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ESMO PHASE B1 MISSION ANALYSIS: TARGETING OPTIONS FOR LUNAR WSB TRANSFERS ALONG WITH A MULTI-BURN INJECTION STRATEGY

Abstract

The European Student Moon Orbiter, currently in phase B1, is the first lunar spacecraft entirely designed by students. Projected for launch as a piggyback payload in 2013 and using a Weak Stability Boundary (WSB) transfer, it will reach an elliptical lunar orbit. This paper presents the trajectory analysis and design performed to fulfil the objectives of the mission.

Two distinct targeting strategies were developed to find WSB Transfers for any possible transfer injection date. Moreover, detailed analysis was performed on how to meet the injection conditions into the lunar transfer trajectory using a multi-burn strategy at the Earth starting from a Geostationary Transfer Orbit (GTO).

The first targeting strategy makes use of forward and backward propagations from respectively the departure and arrival conditions, using the equations of motion of the restricted four-body problem (Sun, Earth, Moon and spacecraft). A reference plane is defined in the inertial ecliptic reference frame and all legs crossing the plane are recorded. First guess solutions are then derived from the legs that nearly match in time, position and velocity. And they are fed into a local optimiser to find an exact solution. It will be demonstrated that this approach can be used for most given departure dates and to generate usefull transfers.

The second targeting strategy uses simply forward propagation and generates first guesses by executing a systematic search over the injection parameters: right ascension of the ascending node (RAAN), departure date and thrust magnitude. First guesses fulfilling certain conditions best on reference cases are selected, then grouped in sets based on their characteristics (time of flight, arrival conditions, etc.). The most promising of each set are locally optimised, minimising the deltaV at lunar orbit insertion while matching the desired arrival conditions.

Transfers determined by either strategy require suitable departure conditions at the Earth. The phase A study showed that a single thrusting for the WSB transfer injection would lead to an excessive navigation budget. Therefore a multi-burn strategy was developed around the Earth, linking the launcher orbit to the injection into the WSB transfer by phasing and modifying the RAAN. Mission robustness requires a similar approach at the Moon. The results indicate that a thrusting sequence of 6 manoeuvres is feasible for decreasing the navigation margin to an acceptable level. As expected, it is very costly to modify the RAAN and therefore only small changes are justifiable.