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Mission Design, Operations and Optimization - Part 2 (2)

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RADIATION MITIGATION STRATEGIES FOR THE LISA PATHFINDER LAUNCH AND EARLY ORBIT PHASE

Abstract

The LISA Pathfinder spacecraft will be launched into an elliptic low Earth orbit and will use its own propulsion module to reach its final operational orbit, which is a large-amplitude free insertion libration orbit around SEL1. The limited thrust of the propulsion module prohibits an insertion onto the stable manifold of the libration point orbit in one burn, and the manoeuvre is split into smaller apogee raising manoeuvres, a so-called Launch and Early Orbit Phase (LEOP). The radiation encountered by the spacecraft during this phase becomes a major issue on this mission. In this paper radiation optimized manoeuvre plans are proposed and trajectories are presented that are carefully designed in such a way that the radiation the spacecraft is exposed is minimized and characteristic regions with high radiation intensities in the magnetosphere are avoided. Also, the feasibility of science operations in a stranded highly elliptical orbit is investigated. Radiation optimized manoeuvre plans are provided for a nominal baseline mission sequence, for a nominal sequence with a minimized transfer time, and for worst-case scenarios, with an at least 48 hours delay in the orbit with the highest radiation impact per hour on the spacecraft. The size of the manoeuvres is chosen to minimize the radiation impact that is represented by the total ionizing dose and is evaluated behind a spherical aluminium shield with a radius of 1.5 mm. A seven burn strategy that is specially designed for a worst-case contingency case is finally suggested for LISA Pathfinder. This sequence satisfies the radiation limit requirement for a nominal scenario as well as for worst-case scenarios with a delay in any orbit and is a trade-off between the encountered radiation dose and the needed Δ v for radiation mitigation. The opportunity of science operations in a highly elliptical orbit if the last manoeuvre fails or is only applied partially is very small. A study over a wide launch window pointed out fields of stable orbit, but other requirements e.g. eclipses, communication geometry, and continuous time of science operations eliminate many solutions from the launch window.