Durability Testing of a Lunar Surface Excavation Rover. R. D. Austerberry[1], P. Bradshaw[2], M.C. Guadagno[3], and P. J. van Susante[4], [1,2,3,4]Department of Mechanical Engineering-Engineering Mechanics, Michigan Technological University 1400 Townsend Drive, Houghton, MI 49931 (contact: pjvansus@mtu.edu).

Introduction: Long-term human presence on the moon has been a major goal of NASA's Artemis program. This goal requires significant development of infrastructure on the lunar surface. As mass transport to other planets is very costly, ISRU (in-situ resource utilization) can significantly reduce mission costs and increase the viability of these missions by making use of materials already present on other planets. Excavation equipment would operate in permanently shaded regions of the moon where materials can be extracted such as frozen water to aid a sustained human presence on the Moon[1]. The Planetary Surface Technology Development Lab (PSTDL) at Michigan Technological University (MTU) participated in Phase 2 Level 2 of NASA's Break the Ice Lunar Challenge, including a 15-day durability demonstration test of the PSTDL's proposed solution, PRIMROSE (the Prototype Regolith In-situ Mining Remote Operated Surface Excavator).

Methods: PRIMROSE, is a lunar excavation and material transportation rover utilizing a chain trencher as its primary means of cemented material excavation and collection. It is driven by a single variable height chassis that allows it to adjust the height of its trencher for excavation and transportation. Material is stored in an onboard hopper for transportation to a simulated material processing facility.

Figure 1 - PRIMROSE during operational testing before the level 2 durability demonstration test.

The durability demonstration test area consisted of an excavation area, a transportation area, and a simulated material processing plant. The excavation area consisted of a flat pad of CLSM (Controlled low-strength material) which simulates ice-cemented lunar regolith. The primary goal of the demonstration was to excavate 800kg/day of simulated icy regolith and deliver the material to a simulated processing plant 500m away. Throughout the test, PRIMROSE excavated and transported 3000kg of icy-regolith simulant.

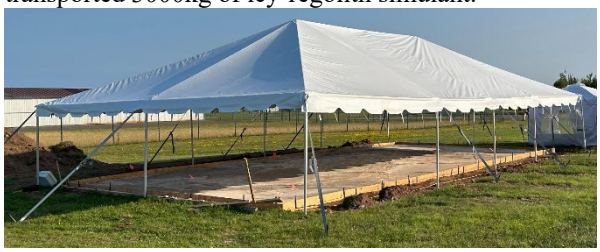

Figure 2 - CLSM icy-lunar regolith pad

The transportation area track consisted of a lunar highland regolith simulant similar to MTU-LHT-1A[2]. PRIMROSE drove 30 km over the lunar simulant during the 15 day durability demonstration test.

Figure 3 - Lunar regolith simulant track.

Many lessons were learned during the 15 day test and PRIMROSE's systems have been redesigned for the June 2024 final Phase 2, Level 3 competition.

Future Plans: A three-axis force test stand has been designed and fabricated to further characterize force generated and power usage resulting from excavation as well as optimize speed, feeds, and cutter layout. MTU's PSTDL advanced from the Level 2 challenge and will compete at a NASA-selected facility for Level 3. This level requires environmental considerations not present in the Level 2 durability demonstration test including transportation over more complex terrain as well as excavation under reduced gravity. If available, a further test campaign will be conducted at the site of Level 3 testing to better understand excavation forces under lunar conditions. These results will be compared to full-weight data to determine the effects of lessened gravity on excavation. Awards may include the opportunity to test in a NASA thermal vacuum chamber to better simulate lunar conditions.

References: [1] Bullard, S. (2022) *Break the Ice Lunar Challenge Phase 2.*

[2] van Susante, P. and Carey, C. (2022) *Michigan Technological Universities' Lunar Highland Simulant MTU-LHT-1A.*