VACUUM SEALABLE CONTAINER (VSC) AND ASTRONAUT LUNAR DRILL (ALD) FOR ARTEMIS

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Introduction: NASA's Artemis Program is under development to send the first woman and next man to the Moon. Artemis will utilize a suite of new technology for Lunar exploration, including new space vehicles, new space suits, and new geology tools for sample return from the Lunar south pole. Honeybee Robotics has been working with NASA JSC to develop a new Vacuum Sealable Container (VSC) and new Astronaut Lunar Drill (ALD) for the upcoming Artemis missions.

Vacuum Sealable Container: Sample return continues to be the "Holy Grail" of space exploration, allowing for the analysis of materials using Earth-based laboratories instead of needing to miniaturize and ruggedize instrumentation for space. The VSC is designed for astronauts to hermetically seal a Lunar core sample on the Lunar south pole for return to Earth.

The Apollo missions to the Moon had several kinds of Sealable Containers which brought back Lunar samples for analysis [1]. These samples are still being analyzed, fifty years later. The VSC requirements are different from that for Apollo containers and as such, new development was required. One major difference between Artemis samples and those from Apollo is the desire to bring back volatiles which may be part of regolith on the Lunar south pole. The VSC is designed to withstand a high-pressure differential caused by sublimating volatiles, as well as avoid sample contamination from careful material selection. The VSC design is the result of requirements derivation, trade studies, and breadboarding. Functional prototypes for the VSC were assembled and underwent human factors testing and helium leak rate testing in vacuum.

Astronaut Lunar Drill: The ALD is designed to be a multi-functional platform for Lunar sample acquisition. The system consists primarily of a rotary-percussive drill head, a linear stage, and drill stems, all designed for use by astronauts on the Lunar south pole. The main functionality of the ALD is Deep Core Regolith Drilling, which can capture regolith cores up to 3 meters below the surface. Additional functionality includes Surface Rock Coring (SRC), which allows collection of shallow rock cores, and GeoTech Tools (GTT), which performs geotechnical measurements of the Lunar surface with a static cone penetrometer and shear vane. Finally, the drill can also be used as a power tool for surface or on-orbit activities.

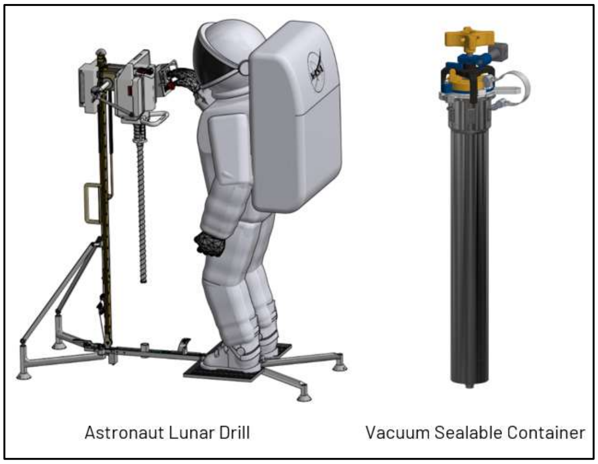

Figure 1. CAD images of Astronaut Lunar Drill and Vacuum Sealable Container (not to scale).

The drill builds on lessons learned from the Apollo Lunar Surface Drill (ALSD), as well as Honeybee's long history of mechanized sample acquisition devices for space [2]. The drill head is designed to have decoupled rotary and percussion subsystems to allow for maximum battery life and reduced fatigue on the crewmember. Drilling algorithms will automatically engage the percussion when needed to drill at maximum efficiency. The drill head mounts to a linear stage to improve drilling efficiency, simplify the drilling process for astronauts, and aid in the extraction of deep cores, which was a problem encountered during Apollo. The SRC functionality of the ALD utilizes Honeybee's Eccentric Tube Core Breakoff technology to collect and retain rock core samples [3]. The ALD is removable from the stand to allow crewmembers to collect samples from large boulders. Bringing back rock cores samples instead of full rocks allows for a wider variety of samples to be returned to Earth and puts them in an engineered form factor for effective sealing and analysis. Honeybee has developed a design for the ALD supported by requirements derivation, trade studies, and breadboarding.

References: [1] Bar Cohen and Zacny(2009), Drilling in Extreme Environments- Penetration and Sampling on Earth and Other Planets, Wiley. [2] Bar-Cohen and Zacny, Advances in Terrestrial and Extraterrestrial Drilling, CRC Press. [3] Myrick (2003), Core Break-off Mechanism. US Patent No. 6,550,549.

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