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HIGH-FIDELITY OPTIMUM ELECTRIC PROPULSION TRANSFER DESIGN TO GEO AND MEO

Abstract

With the maturation of Electric Propulsion (EP) technology and the feasibility of employing EP thrusters both for orbit changes and top-up as well as station-keeping, it has become so attractive to exploit the high Isp and reduce the propellant budget for transfer from GTO to GEO that the majority of platform developments for telecom spacecraft now include EP transfer capability. Also, it should be noted that the versatility of EP opens new possibilities with respect to alternative launch orbits (SSTO, LEO), facilitating the procurement of smaller launchers. The benefits are not limited to GEO transfer scenarios, but can be traced also for MEO and other target orbits, provided that the spacecraft business case is able to accommodate a prolonged period of several months from launch to arrival on station.

The general benefits of EP have been variously demonstrated in the past and tools have been devised to compute and/or optimize the transfer trajectory. Most of this work has been academic and considered simplifications that are detrimental for realistic performance evaluation, system sizing and for deriving subsystem specification.

This presentation provides an in depth assessment of the optimum EP transfer concept from a GNC (Guidance, Navigation and Control) and practical implementation perspective. An overview of heritage algorithms and tools for optimization of low-thrust planetocentric transfers is given. Then, advanced methods and solutions for transfer scenario optimizations are presented. Further, emphasis is placed on mission and model related constraints stemming from technical spacecraft system limitations. This includes orbit determination technologies, spacecraft agility, EP thruster cycling, on-board autonomy and operations. Thereto, optimization solutions are showcased –including GEO crossing avoidance- and are analysed concerning their flyability (controllability, implementability, safety, etc.).

The presentation highlights trade-offs of launch orbits and EP transfer and assesses system performance under competing objectives, such as minimum transfer duration and minimum fuel consumption. Exemplary solutions will be representative of commercially relevant scenarios from the telecoms and/or navigation spacecraft sector.