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Author: Dr. Antonio Prado
National Institute for Space Research - INPE , Brazil, afbap@uol.com.br

Dr. Vivian Gomes
Saõ Paulo State University (UNESP), Brazil, vivianmartinsgomes@gmail.com
Mr. Jhonathan Murcia
Brazil, jomp13@msn.com

AERO-GRAVITY POWERED MANEUVERS TO CHANGE THE INCLINATION OF A SPACECRAFT

Abstract

The present paper study maneuvers that can be made to change the inclination of a spacecraft using close approaches between a spacecraft and a planet, also considering the effects of the atmosphere of the planet and the application of an impulse during the passage. In a maneuver of this type there is an application of an impulse when the spacecraft passes by the periapsis of its trajectory around the planet. The dynamical system is composed by the planet, the Sun, and the spacecraft. The planet is assumed to have an atmosphere, which generates drag and lift forces, with lateral and up/down components. The planet and the Sun are assumed to be in circular planar orbits. The equations of motion are the ones of the circular planar restricted three-body problem with the addition of the forces given by the atmosphere and the impulse. Mars and Venus are used for the numerical simulations. The equations of motion are numerically integrated forward in time, considering the impulse applied, until a point where it is at a distance that can be considered far from the planet and it is possible to disregard the effects of the planet. Then, the orbit of the spacecraft is integrated backwards in time. The difference from the usual powered close approaches technique is the presence of the atmosphere of the planet, which generates a drag and a lift forces in the spacecraft. The primary objective of the present paper is to map the modifications of the orbits of the spacecraft due to the powered close approach with the planet. Emphasis is given to map the orbital maneuvers that change the inclination of the spacecraft. This type of maneuver has large consumptions of fuel, so savings in that part of the mission are very important. Then, the effects are compared with the same maneuvers performed using only propulsion systems, in order to evaluate the benefits of the studied maneuver. The main parameters are varied: the magnitude and direction of the impulse, the angle of approach and the periapsis distance of the close approach and finally the velocity of approach of the spacecraft. The goal is to find the best combination to maximize the inclination change in the orbit of the spacecraft with respect to the Sun. Those orbits can be used in missions going to orbits inclined with respect to the orbital plane of the planets involved.