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TETHERED SLINGSHOT MANEUVER IN THE THREE-DIMENSIONAL SPACE

Abstract

The Tethered Slingshot maneuver (TSM) [1] is an alternative technique to maneuver a spacecraft in space based in the use of space tethers. A space tether used for this type of application consists in a cable where one of the ends is fixed in a celestial body (a planet, moon or asteroid) while the other end is fixed in the spacecraft that will be maneuvered. The cable is considered thin, rigid, inextensible and with negligible mass. There are several options to make this maneuver. The tether can be taken on-board the spacecraft and then fixed to the celestial body by an harpoon mechanism during the passage, or it can installed in the celestial body previously [2]. The purpose of the maneuver is the variation of energy and/or inclination in the orbit of the spacecraft around the Sun. Both aspects obtained by Tethered Slingshot Maneuver will be analyzed. The maneuver works as follows: the spacecraft approaches the body, connects to the cable that makes up the tether, rotates around the body by a given angle and, in sequence, the spacecraft is released from the cable to follow its trajectory. The rotation made in the spacecraft makes significant modifications in the trajectory of the spacecraft. The rotation from the tether and the sequential trajectory of the spacecraft is modeled in three-dimensional space, using the restricted three-body problem for improved accuracy over the usual ”patched-conics” approach. This tethered maneuver gives flexibility to the mission, making possible for the spacecraft to reach goals that would be too expensive, in terms of fuel consumption, for a standard maneuver based only in propulsion systems. Different geometries, sizes and locations of the tether will be considered to make general maps that can guide a mission designer to get the most gains possible for the desired mission. Several examples using moons and asteroids of the Solar System will be shown.

References

[1] Penzo, P. A. and Mayer, H. L., ”Tethers and Asteroids for Artificial Gravity assist in the Solar System.” Journal of Spacecraft and Rockets. Vol. 23, No 1, 1986, pp. 79- 82. (doi:10.2514/3.25086).

[2] Prado, A.F.B.A. ”Using Tethered Gravity Assisted Maneuvers for Planetary Capture.” Journal of Guidance, Control and Dynamics. Vol 38, No. 9, 2015, pp. 1852-1856. (doi/abs/10.2514/1.G001009).