuttle External Tank full of liquid Helium-3 would be enough to power the United States for a year.**
- There is **enough helium -3 in the upper 2 meters of the moondust to bring the whole world up to the US standard of living** and keep it there for a thousand years
- And then? There's **a lot, lot more in the atmosphere of Uranus**

1-8• First **we have to catch that rabbit - *fusion!***

The Moon has the resources to support an industrial economy

Living Comfortably on the Moon

- We will cover ourselves with a 5 meter thick **blanket of moon dust** that will provide protection from the cosmic elements and thermal equilibrium
- Heliostats will funnel **sunshine** inside; periscopic picture windows will connect us visually to the outdoors
- Graywater system toilets will fill the home with **greenery, flowers, and sweet fresh air**
- Each home will enter on a pressurized street for **shirtsleeve travel anywhere** in town
- Lunar materials will provide art and personal decor

Synergies with Planetary Defense from Asteroids

- **Remote control telescopes on the Moon** will identify more and smaller astrochunks and do a better job of tracking them.
- **Lunar industries will be a market** for materials mined from asteroids in the process of being shepherded into safer orbits
- **A Catch-22 of Orbital Mechanics** is that the closer two bodies are in orbital period, the less frequent the launch windows between them. For the main asteroid belt between Mars and Jupiter, the Moon will be the preferred staging point and outfitting point for asteroid belt bound missions, rather than Mars.
- **The Moon itself holds the shattered relics** of hundreds of thousands of asteroid impacts

Synergies between Highways to Moon and Mars

- **The Moon Society can support this long range goal by prioritizing development of technologies useful on both worlds:**
  - √ Modular architectures including modular life support biosphere systems;
  - √ Life support technologies
  - √ Space suit development
  - √ Mining, processing, and construction technologies
  - √ Modular factory systems √small pocket hospitals
  - √ Agricultural and food production systems.
- **Identify trade products** between Mars and the Moon to support each other's economy
- **This is but the start of a potentially very long list.**