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ON THE SMOOTHING OF SLEWING PROFILES FOR LOW THRUST TRANSFER TRAJECTORIES

Abstract

The use of electric propulsion for orbit raising and station keeping purposes has increased significantly in the last years. Through a much higher specific impulse if compared to the chemical option, these propulsion systems make a more efficient use of the available propellant mass, at the expense of a lower thrust level and as a consequence, a longer transfer duration. Determining the ideal pointing direction of the thrust during the transfer in order to minimize the duration of this phase is typically a task for an optimal control problem solver. The qualitative solution to this problem is driven by the kinematics of the problem (which are the orbits to be connected) and not so much by its dynamics (for instance, the ΔV needed for a given transfer is almost fully independent from platform mass and inertias, or from the applied thrust level). For this reason, these solvers do not usually include constraints on satellite attitude control, or power balance, but only (if any) a limitation on the maximum angular rate of the thrust.

Consequently, the attitude profiles may include violations on typical AOCS constraints involving satellite dynamics (angular momentum, torque). In order to cope with these events, a smoothing algorithm is designed to detect constraint violations and to correct them accordingly. The method aims to change the evolution of the satellites attitude profile, but leaving the thrust vector unaltered, i.e., only the rotation around the thrust vector is changed over time such that the angular momentum and torque values match the maximum allowed levels in the intervals containing violations in the original profile, in order to deviate as little as possible from the ideal sun-pointing attitude. The results of this processing show the impact of the AOCS constraints on the satellite power balance.

A further level of smoothing would imply changing also the thrust direction within the optimiser, after imposing a constraint on the maximum allowable rate of the thrust (if needed). However, this would result in suboptimal transfer trajectories that, even if feasible, would denote a non-optimal design of the attitude control devices and/or the power subsystem.

This paper presents a smoothing algorithm to deal with this type of constraints. A practical case study is selected, analysed and discussed, to illustrate the links between the several involved design aspects.