**EVALUATION OF COMMERCIAL HIGH-POWER DC-DC CONVERTERS FOR LUNAR & SPACE ENVIRONMENT.** K. Liang[1], M. C. Tolton[2], C. Nesgaard[3], [1]Orbital Mining Corporation (1600 Jackson Street, Suite 150E, Golden, CO 80401) ken@orbitalminecorp.com, [2]Orbital Mining Corporation chris@orbitalminecorp.com, [3]Orbital Mining Corporation carsten@orbitalminecorp.com

In its Moon to Mars Objectives, NASA aims to establish a long-term robotic and human presence on the surface of the Moon. Providing an "incremental lunar power and distribution system that is evolvable", Lunar Infrastructure Goal LI-1, remains a key technical challenge for any lunar settlement or in-situ resource utilization (ISRU) activities. The lunar grid must utilize different forms of electrical power, transmit that power to different locations, and store that energy to enable operations during the lunar night. However, the associated higher voltages and higher powers in cryogenic cold vacuum conditions pose significant challenges to safe and continuous power electronic operations.

During Phase 2 of NASA's Watts on the Moon competition, the Orbital Mining Corporation (OMC) designed and built a prototype kW-scale electrical transmission and storage system, adapting commercial-off-the-shelf (COTS) components to survive the vacuum and cryogenic cold temperatures of the lunar night. This scalable, 1.2+ kW transmission subsystem included two bi-directional 10kW DC-DC power converters, which were critical to the feasibility of long-distance transmission. This report details the technical challenges and lessons learned from testing and modifying high-power COTS DC-DC power converters for lunar conditions.

In the transmission subsystem, to reduce resistive losses in the cable, the converters increased voltage to 800V (boost) for long-distance (3+ km) transmission, then decreased voltage to ~30V (buck) for usage by the load. At this higher voltage, vacuum-arcing becomes more likely, dependent on gap distance and residual pressure. Testing revealed significant vacuum-arcing damage on many parts of the converters and across multiple tests. Additional failure-mode investigation by the converter manufacturer concluded that higher heat likely caused off gassing of silicone gel, which increased local pressures above the vacuum-arcing potential curve (Paschen Curve).

Additional root-cause analysis uncovered steps in the converter assembly process where dust particles may have become embedded in conformal coatings and contributed to failure modes within the vacuum chamber. This analysis highlighted the importance of maintaining parameter traceability in the inventory of components, e.g., off-gassing potential, dielectric strength, and thermal performance.

Recommendations for vacuum-arc mitigation include additional interior potting and increased layers of conformal coating. These modifications were made, and further testing was conducted for both additional potting and increased coatings. The results will be available in June 2023 (To be updated prior to conference).

These results are widely applicable to any higher-power (1+ kW), higher-voltage (600+ V) power electronics operating in vacuum. COTS power electronics can potentially be used on the lunar surface to satisfy LI-1 with careful selection, testing, and validation of products with high radiation tolerance, dielectric strength, and operating temperature range, as well as low off-gas potential. A first-order economic analysis shows that validating and incorporating such COTS components could dramatically decrease a notional program's overall costs and improve system reliability.