

**AN UPDATE TO THE ORION/MOONRISE MISSION CONCEPT STUDY.** L. Alkalai<sup>1</sup>, J. Hopkins<sup>2</sup>, A. Trebi-Ollenu<sup>1</sup>, J. Mueller, Ben Solish<sup>1</sup>, Tim McElrath<sup>1</sup>

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**Introduction:** The Orion/MoonRise mission concept was first proposed and discussed in an open forum at the LEAG meeting in Greenbelt, Maryland in October 2012, and subsequently published at the IEEE Aerospace Conference in March 2013 [1]. The proposed mission concept utilizes the Sample Return Vehicle (SRV) proposed as part of the MoonRise New Frontiers proposal to return samples from the South Pole-Aitken Basin (SPAB) on the lunar far side. However, instead of returning samples directly back to Earth, the Lunar Ascent Vehicle (LAV) takes the sample canister to the EM-L2 destination where the pre-deployed crewed Orion vehicle captures the canister and returns the samples safely back home. The Orion/MoonRise mission concept has multiple strengths worth noting:

- a) It provides for significant contributions and tasks for the astronauts to demonstrate and train at the EM-L2 destination including: i) providing critical communications coverage for the SRV landing on the Moon; ii) surface operations including tele-operations; iii) critical coverage for the LAV ascent from the Moon; iv) proximity operations with regards to the LAV in EM-L2; v) sample canister capture in EM-L2; vi) sample handling and return.
- b) The Orion/MoonRise approach to the return of samples to Earth allows for up to 30 kg of samples to be returned versus only 1 kg using a robotic only approach. This is a major value added compared to a purely robotic approach. In other words, the Earth entry vehicle mass of the SRV can be traded for additional sample mass.
- c) Orion/MoonRise provides an opportunity for a major demonstration of a human/robotic symbiotic mission with key roles for each (human and robotic) with clear contributions by each. Moreover, this mission provides an opportunity for NASA's SMD and HEOMD to define a common mission of high value to each. Returning samples from the SPAB is a high priority by NASA's SMD as evidenced by multiple Decadal Surveys. Demonstrating deep-space human operations by Orion in EM-L2 is of high value to HEOMD [2].

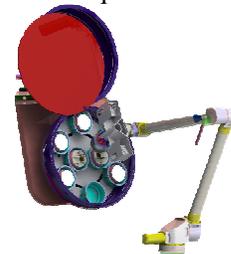
**Overview of Paper:**

This paper describes results since the LEAG 2012 meeting by a joint team at JPL and LM and is based on questions raised during the LEAG meeting including:

- 1) Does the Orion/MoonRise sample return approach support Mars Sample Return (MSR)?
- 2) What is the surface sampling approach to collect more than 1kg of samples?
- 3) What is the LAV/Orion proximity operations approach?
- 4) What is the approach to capture the sample canister by Orion in EM-L2 and bring it inside Orion?

The study team has addressed all the 4 questions:

- a) The team has picked an approach that is consistent with MSR. This includes the deployment of the passive sample canister by the LAV in EM-L2 halo orbit at a safe distance from Orion, and the subsequent tracking and capture of the canister.
- b) Several innovative surface sampling approaches have been studied indicating a possible rich set of options, depending on the ultimate shape of the canister and its location on the LAV. Figure 1 shows one such approach in the canister.
- c) A proximity operations approach has been studied and simulated using the specified capabilities of the LAV and the Orion vehicle relative navigation and rendezvous capabilities. A proximity operations approach will be presented.
- d) A sample canister capture approach compatible with Orion has been defined. This uses a small sample airlock substituted for the Orion docking system. It can be opened to capture the canister into an unpressurized chamber, then closed and repressurized so that it is accessible to the astronauts who stow the canister inside Orion for reentry. No EVA is required. .



**Figure 1. MoonRise robotic arm places multiple small sample modules into the sample canister**

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**References:** [1] L. Alkalai et. al. “*Orion/MoonRise: A Proposed Human & Robotic Sample Return Mission from the Lunar South Pole-Aitken Basin,*” IEEE Aerospace, Big Sky Montana, March 2013. [2] Hopkins, J.B. *Early Telerobotic Exploration of the Lunar Farside Using Orion Spacecraft at Earth-Moon L2*, Global Space Exploration Conference May 2012.