IN-SITU REGOLITH SAMPLING WITH GEOTECHNICAL AND LIFE DETECTION PAYLOADS FOR EXTRATERRESTRIAL GEOLOGICAL RECONAISSANCE. N. Disner[1], W. Madler[1], S. Bouchard[1,2], H. Crawford[1], W. Hudson[1], L. C. Stewart[1], T. Fagan[1], L. Hong Sweet-seip[1], M. Fullmer[1], C. Gustafson[1], I.E.Jehn[2], and F. Zhu[1], [1]Colorado School of Mines (CSM) Robotic Space Exploration (RoSE) Lab (1610 Illinois St, Golden, CO 80401; noradisner@mines.edu, wmadler@mines.edu, sbouchard@mines.edu, haydencrawford@mines.edu, william_hudson@mines.edu, logancobystewart@mines.edu, tfagan@mines.edu, lfsweetseip@mines.edu, mfullmer@mines.edu, codygustafson@mines.edu, frankie.zhu@mines.edu), [2]CSM Space Resources Program (1310 Maple St, Golden, CO 80401; ijehn@mines.edu).

Introduction: Effective In-Situ Resource Utilization (ISRU) requires precise geotechnical knowledge and biological evaluation of regolith. The Overland Rover for Extraterrestrial Discovery & Geological Reconnaissance (O.R.E.D.G.R.) features a modular soil science subsystem designed to collect and analyze subsurface samples autonomously. It integrates automated extraction, moisture quantification, and spectroscopy into one single payload for regolith analysis. It is intended to serve as a prototype for future developments.

Background: The O.R.E.D.G.R. is a Mars analog rover developed for the University Rover Challenge by the Capstone Program, with Dr. Ian Jehn serving as the Project Advisor and Dr. Frankie Zhu as the Technical Advisor. Because the design is driven by competition parameters, the system must adhere to specific operational constraints. The event is divided into several sections, one of which is a Science Mission conducted at the Mars Desert Research Station in Hanksville, Utah. To simulate planetary prospecting, all geotechnical and life detection analyses must be performed onboard the rover. The payload architecture is therefore dictated by these requirements. It must autonomously excavate a soil sample from a depth of at least 10 centimeters, secure a minimum 5 gram sample in a sealed cache container, and conduct a thorough evaluation for life [1]. To accommodate strict competition limitations including a 50 kilogram maximum deployment mass, a 1.2 meter cubic stowed volume, and dusty 100 °F operating conditions, the entire subsystem was engineered to be lightweight, sealed, and modular [1]. This modularity allows the components to be rapidly swapped, which is applicable to future prospecting rovers with modular attachments.

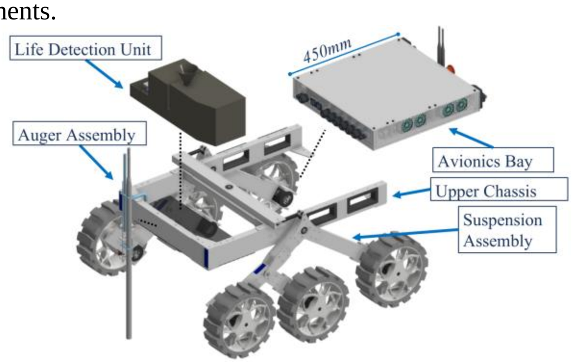

Figure 2: Exploded CAD View of O.R.E.D.G.R.

System Architecture: The soil science module is mounted on a front crossbeam of the O.R.E.D.G.R. with power supplied from a centralized avionics bay, providing space for the operation of three systems: an auger collection system, a hopper and cache unit, and a life detection module.

Auger Collection System: The auger collection system extracts soil samples using a chip clearing drill bit and a 25 cm stroke linear actuator. The auger's rotation is controlled by a 12 V DC motor, and the linear stage is controlled by a stepper motor. The linear actuator lowers the drill to the ground to then transport the soil sample vertically to the soil science module nestled into the body of the main chassis of the rover.

