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OPTIMIZING THE CUTTING POINT OF A DUAL-SPACECRAFT TETHERED SWING-BY

Abstract

There are many options of transportation for deep space missions, and the Swing-By (or close approach) is a very important one. It uses energy from the gravity field of large celestial bodies to change velocity and angular momentum of a spacecraft such that it can even leave the Solar System using this extra energy with no power consumption. This topic has been studied largely in the literature, in particular considering combinations with passages by the atmosphere of a planet and/or the application of an impulse during this passage. To continue this study, the present research studies the situation of a swing-by maneuver made by two spacecraft that are connected to each other by a tether. The choice of the instant to cut the tether makes a large impact on the subsequent trajectories of the two spacecraft involved. The main idea is first to understand the effects of cutting the tether during the close approach, which can be done in the moment of the maximum close approach, some time before or sometime after that. Previous studies have obtained good results combining swing-by maneuvers with the application of an impulse at the periapsis, i.e. while the spacecraft is approaching a celestial body. Although the application of this impulse can generate a larger effect in the variation in velocity, orbital energy, and angular momentum compared to the unpowered swing-by, this maneuver requires additional fuel consumption, as well as extra on-board equipments. In this case, an option to give extra energy to the swing-by maneuver is to use a system of two spacecraft connect to each other and cut the tether linking them at some point of the trajectory. This idea has been proposed by several authors as an alternative which does not require additional propellant consumption. Therefore, the goal of this research is to understand the dynamics of a system like that and then to optimize the cutting point to increase the efficiency of the maneuver, in particular looking for solutions that increase the energy of one of the spacecraft, working like an impulsive thrust. So, the mission proposed in this study combines swing-by with tether cutting to achieve the orbital transfer of a mother satellite and/or the planetary capture of a sub-satellite simultaneously. The maximization of velocity change is achieved considering different values of periapsis distance, angle of approach, attitude angle, and cutting position.