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Illumination and radio-contact conditions for surveying Phobos and Deimos from satellites in quasi-orbits

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Abstract

We study spacecraft in Phobos' and Deimos' quasi-orbits. We compute illumination conditions and radio-contact of spacecraft with Earth stations.

1. Introduction

The Solar system hosts large numbers of small planetary satellites of great interest to scientists. However exploration of such bodies requires complex mission scenarios because the satellites typically move close to the primary and their own gravity fields are too faint to support Kepler-type orbits for the spacecraft. To address this problem we consider quasi-orbits, in which the spacecraft moves in an orbit very similar to that of the satellite, but at slightly different eccentricity and inclination. From the satellite, the spacecraft appears like being in orbital motion. This type of mission scenario is studied for a spacecraft moving near the Martian satellites [1].

We study the dynamics and life times of Phobos' and Deimos' quasi-orbits, and we investigate illuminating and observing conditions for mapping and line-of-sight conditions with Earth ground-stations for communication.

2. Method

For our investigation we calculated spacecraft orbits using explicit Adams-Bashfort method [2]. We consider the Mars gravitation field up to 30x30 degree, third body attraction (7 planets, Sun and Moon), and the gravitation effects of Phobos or Deimos. Parameters of Phobos and Deimos orbits have been obtained by means of SPICE kernels [3] and the HORIZONS system [4].

Initial conditions for quasi-orbits were specified with different combinations of spacecraft eccentricity and inclination. Here, we show calculations, which have been carried out for different eccentricity of quasi-orbits: $e=0.0358$, $e = 0.0500$, $e = 0.0600$ for the Phobos-case and $e=0.0058$, $e = 0.0159$, $e = 0.0259$ for the Deimos-case.

From results of the integration we determine ground-tracks of the spacecraft and calculate illumination conditions on the surfaces of Phobos and Deimos (examples in Fig. 1-2). While for single orbits illumination is limited to one hemisphere only, during the course of a longer mission all parts of the surface will be illuminated and can be mapped from the spacecraft.

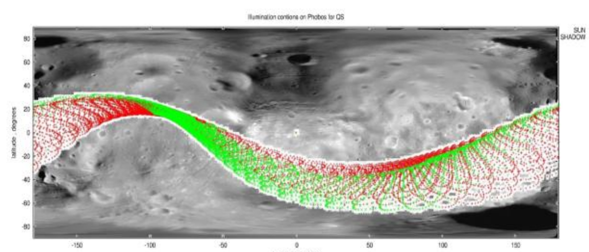

Figure 1: Illumination of sub-spacecraft point on the surface of Phobos (green: daylight, red: nighttime)

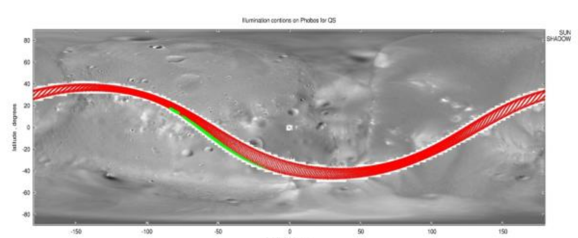

Figure 2: Illumination of sub-spacecraft point on the Deimos (green: daylight, red: nighttime)

From results of the integration we also calculate line-of-sight conditions and times of radio contact with Earth ground stations (examples in Fig. 3-4). Phobos/Deimos and Mars may disrupt communication along line-of-sight.

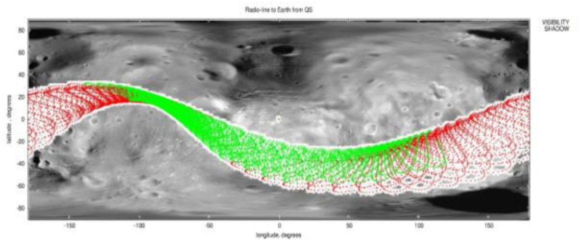

Figure 3: Radio-contact with Earth ground-station from Phobos's quasi-orbit (green: Earth ground-station contact, red: no contact)

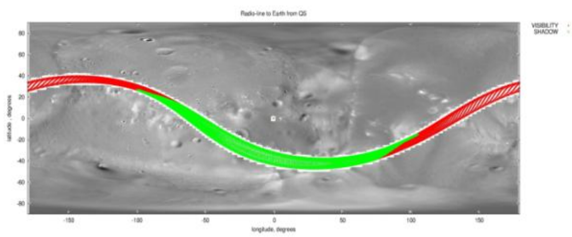

Figure 4: Radio-contact with Earth ground-station from Deimos' quasi-orbit (green: ground-station contact, red: no contact)

3. Summary and Conclusions

In this paper we study spacecraft motion in quasi-orbits of the Martian natural satellites, for spacecraft having different orbit eccentricity and inclination. At the conference, we will present observing conditions and radio-contact conditions with Earth ground-station. Our preliminary results show that conditions for surface illumination and ground contact may be complex and require careful mission planning.

Acknowledgements

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