

REBELS: Rapidly Excavated Borehole for Exploring Lunar Subsurface. K. Zacny¹, J. Palmowski¹, L. Stolov¹, K. Bywaters¹, A. Colaprete¹, R. Elphic¹, ¹Honeybee Robotics, 2408 Lincoln Ave, Altadena, CA 91001 (kzacny@honeybeerobotics.com); ¹NASA Ames Research Center, Moffett Field, CA

Introduction: The depth of lunar subsurface exploration has been limited to 3-meters (Apollo 15, 16, and 17). Soviet Luna 24 sample return mission drilled to 2-meter, while Chang'e 5 drilled to 1-meter. Future missions such as PRIME1 and VIPER are limited to 1-meter depth. Understanding the stratigraphy on the 10-meter scale in the mid-latitude and polar regions would significantly enhance our understanding of the gardening as well as volatile distribution on the Moon.

Rapidly Excavated Borehole for Exploring Lunar Subsurface (REBELS) is a drilling and instrumentation system designed for penetrating >10 m below the lunar surface for in situ science investigation. The design leverages:

- RedWater – a coiled-tube drilling system for penetrating 25 m below the surface of Mars [1].
- LISTER – a 3 m pneumatic drill scheduled to fly to the Moon in 2023 (Mare Crisium), and 2025 (Schroedinger basin) [2].
- SMART – an instrumented drill under development for the RESOURCE project [3].

REBELS uses a coiled-tubing design; the tube contains electrical harness for power and signals as well as the pneumatic lines for clearing cuttings. Mounted to the end of the coiled-tubing, the Bottom Hole Assembly (BHA) has motors, drill bit as well as a Sensing Subsystem for in-situ analysis. These instruments can take measurements real time and as such provide borehole logs such as mineralogy and water

concentration. Specific instruments and their measurements are as follows:

- Near Infrared Spectrometer (NIR):
 - Volatiles, Mineralogy
- Neutron Spectrometer (NS):
 - Hydrogen (water)
- Temperature Sensor and Heater (TSH)
 - Temp., Thermal cond. → Heat flow
- Dielectric Spectroscopy Probe (DSP):
 - Electrical properties
- Camera:
 - Surface texture
- Drill telemetry
 - Strength, Water content, ice texture

All the instruments in the BHA can be activated in real-time and collect subsurface data while drilling. In addition, the cuttings being pneumatically cleared out of the borehole can be collected and analyzed in real-time by surface-level instrumentation.

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References: [1] Palmowski, et al. (2021) AIAA 2021-4038. [2] Nagihara et al. (2020) LPSC [#1432]. [3] L. Stolov. (2022) SMART: Instrumented Drill for ISRU Investigations on the Moon [submitted].

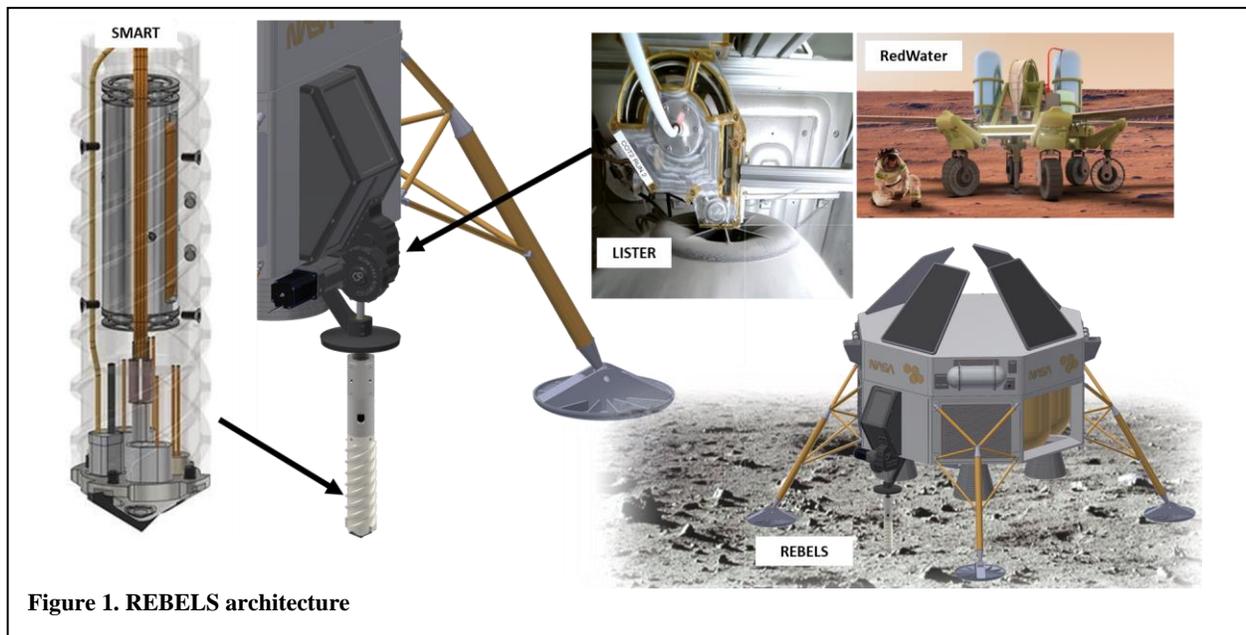


Figure 1. REBELS architecture