

**OPENLUNA: AN “OPEN SOURCE”, PRIVATELY FUNDED, RETURN TO THE MOON MISSION.**

P. Graham<sup>1</sup>, Dr. Gary Snyder<sup>2</sup>, and OpenLuna Science Team<sup>3</sup>, <sup>1</sup> OpenLuna Foundation, Thorton, Colorado – paul@openluna.org, <sup>2</sup> OpenLuna.org Engineering Team, Lakewood, Colorado – gary@openluna.org., <sup>3</sup> OpenLuna.org Science Team, London, Ontario



Courtesy, Kelley Sands, OpenLuna Art Dept.

**Introduction:** The OpenLuna Foundation seeks to return mankind to the lunar surface through private enterprise and to do so in a way that it is accessible to everyone, including but not limited to academia, industry, government, and the public. Our research is publicly available, and our development will be open source. By following this path of openness one of our primary goals is to reach out to the community and educational systems to spread interest, enthusiasm, and involvement.

**OpenLuna Concept:** OpenLuna is unique in that the program is privately funded and “open source”. This term refers to processes and procedures by which source materials or defining characteristics of a product are made available to the community for review, update, or collaborative development. This strategy provides several advantages.

**Funding.** Being privately funded opens up new and innovative funding models not normally available for space exploration. Examples range from simple donations, to product placement and merchandising, to advertising space sold (e.g. NASCAR, where the advertising can bring in most of the operating budget), or TV/motion picture media deals.

**Open source development.** The advantages of open source software development are well known [1]. Through the careful application of both open source development and openness, to the field of space exploration, several advantages can result such as: great education and public outreach (E/PO) opportunities, reduced development cost, greater community involvement, and public awareness. This openness will produce several trickle-down effects. For example, financial transparency will result in greater confidence that donations will be used in the manner that was intended, thereby increasing sponsorship. Our open nature also leads to unique “victory conditions” in that, if we do not actually land hardware on the moon, *but* research that we conduct, or hardware or technology that we develop (or participate in developing) is used

in a meaningful way to return humankind's presence on the moon, we have achieved success.

**Program Overview:** Although the end goal of the program is a manned lunar outpost, we plan a stepped series of robotic and limited manned missions leading to outpost construction. These missions are broken into four phases:

*Phase one:* Scout Class Mission. This mission will include a “hopper”-style lander, which will deliver four to eight robotic rovers to landing sites pre-selected for their scientific interest and exposure to sunlight, near the lunar South Pole. This mission is expected to occur in the southern-lunar “spring” to provide maximum sun exposure time. The lander will hop from site to site depositing small, lightweight rovers, carrying sufficient scientific instrumentation to determine the most beneficial locations for the phase two missions.

*Phase two:* Sample Return Class Missions. A minimum of two containers, each containing 160 kg of lunar samples will be returned to Earth for examination. These missions are currently planned to happen within several months of the Scout Class missions. The results of these studies will be used to determine the most scientifically interesting and logistically beneficial site for the location of the phase three and four missions.

*Phase three and four:* Pathfinder Class and Explorer Class Missions. These missions will establish the protocols, procedures and tools required to construct the outpost, and finally, will lead to building the outpost. These missions are planned for the following spring.

*Post-mission plan:* When the outpost is completed, it will be open for anyone's use (ranging from private individuals to government agencies), provided they respect applicable national and international legal treaties and cultural heritage policies (more planning information is available, but outside the scope of this paper).

*Other goals, plans and considerations include:*

1. As earlier described, all aspects of the mission plan and hardware will be open source. This information will be publicly available and community support and involvement will be actively pursued and welcomed. Special efforts will be made to involve students, educational facilities, and amateur space enthu-

siasts. These missions will strongly emphasize community participation and collaboration.

2. A strong media presence will be a priority. The entertainment and educational potential of the mission will be exploited to allow the mission to reach the maximum number of people possible. This furthers the educational potential of the mission, provides publicity for sponsors (which will encourage support for future missions), and demonstrates to people that this is possible in the present, and inspires the next generation to continue and exceed these mission goals.

