International Lunar Way Station: A Planetary Outpost Test Bed

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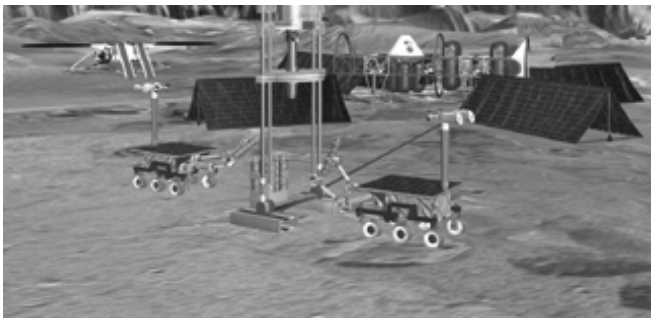
A Recommendation from The Planetary Society



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Summary
The Planetary Society recommends establishment of an international Lunar Way Station – as a first step toward a Planetary Outposts exploration strategy, which systematically builds sustained robotic, then human assets at selected sites on a given planetary body. A Lunar Way Station would serve as a test bed for operational aspects of Planetary Outposts in a closer-to-home environment and would focus lunar missions in the coming decade. Following this strategy would also serve to focus and organize future Martian exploration. In addition, Planetary Outposts would maximize science and engineering effectiveness, bridge robotic and human exploration, improve safety of human missions, and engage the public, while being flexible to budget variations, new scientific and technical results, and international cooperation.

Introduction
In light of the new Moon to Mars space policy, many decisions on implementation must now be made. The Planetary Society has evolved a strategy for exploring solar system bodies called Planetary Outposts: a series of landed elements—first robotic, then human—working together at a specific location on a planetary body. We propose, as a first step toward Planetary Outposts, establishment of a Lunar Way Station to test aspects of Planetary Outpost implementation. We first discuss the Planetary Outpost exploration strategy, followed by its application at Mars, and the establishment of a test bed Lunar Way Station as a first step.

The Planetary Outposts Exploration Strategy
A Planetary Outpost is a systematically emplaced set of landed elements—first robotic assets, followed by humans—at a given location on a planetary body.

A Planetary Outpost means initially concentrating automated resources at a site likely to be a future human landing site. Such early emplacement of dual-purpose infrastructure can increase safety, increase near-term value, decrease costs of the human missions themselves, and increase overall flexibility and robustness (see Appendix 1 for more details on advantages of the Planetary Outposts strategy).

Development of a Planetary Outpost follows this approximate order: reconnaissance, selection of location, emplacement of robotic exploration and science elements, emplacement of dual purpose (robotic and human support) elements, emplacement of human-specific support elements, and human exploration including use of robotic assets. See Appendix 2 for details on Planetary Outpost development steps. Every step should include public engagement in the process.

Mars Outposts
Planetary Outposts on Mars represent excellent applications of this strategy. Selection of a landing site location for the initial Outpost could begin now. With the 2005 Mars Reconnaissance Orbiter (MRO), one or more additional candidate future Mars Outpost sites could be selected, and the public could be engaged with images and models of the sites. The 2009 *Mars Science Laboratory* could be the first robotic infrastructure to be emplaced. Navigation beacons, either in orbit or at the sites themselves, could be

emplaced to reduce landing ellipses. Then additional assets could follow. A Planetary Outpost strategy works well with automated sample return, currently under consideration as an important science and engineering step prior to humans to Mars. Gradual building of assets, systematic exploration, and other aspects of Planetary Outposts are logical whether or not automated sample return occurs at a given Outpost.

Lunar Way Station

As a test-bed for the Planetary Outpost(s) on Mars, many of the same activities could be conducted at a "Lunar Way Station." The main point of the Lunar Way Station is to learn what we can for Mars and other future Outpost exploration, and establishing a Lunar Way Station will focus and guide our upcoming new era of lunar exploration. The pace for human occupation and activity will be significantly faster for a Lunar Way Station compared to a Mars Outpost, and need not wait for build up of massive amounts of infrastructure. A Lunar Way Station will be a logical way to:

- Gain experience close to home relevant to Martian exploration.
- Simultaneously do valuable lunar science.
- Engage the public with meaningful milestones leading to human Mars missions.

The following elements that will be needed for Planetary Outposts on Mars can be successfully tested at a Lunar Way Station:

- Robotic (science and engineering) reconnaissance, both orbital and *in situ.*
- Emplacement of autonomous and nearly autonomous robotic assets (*e.g.,* beacons, communication assets), including practicing surface rendezvous.
- Interactions between robotic elements.
- Use of communications satellites and data links similar to what would be used at Mars.
- Human surface operations, including scientific exploration.
- Interactions between robotic and human assets.
- Effective ways to engage the public.

Conducting operations on the Moon such as these could materially advance Martian mission readiness. Note that certain attributes of Mars cannot be duplicated on the Moon, most notably the use of indigenous resources for propellant and life support. These aspects will have to be tested on Mars or simulated on the Moon using material brought from Earth.[1]

We see no inherent need for permanent human presence at a Lunar Way Station, which would be very expensive. Duration of human presence should be dictated by what is necessary to gain experience relevant for exploration of Mars. Similarly, duration and

[1] It is noted that the use of "lunar resources" to provide life support or to make propellant on the Moon has been frequently referenced in the popular press. We do not believe in that possibility, and think that any use of putative lunar oxygen, water, helium-3, etc. for space exploration is speculative at best. The Lunar Way Station should not have any requirement for use of lunar resources.

number of supported Lunar Way Station robotic elements should be dictated by relevance to Mars exploration.

