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ASTRODYNAMICS SYMPOSIUM (C1)
Attitude Dynamics (1) (3)

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BEPICOLOMBO: DYNAMICS ANALYSIS FOLLOWING MODULE SEPARATION

Abstract

BepiColombo is the joint Mercury exploration mission of the European Space Agency (ESA) and the Japan Aerospace Exploration Agency (JAXA). The mission objective is to place two scientific modules, ESA's Mercury Planetary Orbiter (MPO) and JAXA's Mercury Magnetospheric Orbiter (MMO) in orbit around Mercury. A composite spacecraft is developed, consisting of the MPO, MMO, the solar shield to protect MMO (MOSIF), as well as the Mercury Transfer Module (MTM) which provides low-thrust transfer to Mercury. Upon arrival at Mercury the MTM is separated and the remaining spacecraft is inserted into a Mercury orbit.

One of the critical events of the mission is the MMO separation. At the target MMO orbit, the Japanese module will be detached from the remaining spacecraft. Because the MMO is spin-stabilised spacecraft, JAXA developed a Spin Ejection Device (SED) to generate both linear and angular momentum during separation. Due to uncertainties of the entire system caused by misalignments of the centres of mass of the modules, imperfections in the separation device and fuel sloshing, a risk of collision between the MMO and the sun shield exists. Furthermore, there are restrictions on the attitude of the MPO with respect to illumination of the radiators, star trackers and solar panels.

This paper addresses the separation dynamics analysis for assessing the collision risk and the optimal strategy for the separation. Dynamical models of MMO and MPO as well as kinematic expansion of the SED are developed. The MPO and MMO bodies are modelled as rigid structures and fuel sloshing and the flexibility of the solar array of the MPO are taken into account. The model uses Lagrangian mechanics with the MPO at the centre and the rest constructed around it.

The initial conditions are set at the start of the separation sequence. The following, uncontrolled motion is simulated with a sensitivity and Monte Carlo analysis to assess the worst case conditions and the optimal initial conditions for the separation strategy. In the analysis, all input parameters are varied over the current design margins. According to the analysis, the minimum distance between MMO and MOSIF remains sufficiently large to avoid the collision. Furthermore the initial spacecraft attitude and appendage orientations are then optimised to increase the time before the Sun illuminates the danger zones of the spacecraft. The separation dynamics analysis has been verified using hardware tests.