ASTRODYNAMICS SYMPOSIUM (C1)
Mission Design, Operations and Optimization (2) (9)

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DETERMINISTIC METHOD FOR SPACE TRAJECTORY DESIGN WITH MISSION MARGIN CONSTRAINTS

Abstract

The problem of designing robust low-thrust transfer trajectories is considered. As the technology mature, the use of low-thrust propulsion for interplanetary missions become more and more necessary. Recent experiences on low-thrust interplanetary missions show however that because of the very long thrust duration the propulsion system is prone to failure, even temporary. Also, the complex dynamics result in discrepancies between the flying trajectory and the desired one such that correction manoeuvres must be executed. The question is when the spacecraft can recover from a failure. To some extent the question is whether there is sufficient time for (1) using a recovery trajectory that would satisfy the terminal constraints in case of failure, or (2) performing necessary corrections for missed-thrust.

An approach is thus to design the interplanetary low-thrust trajectory to account beforehand for these unexpected events and corrections. The concept of mission margin is thus introduced. A mission margin defines how long the system can fail thrusting but still being able to recover and satisfy terminal constraints. The mission margin can be indeed described as a function varying with time. The problem is posed as an optimisation problem with terminal constraint and maximum mass objective function. Using a direct approach, it is possible to place a mission margin constraint at selected nodes. An issue is that the mission margin function is computationally heavy, and thus it is not possible to place a constraint at each node. The solution method proposed is based on an analysis of the variations of the mission margin function, and a sampling method. Interior constraints are thus placed on a particular selection of nodes.

The approach is applied to an interplanetary transfer, considering one intermediate swing-by.