THE LUNAR OUTPOST MAPP ROVER VOYAGE 1 TO MONS MOUTON: MISSION SUCCESSES AND LESSONS LEARNED A.J. Gemer[1], J.A. Cyrus[1], F. Meyen[1], and J.B. Cyrus[1], [1]Lunar Outpost, Inc. (12555 W. 52nd Ave, Arvada, CO 80002, AJ@LunarOutpost.com)

Introduction: Lunar Outpost's Lunar Voyage 1 MAPP rover successfully made it to the Moon, collected data from the lunar surface and in transit, and proved that MAPP was ready to drive, becoming the first US teleoperated rover operated on the lunar surface and in cislunar space.

MAPP transited to the Moon aboard the Intuitive Machines' IM-2 Nova-C lander, which came to rest on its side in a crater on the Moon around 10:30am MT on March 6, 2025. The Nova-C lander ended up on its side with MAPP's garage wedged upside down under the lander, preventing MAPP's deployment to the lunar surface. Our data paints a clear picture that MAPP survived the landing and would have driven on the lunar surface and achieved our mission objectives had it been given the opportunity.

Mission Successes: During Lunar Voyage 1, our MAPP rover and Lunar Outpost team accomplished over 30 key milestones including successful spacecraft mission operations of 132.2 hours during lunar transit, 77.1 hours during lunar orbit, and 2.7 hours operating on the lunar surface in a deeply shadowed region. Key rover subsystems achieved lunar TRL 9, including compute subsystens, memory, communications, and imaging, including a pass through the Van Allen Radiation Belts and shadowed region. Of particular note, MAPP's Active Thermal Control System maintained rover and payload temperatures within desired ranges during in-space transit and on the lunar surface, and recorded extensive thermal data from MAPP's network of thermosensors, which are being utilized to refine and validate thermal analyses of rover performance in cold, shadowed lunar surface regions.

Ground systems also performed nominally; Lunar Outpost's Stargate Mission Control Software maintained an uptime of 99.998%, surpassing the requirements for human-rated, Class A programs such as NASA"s Lunar Terrain Vehicle Program. This included flawless operation of cloud infrastructure, segmented and unsegmented telemetry, file loads, task management, and vehicle commanding. 57,574 datapoints were received from MAPP on-mission, multiple images were downlinked using MAPP's Stereo Navigation Cameras, and 268 commands were sent to the rover with a total lander network provided downlink of only 6 Mb for transit and surface operations combined.

MAPP also demonstrated the first successful commercialization of a lunar rover system through successful integration, transit operations, and delivery of numerous partners and payloads including Nokia's 4G/LTE Network, MIT Time-of-Flight Depth Camera, MIT AstroAnt miniature rover, Regolith Collection Mechanism for NASA Space Resources Contract, MIT HUMANS Message Wafer, and LunarCrush Nakamoto 1 Bitcoin Interplanetary Treasure Chest. Mission collaborators including LEGO, Juventus, adidas, and Castrol helped bring the excitement and inspiration of space exploration to an unprecedented audience, engaging people across the globe.

Lessons Learned: The off-nominal landing orientation of the IM-2 Nova-C lander highlighted challenges and the need for improvements on future CLPS missions. Development of contingency procedures, including data downlink, comms allocations, payload interfaces, and power allocations for mission scenarios are required in advance of future missions to ensure customer objectives are met. Success of the CLPS program relies upon the ability to provide value to payload customers even in off-nominal cases, driving future revenue and mission opportunities.

Telemetry handling offers opportunities to improve power management and stability during transit. Predictive analytical thermal models correlated well with the observed mission data for MAPP environments through transit and shadowed lunar surface environments, offering potential for expanded future shadowed and PSR MAPP rover explorations and supporting CONOPS models.

Future Outlook: The data gathered and technologies demonstrated on LV1 support the expanding commercial space and space resources future on the Moon. We look forward to our upcoming missions – including exploring Reiner Gamma (Lunar Voyage 2), heading back to the South Pole of the Moon (Lunar Voyage 3), and delivering the first Australian rover mission to the Moon (named Roo-ver, our fourth Lunar Voyage). In addition to our four upcoming missions, Lunar Outpost's Lunar Terrain Vehicle, Eagle, developed for NASA LTVS contract, has been engineered to be the most capable and reliable mobility solution ever created enabling future crewed and uncrewed missions on the Moon. With our capabilities clearly demonstrated in space, we look forward to further demonstrating what commercial mobility systems can achieve and utilizing our space heritage to develop the most advanced lunar terrain vehicles possible.