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OPTIMISED DESIGN OF A MISSION TO MULTIPLE TROJAN ASTEROIDS FLY-BIES

Abstract

A mission design to explore the Trojan asteroids is presented. These asteroids are confined in 2 groups located around the stable L4 and L5 Lagrange points of the Jupiter-Sun system. This group of hundreds of known asteroids is very puzzling: their existence, their motion dynamics and physical evolutions represent major challenges. In-situ exploration of these bodies, beyond the interest of their characterisation, would be likely to raise clues on the understanding of formation and evolution of the solar system. A mission to the Jovian Trojan asteroids area to characterise these objects was initiated at CNES in 2008 and is still under investigation. Other international initiatives and studies on similar missions have also been performed these last years, in particular in the USA and in Japan.

In this paper, a large number of options are investigated. The spacecraft velocity issue in asteroid vicinity, from insertion around a body to high-velocity fly-by of a maximum number of asteroids is analysed. Trade-offs trajectories and spacecraft performances are presented. The choice of a launcher in a range from Soyuz to heavy-weight Ariane 5 or Atlas 5 has also a strong impact on mission duration and trajectory selection as well as transfer strategy, either direct or using inner planets or Jupiter gravity assists strategies. Different kind of propulsion technologies, as chemical, solar electrical or radio-isotopic electrical are taken into account in the study.

The paper presents the main trade-offs and conclusions of this mission evaluation. More specifically, the potential of each propulsion type is identified. The main characteristics of the most promising configurations are also described.

The selection of the visited asteroids and the maximum number of reachable bodies in this large Trojan cloud would depend a lot on the potential amount or propellants and associated DV that the spacecraft could use for trajectories corrections. The asteroids to be visited selection criteria are mainly their orbital position and closeness one from the other in inclination. As the motion dynamics in Lagrange points area is quite complex, the trajectories, manoeuvres, close fly-byes and navigation strategies can be quite different than in classical interplanetary missions. The trajectories optimisation techniques involved in this mission design are presented.