LUNAR NIGHT SURVIVAL STUDY FOR CUBEROVER WITH ULTRA FAST PROXIMITY CHARGING STATION.

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Introduction: Astrobotic, WiBotic, Bosch, the University of Washington (UW), and the NASA Glenn Research Center (GRC) are developing a lightweight, ultra-fast wireless charging system for use on the lunar surface. The wireless charger system, consisting of a transmitter and onboard charger, is the first of its kind in space applications and can enable a variety of new capabilities, including providing power to rovers and surface assets to achieve lunar night survival. Based on magnetic resonance charging technology that WiBotic and the University of Washington have co-developed and commercially offer in global industrial markets, these units are being developed to withstand the harsh environments of launch, cislunar transit, and the lunar surface.

One of the most valuable near-term uses for proximity chargers is for lunar night survival applications. Systems that have survived the lunar night to-date have traditionally relied on complex, high-mass, nuclear power systems. This wireless charging technology can be leveraged to enable lunar night survival of mass and power constrained robotic systems, such as small-scale mobile platforms, by transmitting power from a lunar lander or deployable solar array directly to heaters placed on sensitive components. The team intends to demonstrate this very scenario using a transmitter and onboard charger mounted inside of Astrobotic's 2U CubeRover, both via analysis and testing in a dirty cryogenic thermal vacuum chamber.

Thermal Model: A thermal analysis of a 2U CubeRover was conducted using a finite difference thermal math model (TMM) with Thermal Desktop software, shown in Figure 1. The rover TMM contains 3,332 nodes and represents the key components of the 2U CubeRover design, including an aluminum frame, PEEK wheel spokes, multi-layer insulation (MLI) blankets, avionics components (camera, batteries, PCBs, carrier board, CPU, motor controller, motors), and the wireless charger (WC) system.

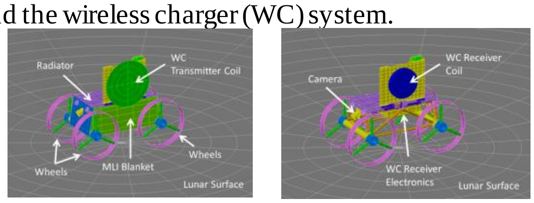

Figure 1: CubeRover Thermal Model with wireless charger system

Results: A heater sizing study was performed to determine the minimum required heater power for the 2U CubeRover to stay alive throughout the 14-day lunar night. A heater activation setpoint of -20 °C was chosen based on the overall CubeRover system survival temperature limit. To model a worst-case scenario, the WC transmitter coil temperature was set as a boundary of -40 °C during charger operational cases. The lunar surface temperature was set as a 50K temperature boundary with no solar heating effects to simulate the lunar surface during nighttime conditions at the lunar poles [1]. Two different rover configurations—open panel and closed panel—were studied to examine the difference in required heater power. A representative temperature contour plot for an open and closed panel configuration is shown in Figure 2. For the open and closed panel configuration, the 2U CubeRover requires a minimum continuous heater power of 9.24W and 7.30W, respectively, to survive the lunar night.

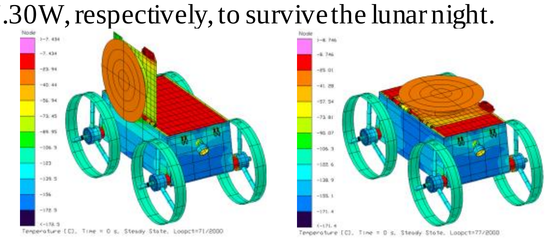

Figure 2: CubeRover Thermal Analysis Results with wireless charger system

Conclusion: The heater sizing study demonstrates that the required heater power to survive the lunar night is well within the 125W capacity of the wireless charging system, and therefore shows this system can feasibly enable robotic systems to survive the lunar night. For future work, a worst-case hot analysis covering additional mission phases should be performed to verify the wireless charger and CubeRover system design can meet temperature requirements in both hot and cold lunar environments. Thermal model parameters will be tuned and verified via testing in GRC's VF-13 Dirty Thermal Vacuum Chamber.

Acknowledgements:

The authors would like to acknowledge the cooperation of NASA GRC, WiBotic, the University of Washington, and Robert Bosch LLC for their assistance in the development of the wireless charger system.

References:

[1] Sefton-Nash, E., Siegler, M., and Paige, D. (2013). Thermal extremes in permanently shadowed regions at the lunar south pole. In Proc. of the 44th Lunar and Planetary Sci. Conf. (Lunar and Planetary Institute, 2013) (Vol. 2617).