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APPLICATION OF REFLECTIVE CONTROL DEVICES FOR POSITION AND ATTITUDE CONTROL OF SPACECRAFT

Abstract

Reflective control devices present a novel method of utilizing solar radiation pressure for orbit and attitude control of a spacecraft. While current solar radiation pressure techniques for spacecraft control rely on changing the area of a control surface or the offset between the spacecraft's center of mass and center of pressure, reflective control devices extend these capabilities by allowing for an additional degree of freedom to a spacecraft's controller by changing the reflectivity of the sail. This additional degree of freedom allows for novel attitude-only or combined position and attitude controllers that do not consume propellant, extending spacecraft lifespans and increasing science capabilities. Reflective control devices have been previously demonstrated in space, but require further analysis for future applications. This paper outlines how these unique devices can be leveraged to solve spacecraft position and attitude control problems in terms of device placement, orientation, and optional gimballing. An overview of reflective control devices is presented including examples from the literature, followed by an optimization problem to designate the optimal placement of reflective control devices on a spacecraft in order to maximize control authority. An algorithm is presented for controlling the reflectivity when the reflective control device orientation is static or is allowed to gimbal. Motivation for the use of reflective control devices is provided through two use cases. First in regulating a spacecraft's Halo orbit around the Sun-Earth collinear Lagrange points without the use of propellant, and second in countering the swirl torque produced by Hall thrusters.