ACCESSING THE LUNAR FARSIDE AND FACILITATING HUMAN-ASSISTED SAMPLE RETURN WITH THE DEEP SPACE GATEWAY. David A. Kring[1,2], [1]Center for Lunar Science and Exploration, Lunar and Planetary Institute, Universities Space Research Association, 3600 Bay Area Blvd., Houston, TX 77058 USA (kring@lpi.usra.edu); [2]NASA Solar System Exploration Research Virtual Institute.

Introduction: Twenty-seven missions have successfully reached the lunar nearside surface, while none have reached the lunar farside. If we are going to explore the unexplored, the lunar farside is our obvious target. It is the nearest, most accessible location to test scientific concepts, expand our technological horizons, and develop the type of integrated robotic and human exploration program that is needed to carry us successfully into deep space.

To address lunar science and exploration objectives, the best results will be obtained a well-trained crew on the surface. Crew on the surface will greatly accelerate scientific discovery while also testing methods for in situ resource utilization (ISRU) and sustainable exploration. Incremental progress can be made, however, with a human-assisted robotic architecture until the capability to land crew exists. In general, human and robotic assets will need to be integrated to maximize productivity and safety.

Human-assisted Sample Return: The Global Exploration Roadmap (GER) [1] includes a human-assisted lunar sample return mission. In this mission concept, a robotic rover is deployed to the lunar surface. It is tele-operated from Earth or by crew in the lunar vicinity. For farside operations, this requires a communications relay from Earth to the farside surface and/or crew in orbit above the farside surface. Both the Orion crew vehicle and Deep Space Gateway (DSG) can provide that capability.

In contrast to Mars robotic rover missions, the Moon favors real-time or virtually real-time rover operations. That capability was demonstrated by the USSR with the Lunokhod rovers in 1970 and 1973. More recently, tele-robotic control of rovers was tested at Meteor Crater, a realistic lunar-like field terrain (Fig. 1) [2]. Tele-operation by crew was also demonstrated by astronauts on the International Space Station controlling a rover on the ground at NASA Ames Research Center [3].

Landing Site: We conducted a global landing site study [4] of locations that address National Research Council recommendations [5] and found that the Schrödinger basin on the lunar farside is the highest-priority landing site. For that reason, detailed landing site and traverse studies have been conducted using all available orbital data, including 0.5 m resolution surface images. Landing sites, traverses, and sample stations have been identified for both a short-duration, 14-day-long mission [6] and a long-duration, 3-year-long mission [7].

Fig. 1. *(top) A Talon rover deployed at Meteor Crater, Arizona, for a field test of the human-assisted sample return concept. (bottom) A rock sample of impact ejecta recovered by the rover.*

The initial target in both cases is an immense pyroclastic vent deposit that may be the largest indigenous source of volatiles in the south polar region during the past ~2 billion years [8]. That material can be used to determine if farside interior water abundances are similar to that of nearside abundances. The pyroclastic vent was an ISRU target of the Exploration Systems Mission Directorate (ESMD) portion of the Lunar Reconnaissance Orbiter (LRO) mission. In that same area, a rover can also collect material to determine the age of the Schrödinger impact basin and, thus, help test the lunar cataclysm hypothesis, the highest priority goal of [5]. The rover will also be able to collect peak-ring lithologies that may be samples from deep within the lunar crust [9] and, thus, test the lunar magma ocean hypothesis. In a long-duration version of the traverse [7], samples of mare basalt lava flows can be collected from the center of the basin to assess the magmatic and thermal evolution of the Moon. Alternatively, samples of South Pole-Aitken impact melt can be collected from the basin walls to determine the age of the oldest, largest basin on the Moon [10]. Returned samples will include both rock and regolith components. Tele-operation of the rover along the traverses can occur from Earth, relayed through Orion. It can also be conducted by crew in Orion or the DSG (Fig. 2, top panel).

Orion and the Deep Space Gateway: Once samples have been recovered by a rover, they are transferred to an ascent vehicle (Fig. 2, middle panel). The ascent vehicle rendezvous with the Orion vehicle and, once it is installed, with the Deep Space Gateway (Fig. 2, bottom panel). This architecture has undergone a preliminary study [11] and is undergoing a more detailed science and engineering analysis by ESA, CSA, and JAXA for the GER.

Deep Space Gateway Requirements: Tele-ops and data download, including high-definition (HD) video from the rover, requires >1 Mbps bandwidth. A simple laptop or similar command and control interface in Orion or the DSG will allow crew to control the rover [12]. A sample transfer capability and method for securing sealed samples in Orion for return to Earth will also be needed. Based on initial traverse and sample studies [6, 7], sample masses of 15 to 20 kg per mission are reasonable. Studies of orbits and communication requirements [13] indicate a halo orbit around the Earth-Moon L2 point is ideal.

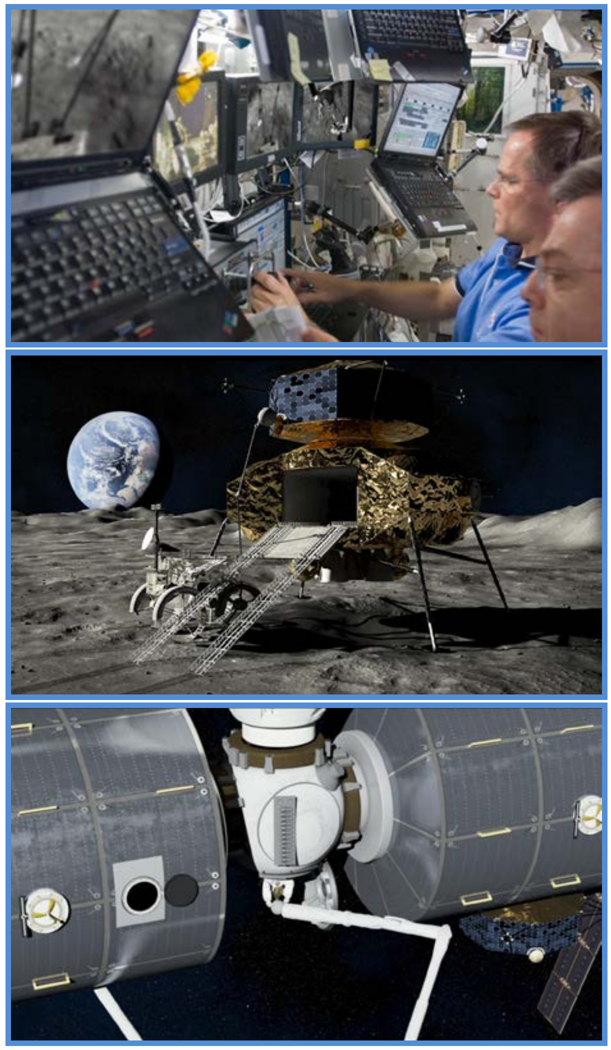

Fig. 2. *(top) Artistic rendering of astronauts tele-operating a lunar surface rover from the Deep Space Gateway. (middle) Transfer of sample container from rover to ascent vehicle. (bottom) Transfer of sample container to the DSG and Orion. Images courtesy of Markus Landgraf and ESA.*

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