

SURVIVING THE LUNAR NIGHT WITH ASTROBOTIC'S NITE SYSTEM. J. Slavik, T. Vazansky, and S. Bedford, Astrobotic Technology, Inc., 1016 N Lincoln Ave, Pittsburgh, PA 15233.

Introduction: Building a sustainable presence on the Moon requires us to survive and operate through the lunar night. The lunar day/night cycle includes 14 Earth days of continuous sunlight followed by 14 days of continuous darkness and extremely cold temperatures as low as -232°C (or -387°F). Flight computers and payloads, however, typically require a minimum operating temperature of -40°F . Without a warming system, these extreme temperatures can cause irreparable damage or cause landers, rovers, and payloads to fail altogether.

Solution: Astrobotic's (previous Masten Space Systems) Nighttime Integrated Thermal and Electricity (NITE) System provides a solution to this challenge by producing both heat and power, enabling landers and payloads to survive the lunar night, and extending operations in shadowed lunar regions, including polar craters and lava tubes.

The NITE System is designed as a low-mass payload that can be attached to landers, rovers, and other lunar assets for both robotic and crewed missions. It creates chemical reactions to deliver heat and power through the oxidation of metals using propellant margin from the lander's propulsion system. It recycles reaction products to maximize thermal and electric energy return. NITE autonomously operates when temperatures fall below a specified threshold and can be deactivated during the lunar day to prevent overheating.



Comparisons: Current solutions for surviving extreme lunar environments include lithium-ion batteries and alkaline fuel cells, but they impose significant mass penalties, have relatively short lifespans, and require complex thermal or fluid systems.

Radioisotope thermoelectric generators (RTGs) can serve as an alternative for longer missions, but their

radioactivity imposes severe constraints on cost, availability, and safety.

In contrast, the NITE System relies on controlled exothermic chemical reactions to generate heat and power, using safe, affordable reactants. The system is restartable on demand, low mass, and unaffected by lunar dust. Further, unlike some alternatives, NITE doesn't require solar power to operate.

Benefits: Astrobotic's NITE System avoids the pitfalls of existing technologies available to survive the lunar night. Based on testing on the NITE heat generation subsystem, the known key benefits include:

- Less mass, more heat: NITE produces significantly more heat (approximately 1900 Wh/kg) with a low-mass solution 12 times lighter than an equivalent battery for lunar night survival.
- Longer mission operations: NITE enables landers, rovers, and payloads to operate for 12 months or longer, depending on the oxidizer and mass allocated to the NITE System.
- Increased lunar accessibility: NITE enables operations in permanently shadowed regions, lunar poles, lava tubes, and other sunlight-deprived environments, providing thermal power at a temperature between -25°C and $+25^{\circ}\text{C}$, as required by the payload.
- More cost effective: NITE saves $\sim\$50\text{M}+$ in direct costs compared to nuclear solutions and saves $\sim\$10\text{M}+$ in mass penalties compared to battery solutions.
- Safer alternative: NITE is dust-proof and non-radioactive, enabling a safer alternative to nuclear and battery-based options.

More results will be available as Astrobotic further develops the power generation subsystem.

Status and next steps: Following a NASA Small Business Innovative Research (SBIR) Phase I award in 2018, Masten Space Systems (now part of Astrobotic) developed the initial proof of concept for NITE and down selected the combustion chemistry. Astrobotic is now in the process of completing the SBIR Phase II award and will finalize the NITE heat generation subsystem by the end of 2022.

Astrobotic is also continuing Masten's work on a NASA Tipping Point award to further develop the power generation subsystem and advance the overall technology readiness of the NITE System, which will bring the company one step closer to testing NITE in the lunar environment.