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OPTIMIZATION OF INTERPLANETARY TRAJECTORY FOR DIRECT FUSION DRIVE SPACECRAFT

Abstract

The Direct Fusion Drive (DFD) technology, at present studied in several research centers, will allow fast and affordable interplanetary travel. It is well known that, to optimize the payload fraction, the thruster should operate in Variable Ejection Velocity (VEV) mode and that a low thrust interplanetary travel can be considered as made of three parts: a first planetocentric phase, a second heliocentric phase and finally a third planetocentric phase. If DFD is used, not only a limitation to the ejection velocity must be introduced in the interplanetary phase because the optimal value exceeds the attainable value, but the optimal ejection velocity in the planetocentric phases is too low since the thruster has a quite high value of the minimum specific impulse. The planetocentric phases must be performed with a higher specific impulse than the optimum one, which implies to use a heavier thruster to achieve the exit from the sphere of influence of the starting planet and the capture into the orbit around the arrival planet: in this way to maintain the duration of the three phases of the journey at the same values computed using the unlimited VEV assumption, the mass of the propellant required would be lower, but the mass of the thruster would be higher. All in all, since the unlimited VEV solution is the optimal one, the payload fraction is lower than the optimal one. To look for an optimal solution, a longer duration of the planetocentric phases and a shorter duration of the interplanetary one (to reason at equal total journey duration) are needed. This approach is implemented by modifying a number of routines of the IRMA mission analysis code. The bacon plot for the interplanetary cruise is first computed accounting for the limitations in the specific impulse. The planetocentric phases are then added and the orbit-to-orbit bacon plot is obtained, with unlimited specific impulse in the planetocentric phases. The plot is finally modified by increasing the time required by the planetocentric phases so that, taking into account the specific impulse limitations, the spacecraft doesn't need in the first and last phases a larger thruster than that required for the second phase. Once the last bacon plot has been obtained, the optimal starting and arrival dates can be chosen for any interplanetary journey. Some examples of very fast Earth-Mars journeys are then computed, showing that DFD allows affordable fast interplanetary travel.