Paper ID: 85176
student

IAF SPACE EXPLORATION SYMPOSIUM (A3)
Mars Exploration – missions current and future (3A)

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QUANTITATIVE ASSESSMENT OF THE MASS-SAVING DERIVED FROM MARS AEROCAPTURE MANEUVERS

Abstract

Aerocapture is a maneuver enabling entry into an orbit around a planet by utilizing the aerodynamic drag created during a singular passage through the atmosphere. In contrast to aerobraking, where the insertion into an elliptical orbit is achieved through propulsion followed by multiple passes in the upper atmosphere to decrease the orbit radius, aerocapture entails a single atmospheric pass from an initial hyperbolic trajectory. The aerocapture maneuver represents one of the most interesting challenges in space missions as it allows a significant mass saving by avoiding the use of propellant. The purpose of this study was to provide a quantification of propellant savings by comparing two different aerocapture maneuvers with the MAVEN mission that occurred between 2013 and 2014 which involved a purely propulsive insertion into an orbit around Mars. In particular, two mission orbits were considered: the arrival orbit with a period of approximately 35 hours and the corrected one with a period of 4.5 hours.
The aerocapture maneuvers were designed using an inflatable shield for the thermal protection of the spacecraft during the atmospheric passage. These shields are also important to compensate the differences in atmospheric density compared to the values used by the atmospheric models in the design phase. Indeed, these variations can cause mission failure, causing the spacecraft to crash into the planet's surface in the case of higher densities, or, vice versa, an exit velocity from the atmosphere greater than the planet's escape velocity that does not allow capture in orbit.
To compensate these variations, the drag modulation technique is considered. In particular, the present work proposes a continuously variable drag modulation that exploits the ability of inflatable shields to change their cross-sectional area by adjusting the internal inflation pressure.
Data relating to the development of aerocapture maneuvers and results regarding propellant savings will be illustrated and discussed during the presentation.