Optimised GTO-GEO Transfer using Low-Thrust Propulsion

Marilena Di Carlo,[1*] Massimiliano Vasile,[2]
[1,2]*University of Strathclyde, Glasgow, United Kingdom*
marilena.di-carlo@strath.ac.uk

Keyword: GTO-GEO transfer, electric propulsion, trajectory optimisation

In this work an optimal electric propulsion transfer from Geostationary Transfer Orbit (GTO) to Geostationary Equatorial Orbit (GEO) is studied.

The objective is the minimisation of the propellant consumption for the GTO-GEO transfer in a given time of flight. During the transfer the thrust is applied on two thrust arcs nominally centred at the perigee and apogee of the transfer orbits. The control parameters are the length of the thrust arcs, the elevation angle of the low-thrust vector and the shift in the position of the thrust arcs with respect to perigee and apogee. The shift of the thrust arcs with respect to perigee and apogee might be necessary when the variation of a given orbital element can not be realised at the apogee or perigee of the orbit (e.g., it is not possible to change the inclination of the orbit at perigee or apogee when the argument of the perigee is either 90 or 270 degrees).

For the optimisation, a direct optimisation method is used in which the control parameters are defined at specific points of the transfer and then interpolated to obtain their time variation during the entire transfer.

The model used for the motion of the spacecraft is an analytical propagator [1], which speeds up the optimisation process with respect to the use of a numerical one. The analytical propagator is based on non-singular equinoctial elements and includes low-thrust acceleration and perturbations due to Earth's zonal harmonics J2, J3, J4, J5, atmospheric drag, solar radiation pressure and third body gravitational perturbation.

Preliminary results show that many local minima exist for the solution of the problem. As an example, Figure 1 shows the variation of semi-major axis and inclination obtained for a GTO-GEO transfer realised in 225 days with a 2,000 kg spacecraft using a 0.5 N electric propulsion engine, when no perturbations are considered.

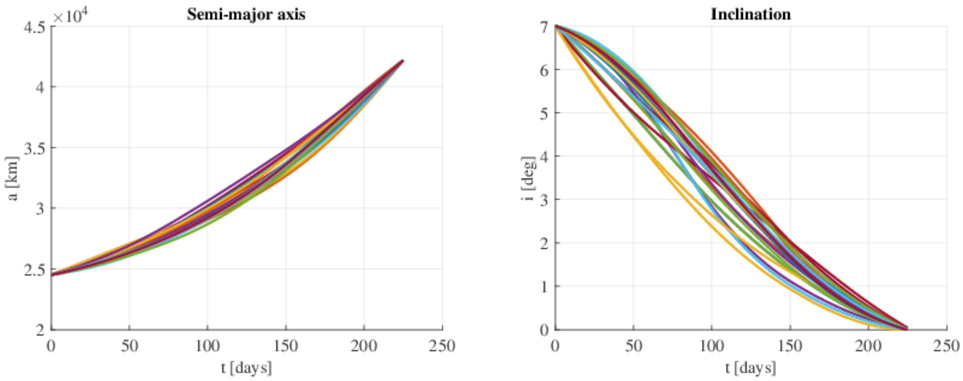

Figure 1 – Semi-major axis and inclination variation of different solutions of the GEO-GTO transfer problem

The validity of the proposed model is assessed by numerically propagating the control profile resulting from the optimisation process. Preliminary results show that the numerical propagation provides results that are in agreement with the ones of the analytical propagation.

To complete the study, the effects of the radiation environment and of the eclipses are also considered.

References

[1] F. Zuiani, M. Vasile, Extended analytical formulas for the perturbed Keplerian motion under a constant control acceleration, *Celestial Mechanics and Dynamical Astronomy*, 121 (2015), 275-300.