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ELECTRO: a SW tool for the ELECtric propulsion TRajectory Optimization

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Low-thrust orbit transfers are becoming increasingly attractive thanks to the mass savings they offer and the maturity of electric propulsion technology. For this reason, there is an interest in developing fast, but still reliable trajectory optimisation methods that can be applied in the preliminary phase of the design of a mission. The tool presented is based on the averaging of the equations of motion written in equinoctial elements over true longitude. The calculus of variations is used to identify the optimal control law. In particular, the indirect optimisation method used here is based on a sequential gradient-restoration algorithm. Perturbations such as zonal gravity harmonics are included as well as shadowing effects, which need to be modelled because electric propulsion is normally switched off during eclipses. For the eclipse detection algorithm, an analytical formulation for the extreme points of the eclipse is mandatory, since the entry to and exit from the eclipse set up the limits of integration for the averaging. Further, low-thrust trajectories require a continuous variation of the thrust direction and this has to be compatible with the capabilities of the attitude control system of the satellite. This constraint can be formulated in terms of maximum angular rate for the satellite axes, maximum angular momentum and/or maximum torque. A discussion on how to cope with these constraints in the optimisation method will be presented. The capabilities of the developed tool are illustrated with examples of transfers to Geostationary Earth orbit (GEO).

Keywords: trajectory optimization, low-thrust, electric propulsion, indirect methods

Summary

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