TECHNOLOGIES FOR LUNAR EXPLORATION. K. Zacny, S. Indyk, Honeybee Robotics, Pasadena, CA, zacny@honeybeerobotics.com

Introduction: Honeybee Robotics with its partners developed numerous technologies for lunar exploration. Most of these technologies are at high TRL and have been designed for small landers, rovers, as well as astronauts. This abstracts presents several of these technologies.

Heat Flow Probe: The probe uses pneumatic (gas) approach to lower the temperature and thermal conductivity sensors attached to a lenticular (bi-convex) tape to >3 meters [1, 2]. The system weighs approx. 1 kg and reached 2 m in 2 minutes in compacted NU-LHT-2M during vacuum chamber tests. The probe is at TRL 4/5.

Resource Prospector Drill: This 1 m class rotary-hammer drill captures and delivers samples to instruments [3]. The drill weighs 15 kg and it is at TRL6.

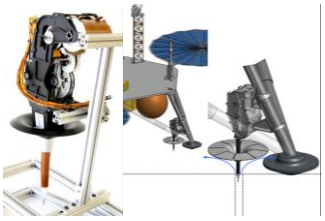

Figure 1. Heat flow probe.

Figure 2: Resource Prospector Drill

Pneumatic sample acquisition and delivery: This technology has been designed to capture and pneumatically deliver regolith samples to an instrument [4]. It's an end to end system and it has been tested in vacuum and lunar gravity in reduced gravity flights. The sampler is integrated in the lander footpads and requires just one solenoid actuator to deliver sample to an instrument. The system is at TRL 5/6.

Geotechnical Tool: Stinger is a geotechnical tool that is integrated with a rover. It measures bearing capacity and shear strength of soil to provide cohesion and friction angle. These two parameters are required for mobility, mining, and ISRU systems. The system is at TRL 4/5.

Figure 3. PlanetVac: sample acquisition and delivery.

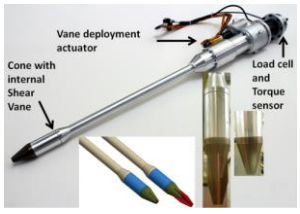

Figure 4. Stinger geotechnical tool.

Hand held coring tool: This astronaut deployable coring tool is used to capture core samples from lunar rocks and deposits them in a hermetically sealed canisters. The tool is at TRL4.

Corner Cube Reflector: This robotic system deploys corner cube reflector and anchors it at approx. 50 cm below the surface in a thermally stable ground [5]. Anchoring allows achieving of extremely high resolution. The system is at TRL 4/5.

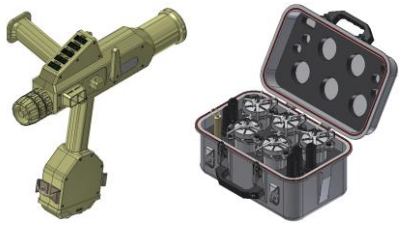

Figure 5. Astronaut coring tool.

Figure 6: Corner Cube

Planetary Volatiles Explorer (PVEx): PVEx is a volatile mining system built around rotary-percussive drill. It can therefore penetrate formations with significant water-ice content [6]. PVEx achieves >80% volatile extraction efficiency and is at TRL 4/5.

Seismic Sensor: The system is designed to emplace seismic sensors at least 50 cm below the surface and in turn decouple the thermal-wave induced noise. The system is at TRL 4.

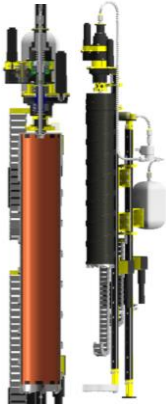

Figure 5. ISRU system.

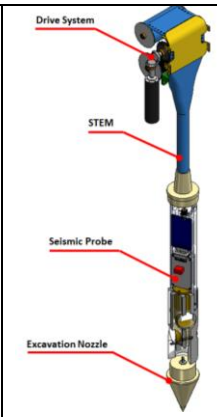

Figure 6: Seismic Sensor

References: [1] Nagihara et al., (2014) LPSC, [2] Zacny et al. (2013) Earth Moon Planets, [3] Paulsen et al., (2017) LPSC, [4] Zacny et al., (2015) IEEE, [5] Zacny et al., (2012) PSS, [6] Zacny et al., (2016) ASCE ES.

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