

RETURN TO THE MOON: SITE SELECTION PROCESS AND CONSIDERATIONS FOR NASA'S LUNAR EXPLORATION PROGRAM. J.L. Heldmann¹, J.M. Moore¹, P.C. Lee², B. Girten¹, and C.P. McKay¹,
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Introduction: NASA has announced plans to return to the Moon with both robotic and human exploration. The return to the Moon has two objectives: 1) scientific research on the Moon and 2) preparation for human exploration of Mars.

Site selection is the keystone to lunar planning and drives the lunar program in terms of both near-term and long-term planning. For long-term planning, site selection forces the clear articulation of the goals for the lunar program and helps resolve the overall lunar architecture. For near-term planning, site selection considerations will provide an imaging target list for the upcoming Lunar Reconnaissance Orbiter, forces a rationalization of the approach to study potential deposits of lunar ice, and defines the science requirements for the upcoming lunar missions.

Preparation for human Mars exploration: One of the goals of the lunar program is to prepare for the human exploration of Mars. The Moon is a high fidelity analog for Mars with real risks and relevant challenges. On the Moon we will build experience in long duration and remote mission operations.

Since the lunar program serves as preparation for Mars, there are several aspects of the lunar architecture which flows down from this high-level requirement. These factors include the following:

1. We will establish a long-term Moon base (we will not only conduct sorties to Moon).
2. Astronauts must be trained in science.
3. We will conduct long stays on the Moon (since missions will be at least six months on the martian surface).
4. There is a need for long term life support and biological hazard assessment.
5. Technology flow-throughs must exist from the lunar program to the Mars program.

Scientific research on the Moon: Another goal of the lunar program is to conduct scientific research on the Moon. The success of the science program on the Moon will be judged by its quality. Science will drive the architecture of surface activities on the Moon and hence

1. Astronauts will do science on the Moon.
2. Astronauts must be field scientists and trained and equipped accordingly.

3. Astronauts will conduct many sortie-type missions.
4. Site selection must include science considerations.

There is a great deal of science to be conducted on the Moon in the field of geology. ESAS lunar science strategies (based on Lunar Exploration Science Working Group (LExSWG) include the following lunar science topics:

1. Formation of Earth-Moon system
2. Impact bombardment history of Earth-Moon system
3. Global differentiation of Moon
4. Origin and evolution of lunar crust
5. Thermal and magmatic evolution of Moon
6. Regolith formation
7. Regolith record of solar history
8. Nature of lunar atmosphere
9. Natural laboratory for natural planetary geologic processes
10. Nature and origin of volatiles (H)

Lunar site selection: The site selection for both robotic and human landings is dependent upon eight factors including 1) general accessibility of landing site (orbital mechanics), 2) landing site safety, 3) mobility, 4) Mars analog characteristics, 5) power, 6) communications, 7) ISRU considerations, 8) geologic diversity. We consider each of these criteria separately to determine optimal landing sites. We then plan to integrate the requirements and suggested sites to recommend optimal landing sites considering all categories of site selection criteria.

Orbital mechanics, landing site safety, mobility, Mars analog: These four factors are not strong drivers for regional landing site selection. The ESAS report has opened the entire Moon to human lunar landings in terms of orbital mechanics. Landing site safety considerations do not rule out any general region of the Moon but instead may affect landing sites at a more local level. Mobility considerations will be dependent upon the particular site and mobility system. In terms of Mars analogs, no particular region of the Moon is a better analog than any other; instead the utility of the Moon as a Mars analog will be in terms of systems testing, operations, training, etc.

Power and light: Regions of permanent and near-permanent sunlight are desirable for continuous solar power supply and the ease of operations in daylight versus nighttime operations. This rationale therefore favors sites near the lunar poles in areas of extended sunlight.

Communications: Sites on the lunar near-side within line-of-sight of Earth are desirable. Therefore regions on the lunar near-side are optimal.

