IAF ASTRODYNAMICS SYMPOSIUM (C1)
Interactive Presentations - IAF ASTRODYNAMICS SYMPOSIUM (IP)

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SAFE SHORT-TERM LOITERING IN GATEWAY'S NEAR RECTILINEAR HALO ORBIT

Abstract

NASA's upcoming luarn space station, Gateway, will be flying in a 9:2 synodic resonant Earth-Moon Near Rectilinear Halo orbit. In this orbit, Gateway will host a number of visiting vehicles, some of which will be docking, undocking, delivering other vehicles, and generally flying in Gateway's vicinity.

Relative motion in this regime has not yet been well-studied under this context. Thus, this work addresses the short-term loitering scenario, where vehicles are visiting or flying in the vicinity of Gateway for time periods ranging from 1 day to 1 week. In this work, Gateway's "vicinity" is defined as motion within a range of 10 km or less.

The analyses presented here carry out simulated loitering operations from a high level. In particular, we examine the case of a vehicle departing from Gateway via impulsive burns, entering into its station, loitering for a given time, and then returning to Gateway with impulsive burns again. We examine multiple variations of this conop, including three-burn and four-burn scenarios. In all cases, the motion is optimized under constraints to deliver low ΔV solutions. The constraints enforce that, once the vehicle has entered its loiter station, it does not violate some minimum distance threshold to the chief (i.e., it maintains its relative distance) until the loitering phase is complete and it can return.

These concepts are examined under nominal operations and contingency operations, wherein missed-burn or other mission disruptions are considered. From these results, we identify the most favorable loitering stations. Specifically, we examine the directions from which to depart Gateway's reference orbit and the stations that safely maintain the relative distance between Gateway and any loitering vehicles. Further, this study leverages tools from dynamical systems theory (DST) to supply initial guesses for differential corrections and optimization routines and to explain the natural behavior.

We show that such loitering conops can be delivered for very low ΔVs, under 10 cm/s, and that different loitering stations are favorable for different considerations (closest approach, minimum drift, etc).