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Author: Dr. Volker Maiwald
Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR), Germany, volker.maiwald@dlr.de

Mr. Marcel Kessler
University of Bremen, Germany, Marcel.Kessler@uni-bremen.de

OPTIMIZATION OF RADIATION EXPOSURE FOR LOW-THRUST MISSIONS WITH A SHAPE-BASED METHOD

Abstract

Low-thrust missions offer the advantage of low propellant consumption due to the efficient thrusters involved. Recently these have not only been used as means for correcting perturbations but also as main thruster for interplanetary and Earth centered missions alike. Next to the more usual electrical thrusters solar sails are also part of the low-thrust regime and the Japanese IKAROS mission has successfully proven the concept of sailing the solar wind. All of these missions have in common that they are spiralling towards their target and assuming Earth centered missions this also means a significant amount of time spent within the Van-Allen-Radiation belts. To enable feasibility analyses of these kinds of missions the System Analysis Space Segment department has investigated if it is possible to optimize low-thrust trajectories with respect to radiation exposure using shape-based trajectory models and what the trajectory properties are. This paper explains the shape-based tool used to optimize low-thrust trajectories and how it has been adapted to incorporate a radiation model, first by using look-up tables and second by using an average function for radiation exposure. The suitability of the approach is discussed as is the respective outcome and its implications on spacecraft and mission design. For a low-thrust transfer form a LEO to MEO or GEO, the optimization using look-up tables results in a lower accumulated amount of radiation than using the functions. With regard to the trajectory shape small differences can be found. Compared to the optimization according to the v requirements a reduction in the amount of radiation can be achieved by an overflight over the target orbit and a subsequent return. The interaction of a limited thrust acceleration with the radiation exposure poses the main challenge for the optimization algorithm to get suitable results.