NASA GLENN RESEARCH CENTER mTRAX PLANETARY EXPLORATION LABORATORIES CAPABILITIES OVERVIEW.

E. T. Rezich[1] and A. Schepelmann, Ph.D.[1] [1]NASA Glenn Research Center, 21000 Brookpark Rd, Cleveland, OH 44134

Introduction: As NASA's Artemis program aims to put the first woman and the next man on the Moon by 2024, research, development, and characterization of spaceflight technologies in terrestrial analog environments is essential. The mTRAX Planetary Exploration Laboratories group at NASA Glenn Research Center (GRC) has recently expanded their range of testing capabilities to support the agency's mission to allow for the characterization and development of manned and robotic mobility systems for planetary exploration, excavation, and in-situ resource extraction tasks. This presentation provides an overview of some of mTRAX's facilities and testing capabilities at GRC for developing and characterizing rover technologies.

SLOPE Laboratory: The Simulated Lunar OPErations (SLOPE) Laboratory is a 4,368 sq. ft. facility designed for real-time data collection, analysis, and characterization of autonomous rovers, robotic mobility systems, and tire technologies. To simulate off-world driving conditions in a controlled environment, SLOPE houses a primary 12x3x0.3m soil tank and 12x3x0.3m adjustable tilting soil bed that can be filled with lunar regolith and Martian soil simulants [1][2] for traction studies on level and sloped ground up to 45º, as well as a secondary 12x3x0.6m sink tank to simulate high-sinkage terrain (Fig. 1). Two cable-driven drawbar pull rigs with an active force range between 20 and 4000N can be used to apply forces to vehicles operating in these tanks to characterize tractive performance during various operational scenarios [3]. This data is synchronized with an OptiTrack Motion Tracking Array consisting of 16 permanently mounted and 12 mobile infrared cameras to provide position measurements with ±0.1mm positional and 0.5º rotational accuracy across the soil tanks. To characterize the performance of single wheels, SLOPE also houses the Traction and Excavation Capabilities Rig (TREC), a single-wheel dynamometer capable of measuring dynamic net tractions, sinkage, and slip curves for wheel and tire assemblies in various simulant media.

Excavation Laboratory: The mTRAX Excavation Laboratory is an 800 sq. ft. facility for developing extraction and excavation tools for in-situ resource utilization tasks. The laboratory currently houses a 2.5 ft. x 6 ft. x 2.5 ft (W x L x H) soil bin containing GRC-3, a lunar regolith simulant to mimic soil properties relevant to lunar surface excavation [4], and the Advanced Planetary Excavator (APEX), an electric, 4 degree of freedom robotic manipulator for developing, characterizing, and testing full-scale mining, burrowing, and agitation end effectors useful for lunar resource extraction. Current testing is investigating the design of an integrated ultrasonic leading edge of an excavator bucket and the behavior of an ultrasonic horn for penetrating granular lunar regolith in a vacuum environment. Due to the capability to test full-scale mechanisms, the platform can also be used for path planning and trajectory optimization research to reduce power requirements of eventual excavation flight systems.

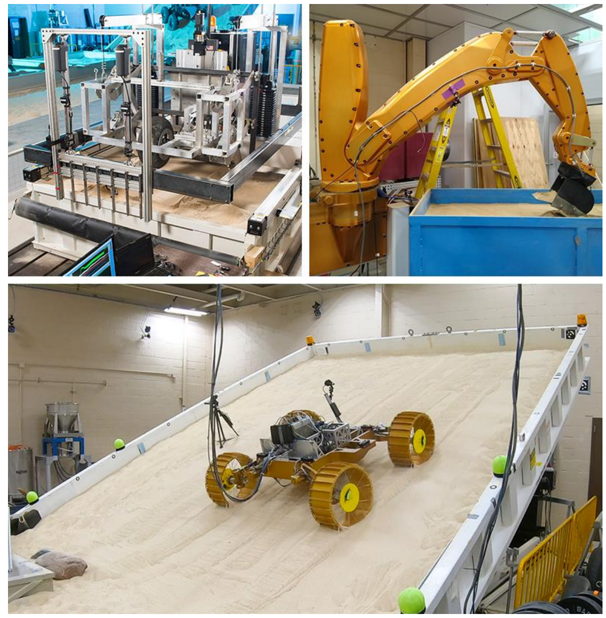

Figure 1. mTRAX Testing Facilities. CW from Top Left: TREC, APEX Excavator, SLOPE tilt bed with rover.

References: [1] Oravec H.A. et al. (2010) *J. Terramechanics*, 47(6), 361-377. [2] Ray C.S. et al. (2010) *J. Non-Crystalline Solids*, 356(44-49), 2369-2374. [3] Creager C. et al. (2017) *NASA TP-2017-219384*. [4] He C. et al. (2013) *J. Aerospace Eng*, 26(3), 528-534.