Executive Summary

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Presentation Title

Site Selection for the Lunar Outpost

Key Ideas

The objective of establishing a permanent presence on the Moon in the form of an outpost will result in a set of site selection requirements different from those of the Apollo program or of robotic missions to Mars.

Environmental conditions (e.g., thermal loading and background temperature, solar illumination) are likely to be key criteria for the site selection since they will drive the system designs.

In situ resource potential will be an important criteria in site selection. A decision about how those resources will be used – volatiles for making-up for losses in the life support system versus fuel production or sunlight for solar power – can significantly influence the site selection.

Scientific objectives are unlikely to be a driver in site selection.

Supporting Information

The Vision for Space Exploration calls for the establishment of permanent presence on the Moon, to learn about the Moon, the Earth-Moon system, the solar system, and the universe by exploration of the Moon; to acquire the skills and develop the systems on the Moon that we need to become a multi-planet species; and to harvest and use the material and energy resources of the Moon to create a new space-faring capability. In order to achieve those goals, an appropriate permanent site must be selected for the lunar outpost.

There are a variety of aspects to the outpost site that must be considered in its selection: among these are the physical properties and topography, environmental conditions (thermal, solar, radiation), and resources.

The physical properties and topography of the Moon are understood well enough that we know that a site with appropriate characteristics (stability for construction, safe landing zones, etc.) could be selected now. We understand the frequency of small craters, the locations of rocks, and the geotechnical properties of the regolith. Differences in those properties would influence the site selection only in the context of the specific location of structures (tens to hundreds of meters) rather than the regional location of the outpost (hundreds of km).

There are several different types of environmental issues that must be considered. Some of these are global in extent and not location-specific, such as the radiation environment or micrometeorite flux. While the flux at any given moment will vary across the surface, averaged over time, all of the surface experiences the same flux. On the other hand, the thermal and lighting conditions are latitude specific. At the equator, the temperature ranges from +107°C during the day to -153°C at night (a range of 260°) with two weeks of sunlight and two weeks of darkness, and a solar elevation ranging from 0° to 90°. At the poles, the sun is never more than about 1.7° above the horizon, the average temperature is more stable (-50°C ± 10°C), and areas of permanent shadow and areas with extended periods of sunlight (perhaps permanent or near permanent sunlight) exist. These issues will have significant impact on the design of the habitat and power systems for the outpost. At present we have a good understanding of the environment at the equator; we have a poorer understanding of the polar environment. Systems could be designed to operate anywhere with our present understanding; the penalty would be a design that would have to accommodate the uncertainties. A considerably better understanding of the polar environment will be gained through LRO and other international lunar missions to be launch this and next year.

The use of *in situ* resources may be one of the biggest drivers on site selection. The first issue to be resolved is the extent to which such resources would be used. Would they be used to generate oxygen to compensate for losses in the life support system, or will hydrogen and oxygen be produced to supply fuel for trips to and from the Moon and then beyond? If the former, then the efficiency of the process and the grade of the resource ore may not be important. On the other hand, if the latter, then the efficiency and the grade are critical. The potential for resources is the one key area where we lack sufficient information at present, particularly for the polar areas. The upcoming lunar missions will provide some additional information, but we will still lack non-model-dependent information on the form, distribution and composition of resources in polar regions. It is assumed, based on morphology, that the polar regions would be “anorthositic highlands” and have a composition similar to the Apollo 16 site, but it would be important to confirm this. It is known from Lunar Prospector that enhanced hydrogen occurs in the polar areas, but whether that hydrogen is uniformly distributed or sequestered in permanently shadowed areas and whether it is in the form of H or H_2O are unknown and can not be definitively determined from orbit. *In situ* analysis must be conducted. If resources are to be used for fuel production, then there may be a trade in the site selection wherein the proximity to a high grade ore is traded against the proximity to a site that has better solar power potential such that it is the overall energy budget of operations and production that is the deciding factor.

In order to optimize the design of surface systems and resource utilization, as well as to reduce fiscal, technical and programmatic risk, the selection of a site must be made only after all of the relevant information is in hand. In some cases, robotic missions to explore potential outpost sites to collect *in situ* information will be required; in other cases, those robotic missions may serve to validate conclusions derived from orbital and Apollo data.