SPACE EXPLORATION SYMPOSIUM (A3)
Mars Exploration - Part 2 (3B)

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MARS SAMPLE RETURN MISSION ARCHITECTURES UTILIZING LOW THRUST PROPULSION

Abstract

The Mars sample return mission is a flagship mission within ESA's Aurora programme and envisioned to take place in the timeframe of 2020-2025. Previous studies developed a mission architecture consisting of two elements, an orbiter and a lander, each utilizing chemical propulsion and a heavy launcher like Ariane 5 ECA. The lander transports an ascent vehicle to the surface of Mars. The orbiter performs a separate impulsive transfer to Mars, conducts a rendezvous in Mars orbit with the sample container, delivered by the ascent vehicle, and returns the samples back to Earth in a small Earth entry capsule. Since the launch of the heavy orbiter by Ariane 5 ECA makes an Earth swing by mandatory for the trans Mars injection, the mission time amounts to about 1460 days.

The present study conducts a mission and system analysis of the space transportation elements, considering various mission architecture options and new technologies like aerocapture, electric propulsion and in situ resources utilization to minimize the launch mass. Therefore, detailed spacecraft models for orbiters, landers and ascent vehicles are developed. Based on that, trajectory calculations and optimizations of interplanetary transfers, Mars entries, descents and landings as well as Mars ascents are carried out. The results of the system analysis identified electrical propulsion as most beneficial in terms of launch mass, leading to a reduction in launch vehicle requirements. Hence, two mission architectures are put forward.

In a hybrid electrical-chemical scenario the chemical orbiter of previous studies is replaced by one utilizing 4 electrical RIT 22 engines with a specific impulse of 4763 s and solar arrays with a characteristic power output of 42 kW at Earth. It can be launched by a Soyuz-Fregat into GTO, performs low thrust Earth escape and interplanetary transfer to Mars. At Mars, the orbiter can stay about 325 days in a circular 1000 km orbit, from which it can provide communication relay for the lander especially during entry, descent and landing. After sample container recovery, the orbiter returns and reaches Earth 1150 days after launch. The second mission architecture requires only one heavy launcher (Proton/Ariane 5). It makes maximal use of the electrical engines of the orbiter by transporting the lander piggyback to Mars. Since the combined lander-orbiter spacecraft can be injected directly into an Earth escape trajectory ($v_{inf} = 0$ km/s) by the launch vehicle, the mission can be accomplished within 1010 days.