The Moon: Why and How we Should Return

A Position Paper in Response to the Bush Moon/Mars Initiative Proposal

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Summary

In response to the President's new space exploration initiative laying out a plan to Return to the Moon in Preparation for Manned Exploration of Mars, it is important to be clear about just why we should return to the Moon, and how we should do so. Without a 20:20 Moon Return Vision and Mission statement, we risk embarking on a dead-end path at great expense. The current window of opportunity is one we cannot afford to waste by foggy-minded planning.

Vision: We go outward into space to expand the range of the human species and of Earth Life which will accompany us, expanding Earth's insular economy into one that fully exploits the resources of the ocean of space surrounding our island. Our explorations must be scouting ones, finding resources and laying foundations for viable and vibrant new communities of humanity.

Mission: If, among other purposes, our return to the Moon is to provide the fullest possible support to a Mars exploration venture, we must develop the Moon's resources to defray the costs of our operations on the Moon by providing an ever-growing portion of the needs of personnel stationed there, by developing exports to minimize net costs of imports needed to support our lunar presence, and by manufacturing items needed to support the Mars Initiative.

It is vital that private enterprise be as involved as possible in any such effort, both in direct support to international government projects and in indirect ways, at private initiative, to develop lunar resources for profit. These efforts may include projects to tap lunar resources to provide abundant clean energy for Earth's growing power needs, and to support tourism to and on the Moon. Such efforts will inevitably work to minimize the costs of government funded projects by making available consumer-prepaid products and technologies, reducing the list of items and technologies that government space agencies must develop in expensive taxpayer-financed crash research and development programs.

It is essential that the site of the initial lunar outpost be chosen to support these mission priorities, not just to make crossing the first threshold to lunar occupancy in as easy and painless a manner possible. Choosing a polar site could turn out to be a dead-end initiative.

1. Inspiration

In the words of the "Lunar Declaration" signed at the Lunar Development Conference, League City, TX, July 16, 1999

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

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

" ... the Moon represents the next and most vital step for humanity as we expand beyond Earth orbit.

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

2. Reasons for a Permanent Human Presence on the Moon

- The Moon is "repository of the history and possible future of our planet, and the six Apollo landings only scratched the surface of that treasure. Far more comprehensive and thorough lunar science will be possible through a permanent, and eventually global human presence on the Moon than by sporadic robotic missions. The extent of water and other volatiles important to lunar industrialization could be more fully determined.
- The Moon's far side, permanently shielded from the noisy Earth, is an ideal site for future radio astronomy. Robotic facilities will be limited in the investigations they can conduct in comparison to an expandable human-tended facility.
- Unique products may be producible in the nearly limitless extreme vacuum of the lunar surface, and these may support a high degree of lunar settlement self-sufficiency, plus the development of boundless clean-energy production systems to supply Earth's ever-growing demand.
- The Moon's remoteness is the ultimate isolation for biologically hazardous experiments as well as the ideal place for Martian Sample Return Quarantine Facility.
- The Moon can serve as a proving ground for a wide range of space operations and processes, including developments toward "living off the land" (self-sufficiency) for human outposts on Mars and elsewhere in the solar system as well as on the Moon itself.
- To accomplish these purposes, an international government funded outpost should have "fully outfitted" capacities: the outpost should prioritize not only field-testing equipment destined for Mars, but developing lunar building materials so that future outpost expansion can rely on locally produced modules etc.; test regolith harvesting techniques for solar wind volatiles, including helium-3; prototype solar collectors made wholly or almost wholly from lunar materials; etc.

3. Precursor Technology Development

Industry/enterprise-funded projects (encouraged by government incentives) are appropriate to the predevelopment, for the sake of profitable terrestrial applications, of technologies that will be needed to open the space frontier ("spin-up"). Smaller enterprises should be encouraged to participate. Among these technologies are:

- "Poor ore" mining technologies
- Novel building materials suitable to available lunar resources. (glass-glass composites, alternative alloys, cast basalt, etc.)
- Synthetic chemical feed stocks
- Hybrid hydroponic/geoponic food production systems
- Mini-biosphere technologies
- Inexpensive energy storage/transmission technologies (needed on the Moon to sustain a base through the long lunar nights)
- Astrobleme prospecting techniques to locate potential asteroidal metal deposits on the Moon and Earth

4. Precursor Robotic Missions

Presently available launchers are sufficient to launch most, if not all of the precursor science missions that would prepare for a successful lunar outpost effort. Government agencies, industry and enterprise, and university consortiums all have a role to play in this effort.

