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THERMAL ANALYSIS OF LUNAR SURFACE HABITATS BASED ON GEOGRAPHIC PLACEMENT

Abstract

NASA will soon award a Foundational Surface Habitat (FSH) / Lunar Surface Habitat (LSH) contract for delivery of a surface habitation module expectedly around the lunar south pole that will allow crews to live and work for visitation lengths of up to 2 months (approximately 60 days). Venturing to previously unexplored areas of the Moon is a primary goal of the Artemis program, as the previous Apollo series missions were primarily landed in equatorial regions due to power and thermal constraints on the vehicle. FSH placements could include areas of permanent shadow, areas of permanent sun, and combinations of areas of heavy-sun or heavy-shadow. The surface temperature range varies greatly as a function of the landing site (from minimum temperatures around 6 Kelvin to maximum temperatures around 416 Kelvin). Nonetheless, the FSH will be required to operate across such a wide range of temperatures with minimal modifications of their designs for economic reasons. In this study we explore how a modification of the landing system height (i.e. a derivative design) may be exploited to control the habitat equilibrium temperature and adapt to different landing sites. This study uses thermal finite element analysis to show the effects that the lunar environment may have on a variety of FSH designs and draw conclusions on what possible thermal placements, and lander designs, for the habitat would be safe for a longstanding crewed settlement. The optical properties collected from samples documented by NASA Glenn Research Center are employed to accurately model the lunar surface layers of regolith. For validation, surface temperatures resulting from the thermal finite element model analysis are compared to those recorded at the Apollo 17 landing site. Preliminary results illustrate and quantify the habitat equilibrium temperature as a function of the lander height in five representative lunar surface thermal environments. The selected lunar environments include the Apollo 17 landing site, a near permanent shadow landing site, the candidate FSH landing site, an equatorial landing site, and a near permanent sunlight landing site. This analysis conveys insight into lander height as a function of surface environment temperature and radiative heat exchanges with the lunar surface. These initial results may inform what PTCS, ATCS, and MLI subsystems will be required for the FSH to operate in multiple landing sites while both crewed and then dormant.