ORION/MoonRise: A Human & Robotic Sample Return Mission Concept from the South Pole-Aitken Basin.

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Introduction: A new mission concept is proposed for a joint human/robotic mission to return samples from the Lunar South Pole-Aitken Basin (SPAB). The mission concept combines architectural elements under development by NASA's Human Exploration & Operations Mission Directorate (HEOMD): the SLS launch vehicle, the ORION Muti-Purpose Crew Vehicle (MPCV), and a human habitat spacecraft potentially located at the Earth Moon Lagrange point-2 (EML-2). It also utilizes NASA's scientific robotic capabilities funded by NASA's Space Mission Directorate (SMD) including: the MoonRise lunar robotic sample return capabilities [1], [2], the AXEL or ATHLETE mobility capabilities [3], [4], [5], and the Atonomus Landing and Hazard Avoidance Technology (ALHAT) [6]. We present a preliminary mission concept, the trade space that was considered during the study, as well as a detailed discussion of the mission design parameters.

The mission concept envisions separate launches of the human crew using the (crewed) SLS launch vehicle with the Orion MPCV to take the astronauts to an existing spacecraft that was previously launched with the (cargo) SLS and parked in the Earth-Moon Lagrange point-2 (EML-2). Separately from these two lauches, the MoonRise robotic lander and sample return system is launched on an EELV to a lunar parking orbit (EML-1). After the astronauts reach EML-2, the robotic lander descends from EML-1 to a designated landing site within the SPAB. The astronauts in the human-rated spacecraft and the docked MPCV in EML-2 are strategically located to monitor the landing and also to provide the essential communication relay service to Earth. Upon landing, the robotic lander, tele-operated by the astronauts, will collect, sieve and cache samples into a canister located on the Lunar Ascent Vehicle (LAV). Once the sample acquisition is completed, the LAV will lift-off from the lunar surface and deliver the sample canister to the vicinity of the human spacecraft parked in EML-2. The astronauts will capture and return the samples to Earth. The capture strategy may involve proximity navigation and docking including a robotic arm to capture the sample canister. This new and innovative sample return mission concept has multiple features worth noting:

First, given that the MoonRise system does not have to return samples to Earth and does not need a communication relay satellite, the mass savings can be translated into delivering more samples to astronauts located in EML-2 and ultimately for their return to the science community on Earth. Preliminary calculations indicate that at least an order of magnitude more samples can be returned, e.g. 10 kg instead of the 1 kg required by the New Frontiers Program. This has a tremendous value to the science community both in the USA and the potential international partners participating in such a mission. Second, the mission concept that demonstrates the capture of samples in lunar orbit has a clear path forward to future sample return missions at Mars. Third, this mission concept gives a significant role to the astronauts to perform in EML-2 including: i) providing critical relay coverage for the Lander landing in the SPAB; ii) tele-operations of the robotic system on the surface of the Moon, and iii) technology demonstration of the sample capture in lunar orbit.

Finally, there is an opportunity to add a mobility system to the MoonRise lander that could have at least two additional functions: i) Collect samples from beyond the immediate vicinity of the lander, and ii) use the rover to deploy another science instrument such as a low-frequency radio antenna to perform an astrophysics experiment [7].

References:

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