Surface Mobility as a Key Capability to Accomplishing Lunar Science Objectives: A South Pole Example. J. E. Gruener[1], [1]National Aeronautics and Space Administration, Johnson Space Center, Constellation Program Office, 2101 NASA Parkway, Houston, Texas, 77058, john.e.gruener@nasa.gov.

Introduction: The Apollo missions to the Moon demonstrated conclusively that surface mobility is a key asset that improves the efficiency of human explorers on the lunar surface. The surface traverses of the Lunar Roving Vehicle (LRV) on Apollo missions 15, 16, and 17 allowed the human crews to increase the distances traveled by an order of magnitude over the earlier Apollo missions constrained to travel by foot [1]. Global exploration strategies for the Moon being developed by the National Aeronautics and Space Administration (NASA) [2] will similarly benefit from having adequate surface mobility assets as part of an evolving lunar architecture. These assets will be essential to address many of the lunar science objectives recently documented by the National Research Council (NRC) [3].

Lunar South Pole: The Moon's south pole makes and attractive location for a lunar outpost from an engineering perspective for several reasons: areas with extended periods of near-continuous sunlight allows the use of photovoltaic power systems, a benign thermal environment relative to other locations on the Moon, anytime return to earth, and access to possible hydrogen deposits in permanently shadowed regions for resource utilization purposes [2] [4]. Scientifically, an outpost at the south pole would allow exploration of the diverse South Pole-Aitken (SPA) basin and its associated surface features and provide samples from a region of the Moon much different than the region explored by the Apollo missions. However, the large expanse of the SPA basin will require surface explorations up to 1000 km away from a south pole outpost.

Human Exploration Traverses: It is likely that future human exploration of the lunar surface will use roving vehicles similar to the Apollo missions. Though it is possible to explore sites at a great distance from an outpost using spacecraft on ballistic trajectories, this likely would only occur if lunar-derived propellants are available. Thus, the operational constraints associated with surface roving vehicles must be taken into consideration when developing and prioritizing lunar science objectives.

Local Traverses. Lunar science objectives that can be met with humans at the outpost site or local to the outpost (~10-20 km) will likely have operational constraints very similar to the Apollo missions, e.g., astronauts in space suits, on unpressurized roving vehicles, for less than 10 hours. These local traverses can be used for infrastructure emplacement, exploration science, and resource development. However, the only major surface features within 10-20 km from a south pole outpost are Shackleton crater and the rugged highlands terrain (Fig. 1), which may represent interior basin materials of SPA [5].

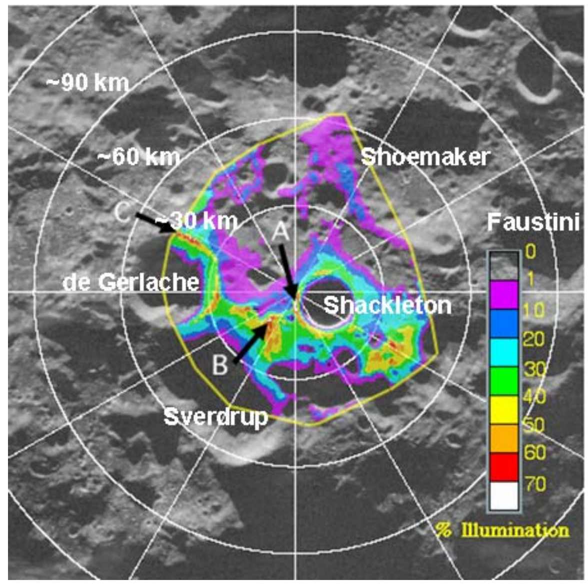

Figure 1 Local area of a south pole outpost (from Bussey et al. 1999)

Long Range Traverses. Many major surface features and the science objectives associated with them, are located at distances that require human crews to be away from a south pole outpost for many days (Fig. 2). This type of human exploration will need a pressurized traverse capability, not unlike how deep sea exploration on earth is conducted with submersibles. The human crews would remain in a 'shirt sleeve' environment while traversing and conducting other intravehicular activities (IVA) such as eating and sleeping. The primary objective of such long range traverses would be to visit major surface features such as large impact craters or basins, basin rim massifs, and resource deposits, characterizing the heterogeneity in age and composition within a geologic unit, and characterizing and sampling a maximum diversity in age and composition across many geologic regions.

Within 100 km from a south pole outpost, some of the major features include: de Gerlache, Shoemaker, and Faustini craters; Malapert massif, and SPA basin massifs. Additional major features within 250 km include: Amundsen and Cabeus craters, Schrödinger basin ejecta, and Drygalski crater ejecta. Additional major features within 500 km include: Drygalski, Zeeman, Schomberger, Scott, Hale, and Demonax craters, Orientale basin ejecta, and most of Schrödinger basin, including a dark halo (pyroclastic) crater on the basin floor. Additional major features within 750 km include: Antoniadi, Lyman, Hausen, Moretus, Boussingault and Neumayer craters, and mare fill within Antoniadi. Additional major features within 1000 km include: Fizeau, Petval, Zucchius, and Clavius craters, Planck and Poincaré basins, Mare Australe and SPA maria, and a cryptomaria near Schiller basin. Assuming driving speeds similar to the Apollo LRV (e.g., averaging 10 km/hr), traverses up to 500 km away from the outpost would involve traverse missions lasting 12-14 days, and could be accomplished in lunar daylight. For distance greater than 500 km, missions would need to extend lunar night.

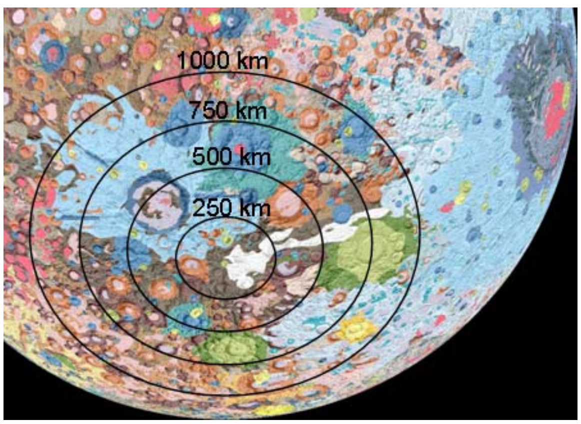

Figure 2 Long range traverse distances from a south pole outpost (from Wilhelms, 1987).

Conclusion: In defining lunar science objectives it is important to include how those objectives can be met. Many lunar science objectives will need surface mobility, and these mobility needs may be quite extensive, involving pressurized mobility assets that range great distance from a lunar outpost. Understanding the operational needs of the lunar science community, such as surface mobility, is critical in developing a lunar architecture strategy that will address those needs.

References: [1] Jones E. M. (2006) http://www.hq.nasa.gov/alsj/. [2] National Aeronautics and Space Administration (2006) http://www.nasa.gov/exploration/. [3] National Research Council (2006) http://www.nap.edu.. [4] Bussey D. B. J. et al. (1999) *Geoph. Res. Let.*, 26, 9, 1187-1190. [5] Wilhelms D. E.. (1987) *U. S. G. S. Prof. Paper* 1348.