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POST-AEROCAPTURE ORBIT SELECTION AND MAINTENANCE FOR THE AEROFAST MISSION TO MARS

Abstract

Aerofast is the abbreviation of "aerocapture for future space transportation" and represents a project aimed at developing aerocapture techniques with regard to an interplanetary mission to Mars, in the context of the 7th Framework Program, with the financial support of the European Union. This paper describes the fundamental characteristics of the operational orbit after aerocapture for the mission of interest, as well as the related maintenance strategy. The main task of the Aerofast mission consists in observing Mars surface with a high resolution camera. The final orbit selection depends on the desired lighting conditions, maximum revisit time of specific target regions, and feasibility of the orbit maintenance strategy. A sunsynchronous, frozen, repeating ground track orbit is chosen. First, the period of repetition is such that adjacent ascending node crossings (over Mars surface) have a separation compatible with the swath of the optical payload. Secondly, the sunsynchronism condition ensures that a given latitude is periodically visited at the same local time, which condition is essential for comparing images of the same region at different epochs. Lastly, the fulfillment of the frozen condition guarantees improved orbit stability with respect to perturbations due to the zonal harmonics of Mars gravitational field. These three fundamental features of the operational orbit lead to determining its mean orbital elements. The evaluation of short period effects (e.g., those due to the sectorial harmonics of the gravitational field or to the aerodynamic drag) requires the determination of the osculating orbital elements at an initial reference time. This research describes an extremely simple and accurate approach that leads to numerically determining these initial values, without employing complicated analytical developments. Numerical simulations demonstrate the short-period and the long-period stability of the orbit when a relevant number of harmonics of the gravitational field are taken into account. However, aerodynamic drag produces a relatively slow orbital decay at the altitudes considered for the mission. This circumstance implies the progressive loss of the sunsynchronism condition, and therefore corrective maneuvers are to be performed. This work proves that actually only in-plane maneuvers are necessary, evaluates the overall delta-v budget needed in the period of repetition (85 Martian nodal days), and proposes a simple maintenance strategy, making reference to the worst-case scenario, which corresponds to the highest seasonal values of the atmospheric density and to the maximum value of the ballistic coefficient of the spacecraft