SPACE PROPULSION SYMPOSIUM (C4)
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VALUE ANALYSIS AND VALUE-INFORMED TRADEOFFS FOR THE ADOPTION OF ELECTRIC PROPULSION ONBOARD COMMUNICATION SATELLITES

Abstract

The adoption of electric propulsion (EP) on board spacecraft has steadily increased over the years, with a compounded average growth rate of about 16% since 1995. EP has been used on orbit for over three decades, principally for station keeping, in conjunction with traditional chemical propulsion for orbit-raising. Despite the advantages it provides (e.g., higher specific impulse and significantly lower mass than chemical propulsion), electric propulsion will not be widely adopted until two fundamental analyses have been conducted and questions addressed. First a value analysis of EP is needed, integrating the various benefits, costs, and drawbacks (including the much longer flight time to achieve final orbit and the corresponding revenues forfeited for example for a communications satellite), and benchmarking it against chemical propulsion systems; satellite operators will make value-informed decision regarding the adoption (or not) of EP, and it is important to understand under what conditions, and for what missions and markets, would EP tip the value balance in its favor. Second, a reliability and risk analysis of EP is needed, and again benchmarking it against the reliability of chemical propulsion systems; satellite operators (and insurers) will also make a risk-informed decision regarding the adoption of EP. In this work we address the first question (the second question is examined in a companion article). We develop and integrate three models in our value analysis: (a) a time of flight model accounting for various levels of (low) thrust to perform the orbit raising from geo-transfer orbits (GTO) to the geostationary orbit (GEO). The model uses launch vehicles User's Guide information to derive realistic time of flight results given the performance of current launch vehicles; (b) a mass and cost model for the EP system, and we trade the resulting mass savings compared with the use of traditional chemical propulsion with an increased payload size (e.g., more transponders onboard a communications satellite for example) to derive an iso-launch mass benchmark (EP vs. chemical propulsion); a discussion of the iso-payload benchmark is also provided; (c) a market and revenue model, accounting on the one hand for delays in achieving final orbit (time of flight results) and corresponding forfeited revenues, and on the other hand the increased revenues resulting from the larger payload. The integration of these three models allows us to identify value-based tipping points beyond which EP becomes the preferred option and situations where chemical propulsion remains the value-preferred solution.