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USING TETHERS TO CHANGE THE ORBITAL PLANE OF A SPACECRAFT

Abstract

The problem of changing the orbital plane of a spacecraft is an important topic in astrodynamics. It is the orbital element that requires the most expensive maneuvers, in terms of fuel consumption, to be realized. Several interplanetary missions have this phase in some part of their trajectory. It means that finding techniques to save fuel in this part of the mission is a key factor to decide if a mission is possible or not. Several techniques have been used to solve this problem, like impulsive maneuvers, low thrust, gravity-assisted maneuvers, etc. The gravity-assisted maneuver is an important tool to solve this type of problem, but it requires massive celestial bodies to be efficient, which is not always available. To improve the possibilities, the literature has a few researches using tethers to make the rotation of the spacecraft, instead of gravity. A tether can be fixed in a small celestial body to change the orbit of a spacecraft that is passing by the body. Along that line, the present paper proposes the construction of a "Plane Change Portal" to modify the orbital plane of a spacecraft using a Tethered Sling Shot Maneuver (TSSM) with an asteroid in the three-dimensional space. The construction of this mechanism makes possible an unlimited number of maneuvers with the same tether. Another advantage is that the spacecraft does not need to carry the tether onboard, which is very important when considering small spacecrafts. This portal consists in a tether that remains fixed in an asteroid, while at the other end a large net is fixed. Therefore, the only action required from the spacecraft to hit the net. The impact will cause the rotation of the net, together with the spacecraft. The net needs to have a mechanism to release the spacecraft after the rotation. This technique also avoids the problem of hitting the asteroid with an onboard tether, which appear when the spacecraft needs to carry a tether on board that is released to hit the asteroid before the maneuver. It is possible to study this problem using the "patched-conics model", considering a series of two-body problems. The results can then be verified using the mathematical model given by the elliptical restricted three-body problem, because the asteroid is assumed to be in an elliptical orbit around the Sun.