IAF ASTRODYNAMICS SYMPOSIUM (C1)
Mission Design, Operations & Optimization (1) (6)

Author: Mr. Matthew Wittal
NASA, United States

Mr. Stéphane Miaule
NASA Marshall Space Flight Center, United States
Mr. Benjamin Asher
MEI Technologies, United States

EARTH-MOON CYCLER MISSION DESIGN FOR LUNAR LOGISTICS

Abstract

One of the key functions of the Artemis program is to drive a sustainable approach to manned Lunar exploration. Current planning takes steps to achieve this through the development of Gateway and a Human Landing System. However, establishing and maintaining a supply chain to and from the Gateway and the Lunar south pole requires a more robust and sustainable approach to logistics. This paper explores the benefits that an Earth-Moon cycler may provide to lunar logistics by removing the necessity for large and often expensive rockets in lieu of more frequent but smaller missions. Furthermore, such a cycler can open up possibilities for lunar cargo return which is currently only fulfilled by Orion's limited return capability. The Earth-Moon cylcer offers a platform for power, thermal systems, guidance, navigation, and control, as well as communications which can open opportunities for the growing market of commercial satellites.

The platform for exploring this concept is the Dragon XL tug due to the fact that the system is already in development, and to be consistent with the vehicle across many trajectories. Rigid body dynamics are considered with Solar Radiation Pressure (SRP) and gravity gradient torques from a non-spherical Earth and Moon. The gravity of the Sun, Jupiter, and Saturn are also considered in the simulations.

Cyclers of various lunar resonance frequencies will be compared against one another in terms of accessibility from Earth, accessibility from Gateway, and accessibility from the Lunar south pole. "Accessibility" will be quantified in terms of flight time, delta-V to and from the destinations of interest, delta-V of orbit maintenance, reliance on refueling, and overall mass delivery capabilities (as a function of delta-V and delivery capabilities) [1]

Both previous work [2] and early, current work shows that Earth-Moon cyclers are possible that provide conceivably affordable access to both the Near-Rectilinear Halo Orbit (NRHO) and to the Lunar south pole. This work plans to determine the cost of implementing a cycler in terms of annual dV, mission dV, mass savings per mission, and overall mass delivery capabilities.

[1] M. M. Wittal, J. D. Smith, and C. A. M., "Mis- sion design considerations for robotic lunar and gateway payload return," in AAS/AIAA Astro- dynamics Specialist Conference, no. 724, 2021.

[2] A. L. Genova and B. Aldrin, "Circumlunar Free- Return Cycler Orbits for a Manned Earth-Moon Space Station," in AAS/AIAA Astrodynamics Specialist Conference, no. 794, 2015.