POKE THE MOON. B. C. Thrift[1] and C. B. Dreyer[2], Center for Space Resources, Colorado School of Mines, 1310 Maple St GRL140, Golden, CO, 80401, [1]benthift@mines.edu, [2]cdreyer@mines.edu.

Introduction: SAMPLR, the Sample Acquisition, Morphology filtering, and Probing of Lunar Regolith payload, is a robotic arm with an end-of-arm instrument suite manifested on a future Commercial Lunar Payload Services (CLPS) mission to the Moon. A part of NASA's Lunar Science and Instrument Technology Payload (LSITP) program, SAMPLR is a collaboration between Maxar Technologies, NASA's Goddard Spaceflight Center, and the Colorado School of Mines Center for Space Resources. [1]

A specialized penetrometer is included as part of the SAMPLR instrument suite. In-situ operation of this specialized penetrometer will be demonstrated on the mission. The specialized penetrometer, while relatively simple and lightweight, provides a great deal of geotechnical data. The penetrometer on SAMPLR will be used to aid in the characterization of in-situ surfaces, determining the geotechnical properties of the regolith at the landing site, and can be used in synergy with co-manifested payloads to enhance the scientific output of the mission. The data acquired with a specialized penetrometer have also been shown to be sensitive to the presence of ice in regolith [2]. Specialized penetrometer experiments are underway at the Colorado School of Mines in support of the SAMPLR payload mission.

Materials and Methods: A force-torque sensor (ATI mini45 Ti or mini40) is used to collect penetrometer data. The probe and sensor are robotically conveyed throughout the operation. In laboratory experiments, the probe and sensor are conveyed by the ISRU Experimental Probe (IEP) or by the uFactory xArm 5 DoF robot arm. The IEP was developed at the Colorado School of Mines as a part of the Institute for Modeling Plasma, Atmospheres, and Cosmic Dust (IMPACT) of NASA's Solar System Exploration Research Virtual Institute (SSERVI) [3] and consists of a zero backlash three-axis translation stage, a force-torque sensor, and a probe. The IEP is contained within a dusty vacuum chamber utilizing a sample container that can be chilled with liquid nitrogen to allow for experiments in a lunar-like environment. Experiments with the sensor and probe conveyed by the xArm are being conducted to aid in the development of operational concepts for the SAMPLR payload mission.

Simulants. The simulants used in testing include highlands simulants, like the CSM-LHT-1 and Exolith Lab's LHS-1, and a mare simulant JSC-1a. CSM-LHT-1 is the main simulant used in the experiments [4].

Data Analysis: Data from the specialized penetrometer are separated into the penetration and relaxation portions for analysis. Penetration occurs while the probe is in motion and is sensitive to sample density, while relaxation occurs after the probe has come to a stop and is sensitive to the cohesion of the sample. Curves are fit to the separated penetration and relaxation data. The penetration model is fitted with a second-order polynomial, and the relaxation response is modeled utilizing a Maxwell rheological model. The relaxation model consists of an external Hookean spring parallel with two Maxwell arms that are each made up of a Hookean spring in series with a Newtonian dashpot. The coefficients of the fitted curves are used in the characterization of the test surface.

Applications: The SAMPLR specialized penetrometer can be used to help characterize the geotechnical properties of a sample surface. Prepared and engineered surfaces can be evaluated with the specialized penetrometer to support in-situ construction and excavation. The data acquired with the penetrometer have been shown to be sensitive to ice content, so it can also be used in prospecting for ice on the Moon [2]. The probe can also be used in conjunction with other payloads to enhance the scientific output of a mission.

Conclusions: The SAMPLR specialized penetrometer is a lightweight and relatively simple instrument that can be used to provide a great deal of useful information about an in-situ surface. Applications of the specialized penetrometer include characterization of a surface, evaluation of prepared and engineered surfaces, and prospecting for volatiles. The specialized penetrometer technology will be demonstrated as part of the SAMPLR payload on a future CLPS mission where it will achieve space flight heritage status.

References: [1] Thrift B. C., et al. (2023) *Earth and Space 2022*, 137 - 149 [2] Atkinson, J., et al. (2020) *Icarus*, 346, 113812. [3] Dreyer C., et al. (2018) *Review of Scientific Instruments*, 89, 6, 064502. [4] Cannon K. (2023) *Planetary Simulant Database.* CSM-LHT-1.