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ENABLING LOW-COST CHALLENGING MISSIONS WITH SMALL SPACECRAFT BY USING HIGH-ENERGY PULSED PLASMA THRUSTERS: INITIAL LOW-THRUST TRAJECTORY SIMULATIONS

Abstract

Small spacecraft are inherently cheaper to build and launch, even if they may pose formidable design challenges, especially for high Delta-v orbit transfers, lunar and interplanetary missions. The development of a propulsion system that is, at the same time, simple, robust and scalable, is of paramount importance to enable this type of missions at the cost levels affordable to the players more frequently interested in them, like academic institutions and small companies, especially in developing countries. In the last decades, increasingly ambitious missions have been planned and executed using small spacecraft. Although different types of propulsion systems have been developed and implemented on Cu-beSats, NanoSats and MicroSats, these have provided, in general, low values of total impulse, thus precluding their application to high Delta-v missions. Particularly stringent mass, volume and power constraints make scaling down electric propulsion systems, beneficial in reducing total propellant mass due to their high specific impulse, far from trivial. Among the many types of electric thrusters developed, Pulsed Plasma Thrusters (PPTs) have been one of the most successfully employed on small spacecraft, due to their low overall system complexity, which makes them eminently scalable, reliable and robust. These characteris-tics are especially evident in solid-propellant (ablative) PPTs, with their lack of moving parts. Such Ablative PPTs (APPTs) were the first Electric Propulsion devices ever to be flown on board a spacecraft, in an actual space mission, and continue to be used today when simplicity, robust-ness and scalability to different power levels are dominant requirements. Therefore, they find a natural niche of application in small-spacecraft missions, where mass, volume and onboard power are at a premium, in spite of their low overall efficiency and not fully understood physical operating principles. This paper presents a preliminary study of the use of an APPT as a simple, robust and relatively cheap primary propulsion system for a sample interplanetary mission. The main operating parame-ters of an APPT propulsion system, obtained analytically by using pre-viously developed scaling laws in a preliminary design, as illustrated in a companion paper, are then used in a simplified mission analysis. This is initially limited to a preliminary Orbit Analysis, in terms of Dynamics, Geometry, Maneuver and Maintenance, Earth-Moon Transfer and Delta-V Budget, to check if the mission can be realistically implemented. Var-ious dedicated software will be used, such as JAQAR Astrodynamics package and STK/Astrogator.