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Author: Stefano Morellina
Jet Propulsion Laboratory, United States

THERMAL CONTROL TECHNOLOGIES TO SURVIVE THE LUNAR NIGHT

Abstract

The Moon's orbital dynamics imposes an extreme thermal excursion between the long-lasting cycles of Lunar day and night, challenging the robotic exploration of its surface. Advanced thermal control technologies are needed to survive the harsh conditions and allow the scientific instruments to survive the cold night and dissipate heat when in sunlight. Ultra-isolation systems have been developed to allow both high performance isolation and passive thermal switching capabilities to automatically control the heat flow. The architecture consists of a dual-nested enclosure with the internal and external housings thermally isolated by Vectran cables and a "spacerless" multi-layer insulation (MLI) to minimize radiation loss. The thermal switching capability is provided by coupling a mechanical thermal switch to a thermal strap or a mini loop heat pipe (LHP) system. In order to efficiently dissipate heat during hot operations, a Parabolic Reflector Radiator (PRR) concept has been developed to reduce the effective sink temperature for radiative loss purposes. The system has been tested in thermal vacuum (TVAC) and it has shown significantly improved performance when compared to a traditional radiator. The hallmark of the PRR is to minimize the radiative thermal coupling between the hot surface of the Moon and the radiative area. The entirely 3D-printed PRR uses parabolic specular surfaces to exploit the physical laws of optics to the advantage of radiative heat loss. These technologies combined allow the implementation of a versatile and scalable thermal architecture to enable future missions to the Moon.