Several countries have the capacity to participate in a coordinated science mission program. "Comprehensive" internationalization of the effort is most desirable: United States, Canada, Russia, Europe, Japan, China, India, Brazil for starters.

Primary Precursor Mission goals are to:

- Learn more about the Moon's history and evolution and resources (Origin and evolution, Geology and typography, Composition and mineralogy)
- Map economically significant resources
- Help identify the best location for an outpost from various points of view
- Demonstrate in-situ resource utilization and deployment of infrastructures preparing for human-tended operation
- Establish robotic-teleoperated astronomical observatories

4.1 Priority government/agency-funded Precursor Missions should include:

- Polar cold trap "ground truth" sampling missions to suspected ice fields
- South Pole-Aitken basin [SPA] farside sample return
- Orbiter-impact probe lavatube detection & mapping
- Orbital missions to detect and map any atypical impact areas i.e. Sudbury-type Astroblemes rich in copper and other "lunar-deficient" elements.
- Nearside central peak sample return (mantle material)
- Deployment of teleoperated Optical telescopes
- Farside robotic Radio Telescope installations

4.2 Government/Industry Precursor Mission collaboration is appropriate to:

- Map, quantify and qualify resources with near-term development potential

4.3 Industry/Enterprise-funded Precursor Missions are appropriate for:

Preparing for industrial use of lunar resources to establish an Earth-Moon economy and provide options for solving Earth's energy and environmental problems. If the needed data can be purchased from privately funded missions, this is preferable as it reduces the taxpayer contribution.

- Orbital resource mapping in higher resolution
- Up close high resolution photography for use in film and other audiovisual productions
- Test transport equipment for near-term tourism use
- On site teleoperated demonstrations of element production, building materials manufacturing, and other near-term product and technology development:
- Helium-3 Harvesting methods
- Gas scavenging and separation methods in general
- Ilmenite Oxygen, Iron, Titanium and Sulfur Production methods
- Glass-glass composites manufacturing systems
- Cast Basalt products manufacturing
- Sintered iron product manufacturing
- Silicon solar cell production
- Site grading and Shielding emplacement methods
- Dayspan/nightspan energy management systems
- Low-gravity mining and transportation technologies
- and much more

5. Goals for Establishing a Permanent Lunar Outpost

5.1 Exploring the Moon and launching the development of lunar resources

The lunar outpost should be designed to grow in open-ended fashion, with additions funded and deployed not only by government agencies, but by industry and enterprise and academia. To this end, the site chosen should:

- Be able to accommodate substantial growth
- Have access to all the major suites of lunar resources, prioritized according to the mass fractions expected to be needed (this puts volatiles, however necessary, at the bottom)
- Have relatively easy overland access to a wide portion of the Near side. This implies demonstration of the ability to "overnight," to survive and operate through the two week long lunar nightspan. Access to the Moon-at-large will be imaginary until we have demonstrated that capacity, and the argument can be made that such a demonstration be goal number one, not a goal indefinitely postponed.

Every effort should be made to rethink, from a Devil's Advocate point of view, the current premature consensus that the initial lunar outpost be deployed at the Moon's South Pole. There are arguments worth considering that on the one hand would consider "anything but the pole" as better, and, on the other hand, that would judge the polar site as both dangerous and inappropriate, its solar-energy advantages as a trap. If the/a South Polar location stands up under this scrutiny, then we will go there with greater confidence. If it does not, we may have well escaped a cul-de-sac on the path to lunar development.

Eventually, we will want outposts or installations on several places on the Moon, including nearside, farside, and polar locations.

