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Mars Exploration – missions current and future (3A)

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MARS SAMPLE RETURN: ERO MISSION ANALYSIS AND PLANETARY PROTECTION FOR PHASE A/B1

Abstract

Mars Sample Return is a joint collaborative project of ESA and NASA aimed at bringing to Earth several surface samples from the Red Planet. The mission is considered a major milestone to enable Mars human exploration, because it will allow scientists to better understand the characteristics of Mars and, based on this information, to design the infrastructure that will receive the first astronauts travelling to the Red Planet. ESA is currently assessing the Earth Return Orbiter (ERO), responsible for locating and capturing a container of Mars samples, collected and launched into Low Mars Orbit by previous missions, and ensuring their safe return to Earth.

DEIMOS, as part of TAS-I consortium, has been in charge of phase A/B1 mission analysis and planetary protection activities. Even if the Red Planet is a recurrent target of space missions since the 70s and the Earth-Mars transfer trajectories have been extensively studied during the last decades, the mission analysis plays a critical role in ERO mission design, mainly due to three factors: 1. ERO is a complex roundtrip mission to Mars not feasible with pure chemical propulsion due to the high propellant consumption of such engines and the limited launcher capabilities 2. Despite that, tight timelines are targeted, especially in the outbound transfer, to provide a full and reliable coverage of the Sample Retrieval Lander entry descent and landing in June 2028 and of the Mars Ascent System launch in September 2029; then the use of pure electric propulsion is discarded due to the corresponding long transfer times 3. Last but not least, ERO is the first mission ever planned that is classified "Category V restricted" by planetary protection Therefore, the proposed solution for ERO cannot be a traditional one, and it relies on a hybrid propulsion system to exploit the advantages of both electrical (high specific impulse) and chemical (high thrust) engines. As a consequence, the mission analysis had to optimize a complex combination of low-thrust and impulsive transfer trajectories, with the goal of minimizing the propellant consumption while fulfilling the full set of space segment requirements. Among them, the planetary protection ones on backward contamination have a special importance and will be treated with proper dedication by the mission analysis team.

In this paper the detailed results of both mission analysis and planetary protection activities for Mars Sample Return Phase A/B1 are presented, detailing, on mission analysis side, the launch window selection, the strategy to design the hybrid outbound trajectory, the approach for the optimization of the low-thrust spiral around Mars, and the highly constrained design of the Mars-Earth inbound leg. While, for planetary protection, the full details to avoid both forward and backward contamination are described, including the long-term orbit stability analysis around Mars and the Earth avoidance and spacecraft disposal strategy of the contaminated ERO in its course towards Earth.