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

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MISSIONS FOR ASTEROID INSERTION INTO EARTH-MARS CYCLER

Abstract

NASA and ESA programs indicate Mars as the main objective for human exploration beyond the Earth-Moon system. The goal is challenging and key technologies are under development in terms of propulsion system, power system, and deep space habitat. One of the showstopper is the protection of the astronauts from radiation when they are not subject to the Earth Magnetic field for a long period. A trip towards Mars can take 500 days and the dose of radiation absorbed by a human being with the actual shielding technology could be lethal. The state of the art considers the use of materials rich of carbon and hydrogen as the best strategy for the shielding from Galactic Cosmic Ray and Solar Particle Events. The main concept is to have a certain amount of mass in order to intercept the charged particles and the particles deriving from their scattering. For a given atomic number of the material, the shielding capabilities increase with higher density. In order to stop most of the dangerous radiation the shields need to be thick and massive. All this mass has to be launched from Earth to LEO and then moved to Mars. If a Deep Space Habitat (DSH) is inserted into a Cyclic Earth-Mars trajectory, harvesting shielding material from an asteroid and putting it on the cycler DSH has been suggested in the past to accomplish the shielding task. Criteria for a preliminary selection of the possible target asteroid, such as the Tisserand Criteria, have been presented in the past (Strange, Landau, Chodasy, Identification of Retrievable Asteroids with the Tisserand Criterion, AIAA 2014-4458). The aim of this research is to actually assess the feasibility of this kind of mission, computing trajectories for a space tug from the Earth to the selected Asteroid and from the Asteroid to the Cycler. Using the asteroid mass that is already close to the Cycler orbit, the overall mass to LEO from Earth is lower. The Cycler trajectories taken into account are Aldrin Cyclers, both inbound and outbound. The target asteroid (o part of it) is moved to the Cycler orbit by means of a Space Tug with low thrust maneuvers and Earth flyby. The propulsion system considered is a Hall thruster with High Isp based on the ARM design. An indirect optimization method is used for computing the low thrust trajectory (Casalino, Vavrina, Optimal Power Partitioning for Electric Thrusters, AAS 17-748).