IAF ASTRODYNAMICS SYMPOSIUM (C1)
Mission Design, Operations & Optimization (1) (1)

Author: Dr. Diogene Alessandro Dei Tos
Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency (JAXA), Japan

Dr. Nicola Baresi
Surrey Space Centre, University of Surrey, United Kingdom
Dr. Yasuhiro Kawakatsu
Japan Aerospace Exploration Agency (JAXA), ISAS, Japan

ORBITAL INSERTION AROUND PHOBOS VIA BALLISTIC CAPTURE AND ITS APPLICATION TO THE MARTIAN MOONS EXPLORATION MISSION

Abstract

The scientific community acknowledges the importance of a science-driven, technology-enabled effort to characterize and understand Mars and its moons as a system, including its current environment, climate and geological history, and biological potential. ISAS/JAXA mission Martian Moons eXploration (MMX) will travel to Mars and survey the planet's two moons: Phobos and Deimos. MMX is in the preliminary study phase, and scheduled to launch in the late 2024. The spacecraft will explore Mars moons and collect a sample from Phobos to bring back to Earth. The design of sample-return mission is very challenging due to large costs associated to a safe return trajectory, robust and possibly autonomous proximity operations, descent and landing on the target celestial body, sample collection with ill-known surface conditions, and sample containment and curation during cruise. In particular, the operations related to insertion into orbit around Phobos are complex and risky, heavily constraining the system design.

In this work, an orthodox trade-off analysis is performed for the orbit insertion strategies and opportunities of MMX around Phobos. Quasi-satellite retrograde orbits around Phobos are first used as generators for ballistic captures, using the eccentricity of Phobos orbit around Mars as a trigger. Then, the transition to a high-fidelity model that includes the ephemeris of the major celestial bodies and the nonuniform gravity field of Phobos is exploited to engineer ballistic captures emanating from quasi-periodic tori. Many low-energy Phobos insertion opportunities are found and compared to the current MMX high-energy three-impulse strategy baseline. It is shown how ballistic captures may be effectively exploited for the design of robust approach and insertion strategies in the Mars-Phobos gravitational system with Δv savings, to be used in the MMX mission.