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ADVANCED OPTIMIZATION METHOD FOR HIGH-THRUST AND WEAK STABILITY BOUNDARY END-TO-END HIGH-FIDELITY EARTH-MOON TRAJECTORIES WITH SPACE MANOEUVRES

Abstract

All the major Space-Powers are looking back again at the exploration of the Moon, this time "to stay". Driven by scientific, geopolitical and economic purposes, the totally unexplored Moon South Pole is set as the preferred target region where to land. Never been on the Moon, Europe is now going to put its best efforts on the so-called Argonaut program: the European answer to the new Moon rush aiming to independently develop a lunar lander able to carry over the lunar surface a greater amount of payload mass (¿ 1.0 tons). The study here presented is focused on the optimization of high-thrust and Weak Stability Boundary (WSB) Earth-Moon transfers trajectories taking into account multiple manoeuvres and real operative mission constraints in the frame of the European ambitions to get to the surface of the Moon. Several dynamic models of increasing precision and complexity have been tested and implemented. Hybrid optimization method is used to minimize the total Delta-V. In the perspective of obtaining the global optimum solution for different set of launch periods (arbitrarily selected by the user), as a first step, the whole set of possible transfers solutions is then explored using a local optimizer (SQP) recursively, allowing to find satisfactory guess solutions in a reasonable time. The second step is then focused on the refinement of such guess solutions through the utilization of high-fidelity models (based in turn on ephemeris data taken from the NASA-JPL SPICE Toolkit), obtaining end-to-end high-fidelity trajectories solutions covering entirely the mission profiles: from spacecraft injection, to the touchdown over the surface of the Moon. Various perturbations, such as extensive Moon and Earth gravitational models are considered, are also considered for the further refinements of the trajectories solutions. The study here presented is fit into a real and competitive context at European level computing the necessary trajectories correction and insertion manoeuvres, as well as optimizing the descent profiles over specified Moon landing site(s), at the date(s) and time(s) requested. Similarly, also the descent dynamics is written in a progressively more complex and detailed model to finally evolve into a complete 3D model. Major results are presented to demonstrate the validity of this method in comparison with past and in particular recent Moon exploration missions. The most promising mission options are finally described and shown in the paper. Eventually main conclusions are drawn from a System and Space Operational point of view.