CONDUCTING SUBSURFACE SURVEYS FOR WATER ICE USING GROUND PENETRATING RADAR AND A NEUTRON SPECTROMETER ON THE LUNAR ELECTRIC ROVER.
David A. Kring[1,2], [1]LPI-JSC Center for Lunar Science and Exploration, Lunar and Planetary Institute, 3600 Bay Area Blvd., Houston, TX 77058 (kring@lpi.usra.edu), [2]NASA Solar System Exploration Research Virtual Institute.

Introduction: Hufenbach *et al.* [1] introduced a design reference mission architecture that utilizes the space launch system (SLS), Orion crew vehicle, a service module, exploration deep space habitat (eDSH) or gateway in lunar orbit, two small pressurized rovers (SPR), and a lunar surface lander with an ascent stage for crew. Two SPR are delivered to the lunar surface, followed by a crew of 4, which conducts a 14- to 42-day-long mission in the SPRs, before returning to Earth with lunar surface samples. The SPRs are then tele-robotically driven to a second landing site, where a second crew lands. The cycle is repeated five times. The landing sites in this scenario are Malapert massif, the south pole, Schrödinger impact basin, Antoniadi crater, and the center of the South Pole-Aitken impact basin. A study of that traverse [2] indicates the traverse is feasible using a flight version of the Lunar Electric Rover (LER), which is a vehicle that has been tested in 1-, 3-, 14-, and 28-day-long mission simulations in the Moses Lake basaltic sand dune complex, Washington, and the San Francisco Volcanic Field, Arizona

Instrumentation on rover: For crewed operations, the LER was outfitted with high-visibility windows, a ForeCam, AftCam, port and starboard cameras, docking cameras, and a GigaPan camera (Fig. 1) to support both intravehicular and extravehicular activities (*e.g.*, [3,4]). Ground-penetrating radar (GPR) was installed on an unpressurized version of the LER, called Chariot, during the Moses Lake test and successfully detected subsurface water. A more advanced unit was installed beneath the aft deck of the LER (Fig. 1) for an extended 14-day mission simulation at Black Point, demonstrating its application in rugged field conditions. A neutron spectrometer is another in situ resource utilization (ISRU)-related survey tool for volatiles (*e.g.*, hydrogen) that could be installed on future LER. A compact device has been designed for NASA's Resource Prospector (RP). It produces optimum signal-to-noise when rover speeds are ≤10 cm/s (Richard C. Elphic, personal communication, 2017).

Surveying for subsurface water: Kamps *et al.* [2] pointed out that the LER could prospect for water and related volatiles while being driven telerobotically between crew landing sites. The GPR, already tested on the LER, and a neutron spectrometer, already tested on a 1-g mockup of RP, would be a powerful instrument suite for that type of survey. Two important targets along the route of the LER in the design reference mission of [1] is the permanently shadowed regions of Cabeus, which LCROSS demonstrated has volatiles, and Amundsen, which is an excellent site for volatile deposits with the characteristics needed to address the scientific goals of the National Research Council (2007) report *The Scientific Context for Exploration of the Moon* [5].

Fig. 1. A GPR unit installed beneath the aft deck of an LER.

Conclusions: Teleoperational driving of an LER between crew landing sites can be used to explore the ISRU potential of permanently shadowed regions and, thus, map the locations of ice deposits that could be used to support a sustainable exploration program on the Moon.

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