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ADVANCED TRANSFER OPTIONS AND INTEGRATED FLIGHT DYNAMICS ANALYSES FOR THE EUROPEAN STUDENT MOON ORBITER

Abstract

The European Student Moon Orbiter (ESMO) is currently scheduled for launch in 2014 – 2015, making it the first lunar micro-satellite designed entirely by students, and the only currently planned ESA mission to the Moon. The limited ΔV budget available to ESMO and the requirement to be a piggy-back payload on any commercial launch in 2014-2015 made the design of a feasible transfer to the Moon a real challenge. To help reduce propellant, a weak stability boundary transfer was proposed. This paper covers some of the advances made recently in the process of analysing and creating transfers for ESMO, and the development of a flight dynamics simulator to verify whether the proposed spacecraft design can fly the transfer and accomplish mission objectives. The use of a commercial launch to GTO imposes limitations on the orbit orientation as launch times are dictated throughout the year by the launch provider and primary client. This causes transfers that would be viable when orbit orientation is free to become infeasible under the conditions of a fixed timeslot for launch. As a result, periods of time exist within the year where no feasible transfers (within the specified ΔV budget) are found. To counter this, some advanced transfer options exploiting multiple deep space manoeuvres compared to the baseline design are implemented to study the effect on the viability of transfers during those periods of time. An improved trajectory optimization process is obtained by computing gradients using the State Transition Matrix instead of finite differences. Work on the development of a flight dynamics simulator (consolidating work from both the Flight Dynamics and Attitude Control Systems student groups) is also presented. A tool able to implement course correction manoeuvres and to simulate the actual (finite thrust) manoeuvres has been developed. Two attitude control strategies, thrust direction fixed or free during manoeuvre, have been considered in order to increase the robustness of the simulator. A PID controller has been developed for attitude control that satisfies the requirements placed upon it in terms of ΔV errors during manoeuvres (especially during lunar capture) and hardware limitations. This has been selected in lieu of a PD controller to cancel the stationary error characteristics thereof. Cancelling this error ensures that for long duration manoeuvres the transverse error will reduce in time. The selected controller design is shown to be robust over the entire inertia range.