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MULTIDISCIPLINARY DESIGN OPTIMISATION OF ALL-ELECTRIC COMMUNICATIONS SATELLITES

Abstract

The European space industry is advancing towards the design and manufacture of satellite platforms making use of electric propulsion for not only station-keeping, minor manoeuvring and end-of-life disposal, but also for the initial orbit raising and mission orbit acquisition. The conventional use of chemical propulsion for orbit raising, station-keeping, and minor manoeuvring within the mission orbit suffers from the disadvantage of requiring a sizeable propellant mass, resulting in higher launch mass and costs.

Electric propulsion systems offer a high specific impulse in comparison to chemical systems, and hence provide the benefit of decreased propellant mass. However the transfer period between orbits is considerably longer and this results in several additional factors that must be considered during satellite and mission design. Examples of these factors are alterations to the satellite radiation tolerance requirements and the fact that the payload is inactive during the transfer, impacting the operator service provision and revenue. Therefore there is a need to quantitatively determine the extent to which the incorporation of electric propulsion as the sole propulsive method affects overall design. As such, a tool for multidisciplinary design optimisation of all-electric satellites has been developed to support the initial stages of satellite conceptual design.

The key impacts of electric propulsion on the satellite design are observed in the propulsion and electrical power subsystems, with additional modifications required for the satellite structure and thermal control. These changes alter the satellite such that conventional sizing relationships used in conceptual design are no longer valid.

The developed tool incorporates subsystem models that have been modified to account for the impact of electric propulsion on overall system design. Models have been developed for the propulsion, power, thermal, structural, and guidance, navigation, and control subsystems. A heuristic optimisation strategy is applied to solve the multidisciplinary optimisation problem via an evolutionary algorithm. The user is able to select the design objective (such as maximum payload mass, or minimum transfer duration or satellite cost), in addition to any constraints that may applicable. The resulting output consists of a set of optimum parameters suited for use in the early stages of satellite conceptual design.