Quasi-Satellite Orbits around Deimos and Phobos motivated by the DePhine Mission Proposal

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In the framework of ESA's Cosmic Vision program, DePhine – Deimos and Phobos Interior Explorer – has been proposed as an M-class mission by the Institute of Planetary Research of DLR and a study team with representatives of the scientific community and the space industry, [1].
The mission is proposed to be launched in 2030 atop of an Ariane 6.2 rocket into a direct Mars transfer orbit. After arrival at Mars it would enter a quasi-satellite orbit of Deimos to carry out a comprehensive global mapping with various remote-sensing instruments. Depending on the available resources, in the second mission phase, the spacecraft would either carry out multiple close flybys of Phobos, or, alternatively, the mission could be extended to include a quasi-satellite orbit around Phobos to perform similar remote sensing experiments as those for Deimos.

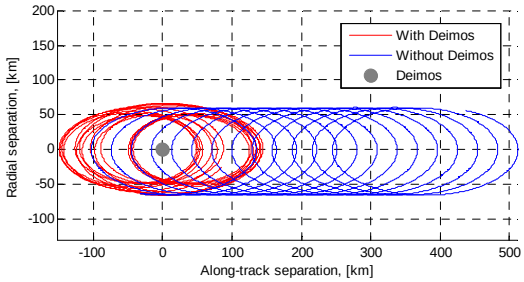

Fig. 1: Sample QSO around Deimos. Red: bounded motion in the presence of Deimos gravity. Blue: unbounded motion in the absence of Deimos gravity. Grey: Deimos, mean radius 6.2 km.

Alongside with some flight dynamics aspects of the proposed mission, the present paper focuses on a study of possible quasi-satellite orbits around Deimos and Phobos.
With the mass of Deimos and Phobos being too small to capture a satellite, it is not possible to orbit the Martian moons in the usual sense. However, orbits of a special kind, referred to as *quasi-satellite orbits* (QSOs), exist and can be sufficiently stable to allow many months of operations in the vicinity of the moon. In the inertial reference frame, the spacecraft is still orbiting Mars; however, the perturbation exerted by the gravity of the moon prevents the spacecraft from drifting away from it. In the synodic reference frame, an "equatorial" QSO (as seen from the moon) can be described as a multitude of ellipses (also called *epicycles*) with their centres moving back and forth in the along-track direction, Fig. 1.
A number of scientific studies on the subject of QSOs have already been carried out in literature, in particular with a focus on Phobos, [2-3]. In present research, a numerical analysis is performed to characterize QSOs around both Deimos and Phobos in terms of the size and stability of the QSOs. While the objective of DePhine is to cover as much of the surface of the moon as possible, highly-inclined QSOs (as seen from the moon) are of great interest for this study, and are investigated in the present paper in terms of the covered ground-track. The results of this study can be of interest for future missions to the Martian moons.

References

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