THE INFLUENCE OF LUNAR OUTPOST OBJECTIVES ON OUTPOST CAPABILITIES.
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Introduction: As various countries examine concepts to send humans Moon, the raison d'être for human spaceflight beyond the ISS remains unclear. NASA has suggested grand themes such as human civilization, exploration preparation, economic expansion, scientific knowledge, global partnership and public engagement. But these are vague concepts lacking any specificity and thus decisions about whether an outpost is required, and the objectives, location or capabilities of such an outpost remain undefined.

Depending upon the style and the ultimate goal a nation sets for its lunar exploration program, different requirements are derived. Various concepts have been proposed to make use of lunar resources (ISRU) such as propellant, power beaming, helium-3 mining, and metal mining. The Moon has been suggested as a platform for astronomical observation across the electromagnetic spectrum. Finally, the Moon could serve as a tourist destination.

If the goal is science and the mission set includes only sorties to diverse locations, then there is no infrastructure / precursor information requirement and the site would be dictated by the science objective.

However, a key aspect of the US Vision for Space Exploration is extending human missions beyond low Earth orbit and learning to exploit lunar materials and energy to create new capabilities. That cannot be accomplished by sortie missions (although such are not precluded). Rather a centralized facility with appropriate infrastructure is necessary and this in turn defines the necessary precursor information and demonstration.

Options: Resource utilization can take two forms: (1) resources used close to where they are collected to support surface operations and (2) resource export. In the case of supporting surface operations, H and O can be used for life support, the regolith can be used for shielding, and solar energy can be used for power. For export, hydrogen and oxygen can be used for rocket propellant, helium 3 or various metals could be extracted and returned to Earth, and solar power could be beamed to the Earth. Depending upon which one or combination of these options was selected, or which was paramount, it would dictate the type of precursor information and demonstration necessary before site selection and it would define the outpost capabilities.

***Propellant Production*:** The production of rocket fuel using O and H has the most far reaching implication for enabling long-term presence beyond LEO and enabling exploration beyond cis-lunar space. Specifically which "ore" would be selected and the process for extraction remain unclear. For example, schemes have been proposed to use high Ti regolith for O_2 production as well as mining water ice in shadowed craters.

Using this example, the following requirements might be derived: assess the form, concentration, and distribution of H and O in different materials (mare, pyroclastics, shadowed craters); demonstration of excavation and processing techniques, demonstration of storage and fueling technology, and demonstration of transport. Because different geologic units offer the H and O in different forms, the cost (both energy and dollars) will vary from site to site. Only when the ore is mapped and the costs of production assessed can an outpost location be selected. If one chose a mare site, then the critical issue might be power during lunar night and the energy to extract the O from minerals. If a polar site were chosen, the critical issue might be mining at low temperatures in the dark. These aspects need to be considered such that an appropriate architecture developed. Resource assessment and process demonstration (excavation and production) could be done robotically. For full scale production, some combination of robots and humans would be used.

Radio Astronomy Observatory: The far side of the Moon is a radio quiet area that has been suggested as an ideal location for a radio observatory. If this were the goal, the precursor requirements and outpost capabilities are minimized. One need only select a site in which the observatory could be established and the outpost would need only survival capabilities (as opposed to the ability to make propellant).

Commercial Potential: The exploitation of O and H for fuel, including not only the processing but the storage and transfer activities, could be done either by NASA or a commercial venture. At this stage, however, it seems likely that NASA would be the sole customer. In that context, the commercial option would almost certainly be more expensive as NASA would incur all of the costs it would on its own, and it would also have to pay a profit to the company. If more countries or other commercial activities were present, then the cost to NASA might be appropriate. Development of propellant production capabilities by NASA might be sufficient to spawn other commercial activities at the outpost.