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QUALITATIVE AND QUANTITATIVE CHARACTERISATION OF SOLUTIONS FOR THE LOW THRUST TRANSFER GTO TO GEO

Abstract

The use of electric propulsion for orbit raising and station keeping purposes has flourished within the last years in the space industry as an interesting option for reducing the demands on propellant mass at the expense of an enlarged duration and a subsequent operational complexity. As a consequence of this increased complexity, new SW tools have been developed in last years to cope with the full optimal control problem implicit in the needs for trajectory design as part of the operational flight dynamics applications.

In this context, the transfer from the Geosynchronous Transfer Orbit (GTO) to the Geostationary Orbit (GEO), in which the minimisation of the transfer duration is commonly taken as cost function, has attracted particular attention. Many different approaches and SW applications are found in literature that solve this Two Point Boundary Value Problem (TPBVP) under different realistic constraints, relying on either direct or indirect optimal control algorithms. The strengths and weaknesses of each one of these methods for efficiently solving the GTO to GEO problem with low thrust are also largely documented, together with many solutions and associated analyses.

However, less attention has been paid to the qualitative and quantitative differences in the results if considering different implementation options for these SW tools. For instance, how much an impact on the trajectory design would have if not considering J2?; how much larger and cheaper is a transfer if we stop thrusting during eclipses, compared to the case without stops?; how relevant is the consideration of other perturbations (third bodies, air drag)?. Further, how much transfer time can be traded off with delta-v if introducing some specific coasting arcs?

All these questions are addressed in this paper, aiming to avoid as much as possible the specific design of a given mission, but instead providing generic 2-D maps that can easily be used during the first development phases to quickly compare and assess several different mission implementations and satellite design options.