5.2 Preparing the way for Human outposts on Mars

The Moon is the ideal place to field-test habitat designs, equipment, and life-support systems for deployment on Mars as well as to better study human factors engineering issues, and health/medical systems issues. Specifically:

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

- Regolith shielding emplacement equipment and other earth-moving equipment
- Mining, processing, manufacturing, and construction equipment
- Life support / biosphere maintenance equipment
- Farming/agriculture/food production equipment
- Power generation equipment
- Communications and ground transport equipment

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

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

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

5.3 Private enterprise participation:

The outpost should accept physically collocated industry habitat/lab modules (with added power & life support) sharing commonalities of spaceport, communications access and roads, etc. for purpose of onsite demonstrations of resource development. In turn, such commercial facilities would contribute extra redundancy and safety. But the greatest contribution of collocated commercial facilities will be towards realization of what must be the overarching goal of lunar outpost deployment: to arrive at economic viability. Only profitability can ensure permanence. Without profitability, all talk of "permanence" is empty hype as the initiative could be suspended or abandoned at any time. "If it pays, we will stay."

To that end, the lunar outpost should have "nontrivial" free-enterprise participation:

- In the areas of lunar resource use and building materials development
- Supplemental surface transport systems
- Energy systems
- Competitive Earth to LEO transport systems
- Participation by smaller and startup enterprises should be encouraged

5.4 Cutting Edge Astronomy on the Moon

- Optical instruments at all outposts, eventually linked interferometers
- Lunar L2 Lagrange point radio telescopes can launch lunar radio astronomy without landing instruments on the farside - and with easy communications with Earth via a relay satellite in Earth-Moon L4 or L5 Lagrange areas.
- Farside surface radio telescopes

5.5 Implementation principles and goals to keep in mind

The following principles and supporting goals should be kept in mind for any lunar development efforts:

- The door should be kept open to private enterprise outposts. Nothing in any international agreement to open and maintain a lunar outpost should preclude free-enterprise/commercial outposts elsewhere on the Moon, whether for the purpose of resource development or for tourism. This may well mean a new "Moon Treaty."
- The role of tourism in opening the Moon should not be discounted for the following reasons:
    - ◇ Early "loop the Moon" non-landing tours will quickly follow routine Earth-orbit tourism as it only requires refueling and reprovisioning of a surface to LEO tourist shuttle.
    - ◇ "Self-contained" landing module excursions will allow tourists to set foot on the Moon, romp around, and possibly go for a rover ride, without pre-landing any permanent facilities to cater to them
    - ◇ Development of land facilities will be the next step, and these facilities will expand if we have learned to make elbowroom modules from lunar processed building materials
    - ◇ Scattered tourist facilities will add to the emerging intra-outpost science & communications networks,
    - ◇ Tourist outposts can serve as forward base camps for science and prospecting expeditions as well, adding to their viability.
- Any government lunar base initiative must have secure financing and sustainable support.

To this end, it is important to produce lunar exports as early as possible to help defray costs.

- A new Moon Treaty is essential to protect private enterprise and property rights on the Moon under a stable regime of law.
- Their roles for Moon-focused Societies to play in furthering lunar enterprise:
    - ◇ Create Work In Process (WIP) list of suggested Masters & Doctoral Theses in various fields that could advance our state of knowledge and preparedness to open the lunar frontier
    - ◇ Outline potential and in process startup business plan opportunities and publicize them to would-be entrepreneurs
    - ◇ Found a Lunar University with a focus on lunar-appropriate industrial design
    - ◇ Design and deploy an analog moonbase at which Moon-appropriate operations, deployment, and other activities could be simulated, including teleoperated shielding emplacement methods and dayspan-nightspan energy management systems and procedures
    - ◇ Hold contests to design and develop best teleoperated shielding methods, etc.; moonbase outfitting & layout, the time-delay limits of teleoperation, etc.
- The role of university consortia in furthering lunar enterprises:
    - ◇ Partnership in industrial experiments & resource development
    - ◇ Cosponsorship of an Institute of lunar appropriate industrial design
    - ◇ Cosponsorship of a Lunar University to keep track of what is known and unknown about the Moon, its resources, and how to tap them
    - ◇ Encouraging young students to get involved

6. The Moon Initiative deserves funding without scuttling worthy planetary science missions

- Government funding of lunar infrastructure development will pave the way for lunar industrial economic growth, paying back that investment many times over
- The energy potential in particular deserves funding as part of our renewable energy portfolio of research and development spending
- Reduced taxation for space businesses, until they have developed sufficiently, should also be considered.

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