Paper ID: 32038
interactive

ASTRODYNAMICS SYMPOSIUM (C1)
Interactive Presentations (IP)

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AERO-GRAVITY MANEUVERS CONSIDERING LIFT AROUND EERTH, MARS AND VENUS

Abstract

The goal of this research is to study the energy variations and the effects in the trajectories of a spacecraft performing a aero-gravity assisted maneuver. The study is made as a function of the ballistic coefficients, lift to drag ratio, velocity impulses and angle of approach of the maneuver. The aerodynamics forces generates modifications in the trajectory and energy of the spacecraft. The mathematical model begin with a spacecraft coming from an orbit around the Sun-Planet system under the dynamics given by the restricted three-body problem. The Sun and Planet are in circular orbits around their center of mass. The initial position and velocity conditions are given according to a Gravity-Assisted trajectory with constant pericenter altitude. The energy is measured before and after the passage. The equations of motion are numerically integrate sing a Runge-Kutta-F 7/8 numerical method. The Earth, Venus and Mars are used as planets for the approach and several different conditions are used for the variables describing the maneuver. The actual results indicates several aspects related to the problem. A single Gravity-Assisted maneuver around the Earth with 90 and 270 approach angles has maximum losses and energy gains, respectively. Using the atmospheric influence (Aerogravity-assisted maneuver), ballistic coefficient around 5.0x10-7 km2/kg, high lift to drag ratio and without impulsives, the energy losses are lower than the ones given by the pure gravity-assisted maneuvers in both trajectories. The aerogravity-assisted trajectories with impulsives and 0.0 lift to drag ratio, an approach angle of 90, has an energy increment for impulsive angles between -30 to 150, obtaining the maximum energy gain at 70. With values as high as 9.0 for the lift to drag ratio, the energy variation is higher. Considering angles of approach of 270 the energy variation is positive for impulsive angles from -150 to -70 and 0.0 lift to drag, but become negative when the lift to drag ratio is 9.0. Results of GA and AGA in Venus and Mars have similar behavior in terms of energy variation, compared to the maneuvers made using the Earth.