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Missions to Mars and his Trojan Asteroid Family – A Feasibility Study

Kai Wickhusen (1), Jürgen Oberst (1), Konrad Willner (1), Enrico Mai (1), and Apostolo Christou (2)
(1) German Aerospace Center (DLR), Berlin, Germany , (2) Armagh Observatory, Armagh, UK

With growing interest in the exploration of the Martian Satellites, we analyze rendezvous scenarios with Martian Trojans, which can possibly be achieved in combination with missions to Mars. The Mars Trojans are small, with diameters between hundreds of meters to a few kilometers. Eight of currently nine known Trojans are located near Lagrangian point L5 (trailing by approx. 60 degrees behind Mars), which we focus on in our study. All have a significant inclination of more than 10 degrees relative to the orbital plane of Mars, which implies high flyby velocities for spacecraft approaching from within this plane. We consider two different transfer options. One is a flyby during the transfer from Earth to Mars. We study Mars mission scenarios in the time frame 2028 – 2032 including transfers that involve more than one revolution about the sun. As the Mars trajectory is relatively fixed in space and time, the Trojan candidate has to be “at the right place at the right time” to minimize costly spacecraft course adjustment maneuvers. We report on several flyby opportunities, most of which, however, require substantial course corrections and fuel. As a second option, we study a transfer starting from Mars, moving along Mars’ solar orbital path. We assume a spacecraft in high equatorial Mars orbit (e.g. near Deimos). Here, the spacecraft may stay at Mars to await a favorable plane crossing for a selected Trojan and leave the Martian gravity field just in time for a rendezvous. We studied flyby opportunities with associated time tables. Such a transfer requires a velocity increment of approximately 1-1.2 km/s to leave the Martian gravity field. We find transfer times of approximately 700 days. As the origins of the Mars Trojans are unknown, such a mission may shed light on the sources of the population. The Gaia spacecraft in its current stellar survey mission may discover additional Trojan asteroids as possible targets. While stand-alone missions to Mars Trojan asteroids will be costly, a mission to Mars combined with Trojan flyby may be an attractive alternative scenario.