Accounting for Orbital Long-Duration Eclipses for Lunar Trailblazer Mission Operations

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The Lunar Trailblazer mission is a joint mission of Caltech, Jet Propulsion Laboratory (JPL), University of Oxford, and Lockheed Martin Space (LMS) that aims to investigate the presence of water on the Moon and the thermophysical properties of the lunar surface. Based on its reference trajectory, the Lunar Trailblazer (LTB) spacecraft will experience three total lunar eclipses after its late February launch date: March 14, 2025, September 7, 2025, and March 3, 2026[1]. As a lunar orbiting spacecraft, every instance of a total lunar eclipse causes an extended period when there is a lack of direct solar radiation reaching the spacecraft. During these lunar eclipses, referred to as long-duration eclipses, the spacecraft spends three or more hours in the shadow of the Moon and Earth. This puts the spacecraft systems at risk due to the solar panels being unable to recharge the spacecraft batteries. To optimize power usage, past strategies implemented by lunar orbiting spacecraft have included changing orbital angles, pre-heating heat-sensitive subsystems, and minimizing the battery usage by non-critical subsystems during the eclipse[2]. The minimization of battery usage and pre-heating of subsystems are methods that similarly will be implemented for LTB when entering a long-duration eclipse. The purpose of this study is to outline the mission operations procedure and an autonomous software sequence which prepare the LTB spacecraft to ensure power management through long-duration eclipse scenarios. The autonomous sequence was validated on both a virtual machine with a spacecraft software simulator, and a hardware testbed, referred to as the FlatSat, consisting of many of the same components as the spacecraft. The results demonstrated the flexibility of the procedure to timing of the different total lunar eclipses and how the spacecraft can return to nominal operations after a long-duration eclipse scenario.

Keywords – flight software, long-duration eclipse, battery usage, thermal control, lunar surface, autonomous procedure

[1] *NASA - Lunar Eclipses* (n.d.). Eclipse.gsfc.nasa.gov. https://eclipse.gsfc.nasa.gov/LEdecade/LEdecade2021.html

[2] Mesarch, M. A. (2023, August 13). *Long-Term Orbit Operations for the Lunar Reconnaissance Orbiter*. Ntrs.nasa.gov. https://ntrs.nasa.gov/citations/20230010952