COMMUNICATIONS RELAY AND HUMAN-ASSISTED SAMPLE RETURN FROM THE DEEP SPACE GATEWAY. T. Cichan[1], J. B. Hopkins[1], B. Bierhaus, and D. W. Murrow[1], [1]Lockheed Martin Space, PO Box 179, Denver, CO, 80201, timothy.cichan@lmco.com

Introduction: The Deep Space Gateway can enable or enhance exploration of the lunar surface through two capabilities: communications relay opening up access to the lunar farside, and sample return enhancing the ability to return large sample masses.

Lunar Communications Relay: The lunar farside is of great scientific interest for planetary science and astrophysics, but no spacecraft has ever landed there because no communications relay infrastructure exists to support missions there. Many lunar polar landing sites also have challenging geometry for direct communications with Earth. The Deep Space Gateway can enable otherwise infeasible robotic science missions to these lunar surface destinations by providing a communications relay to the surface. We envision adding a 2 to 3 m diameter S or Ka-band high-gain antenna on the DSG pointed at the Moon. Data would be transmitted to scientists and engineers on Earth via the DSG's planned Earth-pointing high gain antenna and/or a optical communication terminal. Optical communication enables a significant increase to downlink bandwidth capability compared to traditional radio frequency communication. For example, NASA's Lunar Laser Communication Demonstration demonstrated a record-breaking Moon to Earth downlink rate of 622 Mbps.

Data rate demands for the communications relay system may vary widely. A stationary lander may only need <100 kbps for imagery and data return. A rover may require on the order of 1 Mbps or more depending on video frame rate and image quality. The highest data rate requirement may be set by a radio astronomy interferometer array. The lunar farside has long been recognized as a unique astronomical platform for conducting radio astronomy at frequencies below 10-30 MHz [1]. With the Gateway in orbit over the lunar farside, low frequency receivers can be placed on the lunar surface for continuous radio measurements. Burns et al. have developed a novel concept for telerobotically deploying such an antenna array on the lunar farside [2] and estimate that the interferometer will generate data at 16 Mbps continuously (depending on the number of elements of the array).

Human-Assisted Sample Return: The Moon is key to understanding the early history of the inner Solar System, since the first few billion years of the geological record have been nearly erased on the terrestrial planets. The South Pole-Aitken (SPA) Basin, on the lunar farside, is the oldest impact basin on the Moon and potentially the largest in the inner Solar System. SPA sample return has been identified as a priority in the past two planetary science decadal surveys by the National Research Council and the Lunar Exploration Analysis Group [3]. Returning samples of polar volatile deposits has also been identified as a priority.

Lunar sample return missions which return a few kg of samples can be readily implemented as stand alone missions, returning their samples directly to Earth. This class of mission fits on existing launch vehicles and can use heritage Earth entry systems [4]. However, if the goal is to return a much larger sample mass (perhaps >20 kg), such a mission can benefit from using the Deep Space Gateway as a return transportation node. The lunar ascent vehicle would deliver the sample container to the DSG where it can be retrieved by the Gateway using the robotic arm and airlock elements. Astronauts would transfer the samples to Orion for return to Earth. This saves the mass of carrying a sample return capsule down to the lunar surface and back up to space. Apollo opted for Lunar Orbit Rendezvous for the same reason. By using Orion as the Earth return vehicle, a large quantity of samples can be returned to Earth on a flight-proven system without developing a new robotic re-entry vehicle with a large capacity. This capability would be most useful for lunar polar volatile samples because of the ability of Orion to maintain environmental conditions. Using a non-standard mission kit, Orion can carry a freezer similar to the ISS GLACIER freezer to return frozen samples to Earth in a pristine condition to be analyzed by scientists.

During the sample collection phase of a return mission, trained astronaut-geologists in the Gateway could teleoperate rovers in near real-time operating conditions to focus their expertise on identifying the best samples possible. In doing so, more samples could be collected in a shorter period of time such as to fit within a single lunar day. Human assisted sample return using orbital teleoperations and Orion return would also be a demonstration of future Mars exploration capabilities, such as described in Lockheed Martin's Mars Base Camp concepts [5].

References:

[1] S. Jester, et al New Astronomy Reviews, 53, (2009) 1-26, [2] J.O. Burns, et al Advances in Space Research. 26 (2012) 3–9, [3] Visions and Voyages for Planetary Science in the Decade 2013-2022." National Research Council 2011 [4] J. S. Parker et al. Amer. Astronautical Soc. AAS-13-882, [5] T. Cichan et al IAC 2017 (IAC-17,A5,2,7,x40817)