ISRU Considerations: There are several potential types of ISRU for the Moon.

1) Water: Regions of permanent shadow may be desirable if they harbor potential ice deposits but further data on this topic is needed to determine if ice exists in these locales and its abundance (if present). If ice exists in suitable quantities, then the poles may be a desirable landing site.

2) Oxygen: Oxygen may be extracted from the regolith to support a human presence. Locations of high ilmenite concentrations in the equatorial mare regions may therefore be desirable sites.

Geologic Diversity: There are a multitude of sites of geologic interest on the Moon. Candidate sites are

shown in Figure 1 [1, 2, 3]. The most desirable site for a permanent base is in the northwest quadrant of the near-side of the Moon due to the close proximity to a wide range of interesting geologic features including large craters, multi-ring basins, volcanism, mountain ranges, mare deposits, etc. There are also numerous sortie sites of scientific interest.

Summary: Orbital mechanics, mobility, landing site safety, and Mars analog characteristics are not the major constraints in regional site selection. The importance of the south pole as well as other regions on the Moon for ISRU is unknown. The optimal science site for a permanent base is in the northwest corner of the lunar near-side. Therefore the optimal science and ISRU sites may be different.

References:

- [1] Ryder, G., Spudis, P.D. and Taylor, G.J. (1989) *EOS 70*
- [2] Cintala, M.J., Spudis, P.D., and B.R. Hawke (1985) *Lunar Bases and Space Activities of the 21st Century*
- [3] Spudis, P.D. (2005) LEAG Presentation

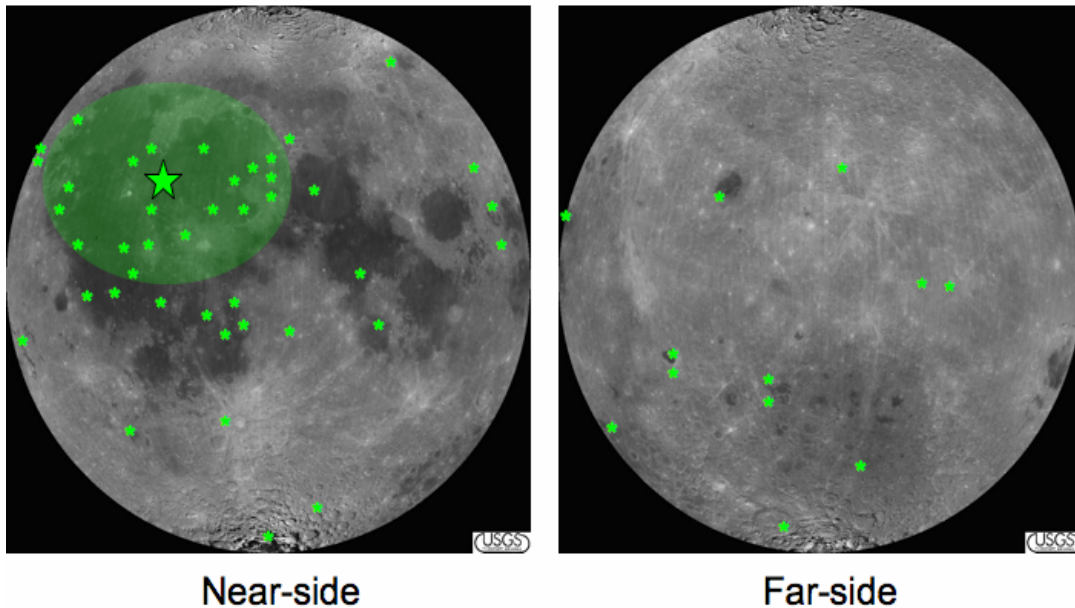


Figure 1: Asterisks denote locations of geologic interest on the Moon [1, 2, 3]. The star represents an ideal human base site to allow sortie missions to sites within and around the shaded area, depending on mobility capabilities.