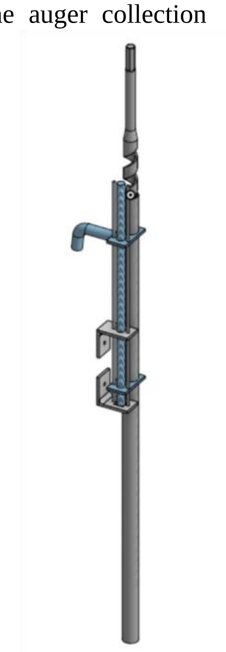

Figure 3: CAD Model of Auger Collection System

Hopper & Cache Unit: From the auger system the soil flow continues through the rest of the module. First, the sample flows through the entirety of the system to the hopper where the undesired soil from above 10 centimeters of depth is discarded.

Then, the soil is carried into the cache containment unit. While soil is deposited into the caching system, the secondary soil science test, a capacitive moisture sensor, records soil moisture values in parts per million. This test is designed to give valuable insight into the geotechnical properties of the soil samples taken by the rover. The in-field readings are compared against and quantified with soil sample moisture content test results as described in the ASTM D2216-98 guidelines [2].

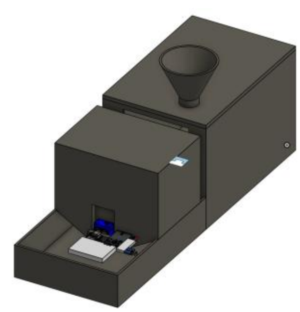

Figure 1: CAD Model of Hopper & Cache Unit

Life Detection Module: The primary soil experimentation test is meant to analyze the potential to support microbial life through a spectroscopy life detection test. Spectroscopy experiments utilize nucleic acid dyes to bind DNA and RNA, then emit light at specific wavelengths when bound. These wavelengths may be related to the number of microbial cells, specifically bacteria and viruses, within a sample [3].

The sample enters a magnetic mixer assembly where the soil is vortexed in a phosphate-buffered saline (PBS) solution for 2 minutes to maintain a stable pH and osmotic balance for the experiment, then left to settle for 1 minute [4]. The top of the PBS solution is then siphoned into a cuvette holding diluted DAPI nucleic acid dye.

In the cuvette the solution is excited with a 365 nm UV LED, and emitted fluorescence centered around 461 nm is collected using an achromatic lens positioned between the cuvette and the spectrometer to focus the emission onto the spectrometer's entrance. The spectrometer is integrated using a Raspberry Pi computer according to experimentation that proved the feasibility of the device in handling organic material measurements [4]. Collected spectrometer data is then compared against the fluorescence calibration curve to quantify microbial life detected at that sample site.

Conclusion: The O.R.E.D.G.R. soil science subsystem utilizes a modular approach to autonomous in situ regolith sampling and analysis. With a mechanical extraction system, geotechnical sensing and spectroscopy life detection experimentation, the payload supports in situ evaluation of extraterrestrial materials to aid the future development of the field of ISRU. Results from this system could support an improved understanding of regolith properties and potential biological signatures in extraterrestrial environments, and ultimately the search for life beyond Earth.

References: Use the brief numbered style common in many abstracts, e.g., [1], [2], etc. References should then appear in numerical order in the reference list, and should use the following abbreviated style:

[1] Author A. B. and Author C. D. (1997) *JGR, 90,* 1151–1154. [2] Author E. F. et al. (1997) *Meteoritics & Planet. Sci., 32,* A74. [3] Author G. H. (1996) *LPS XXVII,* 1344–1345.

[1] Mars Society (2026) *URC Guidelines*. [2] ASTM (2017) *Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*. [3] Spear J. (2025) *Introduction to Fluorescent Spectroscopy*. [4] Worwood M. (2009) *Dacie and Lewis Practical Haematology (Tenth Edition)*, 131-160. [5] Tunens G. et al. (2024) *Optical fiber-based open source low cost portable spectrometer system*.