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DYNAMICS OF JETTISON DURING EARTH-TO-NRHO TRANSFERS

Abstract

The Gateway is the next human outpost in space: a proving ground for deep space technologies and a staging location for missions to the lunar surface and beyond Earth orbit. The Gateway will be constructed over time by an international team as various components are delivered either as co-manifested payloads with Orion or independently without crew presence.

During transit from Earth to NRHO and back, it may be desirable to jettison objects from the spacecraft. Examples could include comanifested payloads such as cubesats, docking covers to be removed prior to arrival, or docking adapters to be disposed after the mission is complete. It is critical to design safe paths for jettisoned objects that will not litter cislunar space with persistent debris that could threaten sensitive regions on the lunar surface, the Gateway and Orion, future missions, or the Earth. The dynamical environment in cislunar space is significantly complicated by the simultaneous gravitational influence of the Sun, Earth, and Moon, and designing safe disposal trajectories is nontrivial.

Previous investigations explore jettison from the Gateway in NRHO. The current investigation extends these studies to consider jettison during transit to the Gateway NRHO and back to Earth. Several distinct regimes are defined along a fast transit. Objects jettisoned prior to an outbound powered flyby (OPF) of the Moon are relatively energetic, and on favorable epochs, are likely to be pulled into heliocentric space via the tidal acceleration from the Sun. Because of the high starting energy, a small jettison maneuver does not have significant influence over the orbit, so it is critical to consider Sun-Earth-spacecraft geometry. Conversely, objects jettisoned between the OPF and the NRHO insertion are considerably lower in energy, but careful, accurate application of a small jettison maneuver can target an energy-increasing flyby of the Moon to achieve sufficient energy to depart the Earth-Moon vicinity in some cases. On the return trip to Earth, jettison prior to a return powered flyby results in a low-energy trajectory, but by targeting an Earth-Moon resonant orbit with a relatively significant maneuver, escape to heliocentric space is achievable in some cases. Conversely, a small anti-velocity maneuver can lead to quick, controlled lunar impact.

As humanity returns to the Moon, it is critical to be responsible stewards of the cislunar space environment. This study focuses on the complex and often non-intuitive behavior of jettison trajectories during transit to and from the Gateway.