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ANALYTICAL TECHNIQUES FOR ASSESSING GATEWAY AND OTHER SPACECRAFT ANTENNA LINE-OF-SIGHT FOR THE ARTEMIS PROGRAM

Abstract

NASA's Artemis program is committed to landing the next man and the first woman on the Moon by 2024. A critical piece of infrastructure for the mission, the Gateway will inaugurate a sustainable crewed presence beyond low-Earth orbit in cis-lunar space and serve as a staging point for a lunar landing system. The Near Rectilinear Halo Orbit of the Gateway offers numerous operational benefits in terms of its Earth access via the Orion Multipurpose Crew Vehicle, the degree of lunar visibility and surface access it provides, and favorable conditions for station-keeping. To minimize burns during station-keeping and conserve propellant, the Gateway will continually align itself to a solar pressure equilibrium attitude with the Sun; this is convenient for solar array orientation and power generation, but causes difficulties in terms of communication line-of-sight with the Earth, Moon, and visiting vehicles, which appear to be continually rotating about the Gateway's local frame. A fixed antenna on the Gateway is continually subject to a moving target and can find itself obstructed by the Gateway's own geometry frequently if not placed carefully. To understand the performance of either Earth-pointing or Moon-pointing antenna placements for a given Gateway geometry, a transient solar system simulation of the Gateway is used to step through orbital ephemeris data and determine the periods in which line-of-sight to a chosen target is achieved and lost. Antenna placements can be tested in the simulation and optimized to increase the average line-of-sight exposure to the target, while also minimizing the maximum duration drop-out in line-of-sight communication experienced; long durations without a successful communication link could pose threats to operations, safety, and mission success. It may be necessary to deviate from the Gateway's solar pressure equilibrium attitude for short periods of time in order to continue a successful line-of-sight link to a chosen target. Communication coverage spheres can offer insight into what these necessary attitude adjustments may be and are generated by using a 3D mesh of the Gateway and an implementation of the Möller-Trumbore intersection algorithm. This paper outlines the analytical techniques used to perform such antenna placements on the Gateway, offering examples of how line-of-sight strength can be enhanced with an understanding of the Gateway geometry and attitude constraints. These techniques have had direct impact on the writing of communication requirements for NASA and international partner-owned Gateway elements.