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Author: Dr. David Dunham
KinetX, Inc., United States, david.dunham@kinetx.com

Mr. Kjell Stakkestad
KinetX, Inc., United States, kjell@kinetx.com
Dr. Peter Vedder
KinetX, Inc., United States, peter.vedder@kinetx.com
Mr. James McAdams
KinetX, Inc., United States, jim.mcadams@kinetx.com
Mr. Anthony Genova
United States, Scjb1@aol.com
Prof. Roberto Furfaro
University of Arizona, United States, robertof@email.arizona.edu
Mr. John Kidd Jr
University of Arizona, United States, johnkiddjr@gmail.com
Mr. Jerry Horsewood
SpaceFlightSolutions, United States, Horsewood@SpaceFlightSolutions.com

HUMAN EXPLORATION OF THE MOON, NEAR-EARTH ASTEROIDS, AND MARS USING STAGING FROM EARTH-MOON L-2 ORBITS AND PHASING ORBIT RENDEZVOUS

Abstract

This work extends the trajectory concepts for human exploration reported at the 2014 IAC in Toronto that expanded on ideas developed by the International Academy of Astronautics exploration study group presented by Robert Farquhar at the 2008 IAC in Glasgow. The advantages of using an Earth-Moon L-2 (EM-L2) halo orbit for accessing all parts of the Moon, and for departures using powered lunar and Earth gravity assists to explore near-Earth objects, Mars, and Phobos will be demonstrated. Different halo orbits will be considered, including lunar near rectilinear halo orbits (NRHOs) and the small-amplitude halo orbits studied earlier, to assess which may be best for overall exploration goals. An NRHO is now considered for the maneuverable Deep Space Gateway (DSG), which fits in to our architecture. The basic idea is to use an Interplanetary Transportation Vehicle (ITV) that would stay in high-energy orbits when near the Earth, parked in an EM-L2 orbit, nominally near/at the DSG, between missions for reusability. For going to a new destination, the ITV would be placed in highly elliptical Earth orbits (HEOs) following a lunar powered swingby after departure from the EM-L2 orbit, and before the powered Oberth perigee maneuver performed at the right time to depart for the interplanetary destination. This could be done robotically, without a crew. While in the HEOs, we will show how there are multiple opportunities to rendezvous with the ITV from Earth with the capabilities of the Orion capsule and heavy launch vehicles; this provides a robust method of transferring astronauts, fuel, and supplies to the ITV shortly before the interplanetary departure. The HEOs serve as phasing orbits, to achieve the right direction and time for the ITVs hyperbolic departure following the Oberth maneuver, so we call this idea of adding crew and supplies phasing orbit rendezvous. At Mars, staging is also possible for the ITV, from an elliptical Mars orbit, perhaps with a period of 10 days, from which astronauts could be ferried to Phobos or the Martian surface with a pre-positioned Mars vehicle designed for this, possibly using fuel generated on Mars. The

apoapse of the ITV, uncrewed while the astronauts explore Phobos or Mars, can be raised robotically with relatively small maneuvers to a high-enough distance where solar perturbations can change the line of apsides to the direction needed for the departure back to Earth, then lowered back to the 10-day orbit before the return departure.