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Author: Mr. Kevin Post
The Boeing Company, United States, kevin.e.post@boeing.com

Mr. Michel Loucks
United States, loucks@see.com

LUNAR DISTANT RETROGRADE ORBIT MISSION DESIGN

Abstract

There are a substantial number of papers written about distant retrograde orbits, outlining the processes governing them and the celestial bodies which follow them. The nature of this paper is different; it investigates the potential mission design for a human mission to a lunar Distant Retrograde Orbit (DRO) given the current system development investments being made by the United States' National Aeronautics and Space Administration (NASA). The timing of NASA's Exploration Mission 1 (EM-1) mission and EM-2 mission are such that the defined system requirements to successfully execute these missions are heavily dependent on the assumptions made with regards to the Space Launch System (SLS) operational performance. The SLS upper stage configuration, as of the time of this writing, is still a tradable investment asset. We investigated three different upper stage configurations for the EM-1 and EM-2 missions, incorporating the unique requirements and objectives of each mission. The applied upper stage configurations are the Delta-IV Cryogenic Second Stage (DCSS) which is intended to be used on the Orion Exploration Flight Test 1 (EFT-1), a stretched DCSS configuration, and finally a Large Upper Stage (LUS) with a much larger propellant load than the other options and includes four RL-10 engines. The strategy of these investigations and the results are presented here, with recommendations for other potential mission design concepts and considerations. The trade analysis results are presented which show that the EM-1 un-crewed mission can be executed such that the required investment is minimized while objectives are still met. Additionally, an EM-2 mission analysis is presented that proposes an 'investment opportunity' which would provide the human spaceflight community with the greatest return for relatively near-term beyond Low Earth Orbit (LEO) crewed missions. Investment in the LUS for EM-2 provides for not only a substantial increase in performance to the lunar vicinity, but this increase in performance allows the spaceflight community to potentially deliver an in-space habitat to a lunar DRO which would facilitate preparations for deep-space missions and asteroid retrieval operations.