14th HUMAN EXPLORATION OF THE MOON AND MARS SYMPOSIUM (A5)
Going beyond the Earth-Moon system: Human Missions to Mars, Libration points, and NEO's (4)

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ADVANCED MISSION ANALYSIS OF HUMAN EXPLORATION MISSIONS TO NEAR-EARTH ASTEROIDS

Abstract

As a starting point for the analysis of human missions to Near-Earth Asteroids (NEAs), the objectives of this study are to identify target asteroids and evaluate possible transfer trajectories as well as the associated launch windows. Subsequently, typical mission scenarios in terms of flight times are characterized and the feasibility of proximity maneuvering as well as the possibilities of mission abort are analyzed. An improved accessibility model for NEAs is developed allowing pre-selection of asteroid targets for human missions not limited by orbital elements, but only by mission duration (less than 365 days) and round-trip Δv (less than 10 km/s). Investigation of transfers to 1947 NEAs in the timeframe from 2020 to 2040 reveals 71 asteroids to be accessible. 32 of these 71 asteroids can be reached with a Δv $<$ 7.5 km/s, seven of which allow mission durations of less than 180 days. 81 launch windows are found for these 32 asteroids. Most years in the given timeframe offer more than one launch opportunity. Commonalities are observed in missions to different asteroids. It is seen that most launch windows only permit missions with a longer outbound than inbound flight, while some offer the opposite sequence. All 32 asteroids can be reached on the former type of mission. For few launch opportunities, either sequence is possible for the same overall mission duration. For operations during the proximity phase of the missions, the possibility of controlled and solar-stabilized orbiting are investigated as a function of spacecraft mass and size, asteroid mass, rotation rate, distance to Sun, and orbiting radius. Solar-stabilized orbits are seen to only be feasible for a limited range of orbiting radii and the orientation of the orbiting plane is predetermined. Controlled orbits are possible at any orientation and require very low control v, but the maneuver frequency is high. Missions with an outbound trajectory bringing the spacecraft back to Earth again after the launch, e.g., having a period of approximately 365 days, offer good free-return possibilities, however, only few such missions to few asteroids exist in the 2020 to 2040 timeframe and the launch windows are extremely narrow. Mission abort with an anytime return scenario is more promising in terms of safety but is seen to cause Δv penalties. With these results, the mission analysis of the interplanetary part of human missions to asteroids is concluded, setting mission-specific requirements and boundary conditions required for subsequent spacecraft design.