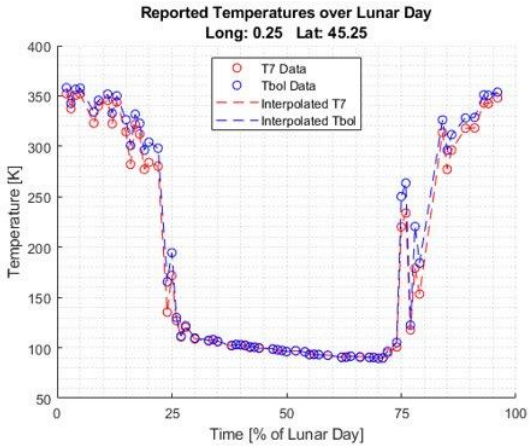
Development of Thermal Control Devices for Extreme Lunar Environments at Marshall Space Flight Center.

W. E. Johnson[1], [1]NASA Marshall Space Flight Center, 4487 Martin Rd, Huntsville, AL 35812. (Contact: william.e.johnson-1@nasa.gov)

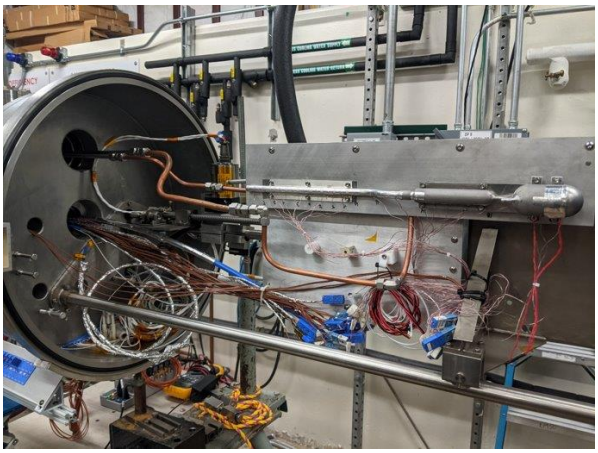
Introduction: NASA's return to the moon brings about many challenges, including issues with survival on the Lunar surface. In order to be sustainable, assets such as landers, rovers, and habitats must be usable for more than a single mission duration. One of the key challenges with sustainability is designing adequate thermal control systems that allow for surface systems to survive both during the day and the Lunar Night.

The extreme thermal environments on the Lunar surface are a challenging design space for thermal engineers. At equatorial regions the Lunar noon can be very hot, requiring systems with high heat rejection to the environment. At polar regions, such as those targeted by the return to the moon, the daytime temperatures are more moderate. During the Lunar night, however, temperatures plummet and can approach -200 degrees Celsius. Such temperatures are formidable and require specialized thermal control systems to allow surface assets to surface the long night.



Developments: Marshall Space Flight Center (MSFC) has been a leader in developing thermal control systems for surviving in the extreme thermal environments of the Moon. In coordination with partners such as Advanced Cooling Technologies (ACT) and Masten Space Systems, MSFC has been testing several thermal control devices that can be used to help solve the problem of surviving in extreme Lunar environments.

One major area of development is advanced heat pipes. MSFC works with ACT via Small Business Innovative Research (SBIR) and other funding sources to develop and test novel designs and applications of Variable Conductance Heat Pipes (VCHP) and Loop Heat Pipes (LHP). Several recent efforts include testing a warm-reservoir hybrid wick VCHP [1] and a LHP with Thermal Control Valve (TCV). Both of these heat pipes have the ability to provide passive modulation of the energy being rejected to the environment. A warm-reservoir hybrid wick VCHP will be flying on Astrobotic's Peregrine 1 mission to increase the Technology Readiness Level (TRL) and prove the technology on the surface. A new VCHP with advanced fluid handling is in development currently. [2]



MSFC has also been working with Masten Space Systems on development of a novel heat source for surviving in extremely cold Lunar environments. [3] Compared to traditional radioisotope heating sources, Masten's system does not have burdensome cost, availability, and regulatory issues. This system will be tested at MSFC in early 2023.

References: [1] Author J. D. (2022) *https://www.1-act.com/case-studies/non-integrated-warm-reservoir-variable-conductance-heat-pipes-vchps-with-hybrid-wicks-for-lunar-landers-and-rovers/*. [2] Author K. L. et al. (2021) *ICES-2021-242*. [3] *https://masten.aero/blog/surviving-the-lunar-night-with-mastens-nite-system/*