23rd IAA SYMPOSIUM ON SPACE DEBRIS (A6)
Orbit Determination and Propagation - SST (9)

Author: Mr. Patrick Miga
Advanced Space, United States

AN ANALYSIS OF BOUNDS AND STABILITY IN LUNAR DEBRIS DESTINATIONS

Abstract

Significant international interest in lunar exploration has been renewed with the recent progress in the Artemis Program (U.S.) and the Chinese Lunar Exploration Program, as well as many private endeavors with the Moon as a destination.

Currently, there are around 15 known, active satellites in the vicinity of the Moon, and the number is expected to grow rapidly. As of now, collision avoidance is performed by NASA JPL with MADCAP, although only the U.S. and its partners, or about half of the listed objects, are participating in MADCAP. Even despite this miniscule level of participation, there are already around 2 collision avoidance response cases per month, which will only increase with additional satellites.

Additionally, a major debate in space sustainability is centered around the responsible disposal of lunar satellites – historically, these have been disposed of by crashing into the Moon, but recent developments have suggested that heliocentric disposal, or leaving the Earth-Moon system for at least 100 years, could be more appropriate.

Furthermore, while there have been no major debris events in lunar orbit, analyses have shown that lost objects from previous missions may still be in orbit, as non-cooperative objects are at times impossible to track. Additionally, if there was to be a debris event, especially in cislunar space, it is uncertain where this debris may end up, and if it may even pose a risk to objects in Earth's orbit.

The above scenarios provide several reasons why it is important to understand the bounds in the natural behavior of objects orbiting the Moon or residing in cislunar space. Several orbits are considered, including generic low lunar orbits, frozen lunar orbits, elliptical lunar orbits, and three-body orbits of highest interest such as the Near-Rectilinear Halo Orbit and the Distant Retrograde Orbit. The long-term stability of these orbits is assessed, as well as the bounds of the resulting destinations. Additionally, for the sake of disposal, adding maneuverability to several of these cases will provide further insight.

The results of this work lead to sensible suggestions on best practices for collision avoidance, disposal of objects in the Moon's vicinity depending on their specific orbit, and additional factors to consider in monitoring risks to Earth-orbiting objects. A comprehensive overview is provided of all factors to consider, and select, high-priority cases are demonstrated to highlight the appropriate suggestions.