Paper ID: 73449
student

IAF ASTRODYNAMICS SYMPOSIUM (C1)
Interactive Presentations - IAF ASTRODYNAMICS SYMPOSIUM (IP)

Author: Ms. Shanshan Pan
Nanjing University, China, shanshan.pan33@outlook.com

Dr. Francesco Topputo
Politecnico di Milano, Italy, francesco.topputo@polimi.it
Prof. Xiyun Hou
Nanjing University, China, silence@nju.edu.cn
Mr. Yang Wang
Politecnico di Milano, Italy, yang.wang@polimi.it

ON OPTIMAL THREE-IMPULSE EARTH-MOON TRANSFERS IN A FOUR-BODY MODEL

Abstract

The Earth-Moon transfer trajectory based on impulsive maneuvers has been extensively studied. The traditional method to construct such a transfer trajectory is the Hohmann transfer, which usually requires a high fuel cost and hardly meets the always-increasing demand of science-to-investment ratios in future space missions. Most investigations focus on the two-impulse Earth-Moon transfers using the simplified dynamical models, such as the patched two-body problem and the circular restricted three-body problem. To enhance the effectiveness of preliminary orbit design, it is essential to study the fuel cost for multi-impulse transfers in high-fidelity models. This work investigates the optimal three-impulse Earth-Moon transfers in the restricted four-body problem with the Sun, the Earth, and the Moon as primaries. Unlike the two-impulse transfers, the three-impulse trajectory optimisation is inherently an optimal control problem with interior-point constraints, and the problem becomes more challenging due to the high sensitivity introduced by the time-dependent four-body model. To address this issue, an efficient methodology for constructing optimal three-impulse Earth-Moon transfers in the four-body model is proposed by using the primer vector theory. First, based on the existing two-impulse Earth-Moon transfer, a feasible three-impulse Earth-Moon transfer as the initial guess solution is constructed by using the calculus of variations. Second, the optimal three-impulse transfer is further achieved by developing a robust continuation method and verified by the primer magnitude time history. Finally, thousands of optimal solutions for different transfer times are successfully obtained. A more general picture encompassing known solutions in literature as special points is allowed to frame, which enables the complete trade-off study between fuel cost and transfer time. It is shown that three-impulse solutions can effectively reduce the fuel cost than the two-impulse solutions. Families of these three-impulse solutions are further defined and characterised, and their features are discussed.