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TRAJECTORIES DESIGN OF A SAMPLE RETURN MISSION TO PHOBOS

Abstract

Phobos Sample Return (PhSR) is an ESA-Roscomos mission that aims to characterize Phobos and to collect a sample of its soil to bring it back to Earth: the main science goal of the mission is to understand the formation of the Martian moons Phobos and Deimos and put constraints on the evolution of the solar system. To do this, samples from Phobos (the moon with the older expected surface) have to be returned to Earth and thus potential landing sites have to be study in depth beforehand to establish sampling usefulness. The PhSR payload is then composed by a lander with sampling capability, an Earth Re-entry Capsule to bring the sample back to Earth and several remote sensing and in-situ instruments to characterize the Martian moons environment. The missions' phases' definition is then driven by the need of performing a proper landing site characterization before reaching the Phobos surface and by the goal of safely returning the Phobos surface sample to Earth as soon as possible. Two different scenarios are envisaged, one based on a collaborative mission between ESA and Roscosmos and another one only involving ESA. Within the collaborative scenario the launch vehicle will be Proton-M and a full characterization of both Deimos and Phobos shall be guaranteed from quasi-satellite orbits (QSO) close to the two moons; potential landing sites on Phobos shall also be locally characterized by means of dedicated fly-bys. Once the sample is collected it will have to be returned to Kazakhstan or, as a backup option, to Woomera. Within the European standalone scenario the launch vehicle will be Ariane 5 ECA and a full characterization of Deimos should (not shall) be guaranteed before approaching Phobos; once the sample is collected it will have to be returned to Woomera. This paper illustrates the trajectories and mission design for both scenarios of PhSR: firstly an overview of the different mission phases (outbound trajectory, Martian phase around Deimos and Phobos, inbound trajectory and Earth re-entry) is presented together with the overall mission timeline; then each mission phase is described in detail with the proposed solutions and their impact at system and scientific level. A relevant aspect of the PhSR trajectories is represented by the use of QSO in the proximity of Deimos and Phobos: these are particular solutions to the three-body problem that can be exploited to perform the Martian moons global coverage at low altitudes (30–50 km).