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MULTI-TETHERED MANEUVERS FOR A SPACECRAFT PASSING NEAR THE MOON

Abstract

The present paper has the goal of studying the problem of changing the trajectory of a spacecraft passing close to the Moon using a multi-tethered assisted maneuver. The idea is to deviate the trajectory of a spacecraft coming to the Moon from an elliptical orbit around the Earth. The literature approaches this problem using several techniques, including impulsive, low thrust and gravity assisted maneuvers. In the opposite side, the present paper explores an idea that is already available in the literature, and uses tethered-assisted maneuvers to change the orbit of the spacecraft, without fuel consumption. The tethers are assumed to be fixed in the surface of the Moon and they are used to rotate a spacecraft that is passing nearby, generating a series of tethered sling shot effects that changes the energy, velocity and angular momentum of the spacecraft with respect to the Earth. The new trajectory will have different values for the Keplerian elements with respect to the Earth, which can benefit the mission. The article focus in the energy gains obtained by the maneuver, considering different values for the tether length, geometry of approach, number of tethers, etc. It is also studied the tension that is applied to the tether, such that it is possible to give an idea of the requirements to build the tether. This study investigates the use of multiple tethers in order to maximize the gains of energy while minimizing tether length and tension, which are two very important factors when building the tether. A simplified mathematical model of the system is developed, assuming an inextensible tether with no mass. To solve this problem, analytical and numerical solutions are combined to obtain the results, which are the energy variations and tension in the tether as a function of the number of tethers and the size of each of them. The main conclusion of the paper is that the proposed scheme can give large variations of energy to the spacecraft without fuel expenses, and that the use of several tethers can reduce the individual size and tension of each tether. So, this study shows an interesting possibility to maneuver a spacecraft in the future and can be applied to a large variety of missions.