3. Mission hardware will be light-weight and geared toward continuity from one mission to future missions. This will save costs and simplify the mission and hardware development. Superfluous hardware will be removed from missions and each component will be made in the lightest fashion possible. This may create initial complications, but it will balance out over the span of the program. Risk levels will be assessed and considered, to balance risk with the cost of safety, and the ability of the mission to continue forward. Much like an Alpine expedition, moderate risks will be acceptable in favor of exploration.

4. Scientific data generated will be made freely available, and acceptance of outside research proposals will be encouraged.

**Scientific Objectives:** OpenLuna's overarching science goals are: 1. To gain a better understanding of the lunar surface environment, particularly from a human health perspective; and 2. To find a suitable site to construct a lunar human habitat. The OpenLuna Science Team has created a list of four high priority and four lower-priority scientific questions along with instruments to address these questions for Phase One (Scout Class Missions). A package containing these instruments could easily fit onto a rover or lander of the projected size. Key scientific questions and rationale are as follows:

*What do the landing sites, and local rocks, regolith and lofted dust look like?* This will be important for navigation and outreach, and also to support all other scientific data. Lunar rocks reveal information about the processes that occur inside the planet, and help us understand the formation of differentiation of a terrestrial planet. Understanding the physical conditions of the lunar regolith is important for many reasons, as the regolith will be the interface for all interactions on the lunar surface.

*What is the volatile content at each site?* Trace amounts of hydroxyl or water have been detected at the lunar South Pole [2], but ground-based instruments are needed to confirm exact amounts on a local scale.

*What is the mineralogy and elemental composition at each site?* Determining *in-situ* target composition,

elemental chemistry, and mineral distribution will be important so that we can understand fundamental geology and *in-situ* resource utilization potential near the future habitat site. This is also important for ground-truthing orbital data.

*What is the nature of the surface and shallow subsurface?* Are large rocks, bedrock, or water-rich regolith present, which may affect site-selection for the habitat? How compacted is the regolith at each site?

*Lower Priority Questions* address the nature of dust-lofting, regolith chemical reactivity, micrometeorite flux, and plant growth. Additional questions will be addressed on subsequent missions, during phases two through four. The Science Team is open to suggestions from the community.

**Instrumentation:** Examples of the types of instruments which will best address the science goals are: cameras (CCD-type, microscopic, and ultraviolet-visible spectroscopic), thermal evolved gas analyzers (or similar), alpha-particle X-ray spectrometers, mini thermal emission spectrometers, ground penetrating radar instruments, trenching devices (TBD), Light detection and ranging (LIDAR) instruments, an instrument to determine lunar regolith chemical reactivity (eg. NASA Ames' "LunaChem"), an instrument to determine micrometeorite flux (TBD), and a plant growth chamber (TBD). Several partners have been secured, but more are welcome.

**Funding opportunities:** There are many ways to participate financially. At this stage of the program there are opportunities for direct donations, or sponsorship of certain events or programs, such as the rover design competitions or the curriculum programs. Prototype hardware is available for lease or sale, and naming rights for hardware or missions are being made available. Negotiations are currently underway for various television show opportunities, and slots on the first missions to the outpost are also under negotiation. There will be many spin-offs from this program, including: suit sales for terrestrial and extra-orbital use; technologies derived from the outpost will be used in developing countries, emergency situations, or wherever very quick deploying, self-sufficient housing is required; and launch services may be available. Investments are being accepted for these business opportunities.

**Summary:** The OpenLuna Foundation takes a unique approach in that all aspects of the mission that can be open, *will* be open and available for the peoples of the world to share in. This will also provide a unique opportunity for people who could not normally be involved with a space program to participate in a real space mission, in a meaningful way.

**References:** [1] Riehle, D. (2007) *IEEE Computer*, 40, 25-32. [2] Pieters et al. (2009) *Science Express*.