SPACE LAUNCH SYSTEM AND MISSIONS TO NEAR RECTILINEAR HALO ORBITS

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The first major evolution of NASA's Space Launch System (SLS) will begin its flights starting in the mid-2020's. This new configuration, called Block 1B, replaces the Interim Cryogenic Propulsion Stage with a larger Exploration Upper Stage (EUS). The additional capability provided by the new upper stage will allow SLS to send heavier payloads into deep space. One destination of interest to the SLS program is called a Near Rectilinear Halo Orbit (NRHO). This is a type of lunar orbit with multiple advantages for deep space exploration. These benefits include Earth/lunar access, low stationkeeping requirements, and high communication potential with Earth. Therefore, it is a leading candidate for the proposed Lunar Orbital Platform-Gateway (LOP-G) [1]. This paper will provide a detailed assessment of the SLS Block 1B requirements and capabilities for sending payloads to an NRHO.

Analysts at Marshall Space Flight Center are producing a multi-year mission availability scan for the SLS Block 1B configuration to a predefined NRHO orbit. The analysis produces an optimized trajectory for each day of the scan window. A maximized payload and minimized propellant requirement are determined for each day. All maneuvers from launch to the end of the Trans-Lunar-Injection (TLI) are being modeled as finite burns. Injections into an NRHO are being modeled as impulsive maneuvers. The payload element is arbitrary, but includes sufficient mass to represent a large habitat or propulsion module. The resulting parameters of payload capability, delta-v requirements, and launch windows length vary over the course of the scan. Many launch days in the scan are eliminated in post-processing as they violate mission constraints such as payload mass and propellant usage to insert into an NRHO. Based off previous one-year scan results for the SLS Block 1B Design Analysis Cycle 2 (DAC-2), it is expected that there will be one to three days per week where the payload is able to insert into an NRHO within SLS constraints objectives. This scan provides results for longer than one-year, allowing analysts to better understand the launch availability and energy requirements of SLS Block 1B over time.

The in-space mission design and scans utilize Copernicus, an n-body trajectory optimization tool originally developed out of the University of Texas at Austin with further development at Johnson Space Center in Houston, TX. To seed the in-space trajectory, Copernicus uses a plugin to call a

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database of SLS ascent trajectories optimized in the Program to Simulate Optimized Trajectories II (POST2). The ascent trajectories are developed using a framework that parametrizes payload mass and LEO inclination, and targets a 100 nmi altitude circular parking orbit [2]. Though this analysis is specific to the SLS program, it will provide a summary of mission design benefits and constraints associated with generic NRHO access, and may be applied to other programs or concepts that will utilize this orbit.

REFERENCES

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