Sample Lunar Scenario

The following is an example scenario for a Lunar Way Station. It is merely an example and not designed to represent a final scenario. Note that because it is technically "easier," humans could be emplaced at a Lunar Way Station much earlier in the process than at a Mars Outpost. This would facilitate earlier testing of human operations on the surface.

1. Using current data, or at the latest using data from the 2008 orbiter, and after thorough consideration, a landing site in the South Pole-Aitken basin is selected as a Lunar Way Station location.
2. Communication orbiters are emplaced with standards agreed upon by the international community to support all future assets.
3. Landing beacons are emplaced either on the surface or through a network of satellites allowing very targeted landing of assets in a way that is relevant to Mars as well.
4. One or more rovers are put down at the South Pole-Aitken Outpost, and they explore the surroundings for both engineering and science. They also select rocks for sample return.
5. The public participates in virtual drives around the Outpost and in other engaging activities that connect the public with the developing Outpost.
6. Sample return spacecraft land, pick up rocks, and return to Earth. This not only enhances science and focuses science questions for the site, but also demonstrates a return capability at least partially relevant to planning a Mars sample return.
7. Power and communications assets are emplaced on the surface that will optimize solar energy collection (for example, from a permanently or nearly permanently illuminated location) and optimize communication for future robotic and human explorers. Nuclear power assets, which will be needed on Mars, especially with humans, initially can be perfected at the Moon.
8. Emergency human return vehicles are emplaced at the Outpost.
9. Humans land and return in a series of missions with important lunar science objectives while practicing operations relevant to Mars Outposts.

The Moon has a number of exciting and pressing scientific questions that can and should be pursued effectively under a Lunar Way Station umbrella. However, The Planetary Society is concerned that humans do not get stalled on the Moon as we have in low Earth orbit. We think that a Lunar Way Station, as well as vigilance, will focus our efforts to do great lunar science and exploration, and prepare the way for humans on Mars.

International Participation

The Planetary Society also strongly recommends international participation in Moon-Mars exploration. Specifically, as a start, a Lunar Way Station should be developed cooperatively with Europe, Japan, India and China, who all have lunar missions

underway or in development now, as well as with Russia and other nations with contributions to make.

International cooperation also makes for a politically stronger vision. Planetary Outposts allow flexibility with international cooperation. As long as standards are established early for resources that will be shared (such as communication assets), then international partners can plan nearly independent missions to the Planetary Outposts or the test bed Lunar Way Station. International partner missions could either be in or out of the critical path of America's broader plans. Either way they still contribute significantly to science, engineering, exploration, and public engagement.

International partners could play a number of roles that could include:

- Contributing analysis and ideas, which could start now, to landing site selection.
- Data analysis from past, current, and future missions.
- Launching their own science reconnaissance missions to a shared Planetary Outpost.
- Launching their own human infrastructure missions to a shared Planetary Outpost; could be redundant for safety with U.S. contribution or could be critical path.
- Providing launch vehicles and engineering subsystems.
- Providing instruments or key experiments for Outpost support.
- Providing a telecom satellite to a shared communication infrastructure.
- Providing beacons or other assets for navigation.

Conclusion

A test-bed Lunar Way Station would positively focus and organize lunar exploration in the coming decade and lead to a Planetary Outpost strategy for exploring Mars. Benefits of these strategies range from their enormous flexibility to their engagement of the public.

The Planetary Society:

Carl Sagan, Bruce Murray and Louis Friedman founded The Planetary Society in 1980 to advance the exploration of the solar system and to continue the search for extraterrestrial life. With members in over 125 countries, the Society is the largest space interest group in the world. It is non-profit and does not receive government funding.

Appendix 1

Advantages of a Planetary Outpost Strategy

- Balances organization with flexibility by providing overall focused strategy that is easily adaptable to discoveries and changes.
- Adaptable to scientific, technological and technical developments.
- Flexible to budget variations, tolerates more or fewer assets, faster or slower emplacement. Resilient and robust.
- Compatible with international collaboration: As long as standards and plans are clear, international partners can independently develop assets that will contribute to overall goals.
- Compatible with private component or private mission collaboration for the same reasons as international collaboration.
- Engages the public with real locations they can get to know and explore. With high data rates, a virtual presence at each Outpost could be developed.

Appendix 2

General steps in the development of a Planetary Outpost are as follows:

1. Using orbital data, and possibly lander data, the community selects one or more landing site(s) for Planetary Outposts on a given planetary body.
2. Establish communication and other necessary standards.
3. Establish initial milestones for science, engineering, and public with input from relevant communities.
4. Emplace dual-purpose robotic assets to support future robotic and human assets (*e.g.,* rovers, navigation beacons, communication assets, power systems, long-term scientific experiments like seismology).
5. *In situ* robotic exploration, reconnaissance, and science (*e.g.,* with rovers, aerial vehicles).
6. Emplace robotic infrastructure to support humans (*e.g.*, communication, fuel production, power for human assets, possibly initial habitat).
7. Human explorers land and utilize existing robotic assets to assist in survival (*e.g.*, fuel, oxygen).
8. Human explorers use telerobotic and autonomous robots to enhance their work and make it safer.

Every step should include public friendly data products and involvement. The public is the constituency paying for the endeavor and supporting it politically. Giving them a sense of the Outposts as homes-away-from-home will generate interest. Also, having a number of systematic milestones on the way to humans on the Moon and Mars will be both programmatically useful and will also help keep the interest and attention of politicians and the public.