IAF ASTRODYNAMICS SYMPOSIUM (C1)
Mission Design, Operations & Optimization (2) (5)

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MULTI-DISCIPLINARY OPTIMIZATION OF THE LOW-THRUST ORBIT RAISING FOR THE HYDROTERRA EARTH EXPLORER MISSION

Abstract

The European Space Agency Earth Explorers are research missions that address important science issues identified by the scientific community while demonstrating advanced technology for Earth observation. Hydroterra was one of three candidate missions selected for Phase 0/A System Study (contract 4000127467/19/NL/AI) in response to the call for Earth Explorer-10 mission ideas. Hydroterra aims at observing and improving the understanding of fundamental processes of daily water cycle, enhancing prediction capability of extreme rainfall and related flooding. To achieve this goal, the mission concept envisages placing a single synthetic aperture radar satellite in geosynchronous orbit.

The baseline system concept is based on the OHB all-electric platform tailored to be launched with VEGA-C into low Earth orbit. One of the key design drivers is the Electric Orbit Raising (EOR) phase, which impacts the transfer to the operational orbit and the platform architecture. During the EOR, the electric propulsion (EP) low-thrust levels and the low injection altitude require the engine to fire for months. The long transfer demands a challenging attitude control, while the long time spent crossing the Van-Allen belts damages the solar cells and reduces the power generation. Therefore, improving overall mission design requires a multi-disciplinary optimization process where the EOR and the satellite sub-systems are concurrently designed.

The system-level optimization identifies the operational constraints deriving from the system design that drive the optimized EOR. The following aspects are investigated: the radiation dose that accumulates during the transfer and degrades the solar cells, the power needs to support the spacecraft, including EP firing and heater power demand, the batteries re-charging before the start of the next eclipse, and the agility requirements ensuring that the ideal thrust profile can be followed without saturating the reaction wheels and that perturbations can be compensated.

The EOR optimization computes the optimal manoeuvre strategy that fulfils the system-level and mission constraints. For such purpose, the Low-Thrust Orbit Transfer Optimizer and Autonomy Simulator

(SPIRO), developed in-house by DEIMOS Space, is applied. SPIRO includes realistic thruster models with varying Electric Power Propulsion Subsystem operational points (OP), handles propulsion system constraints, and imposes attitude rates and target on-station mass constraints. The control law, the launcher injection orbit, and the sequence of OP are optimized to minimize the time spent in the Van-Allen belts, while maintaining acceptable values for Delta-V and transfer time.

This paper presents the analysis performed and the results derived from the multi-disciplinary optimization of the Hydroterra EOR.