ASTRODYNAMICS SYMPOSIUM (C1)
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MISSION ANALYSIS FOR A SPACE WEATHER MONITORING SYSTEM NEAR THE SUN-EARTH L1 AND L5 LIBRATION POINTS

Abstract

Solar phenomena, such as coronal mass ejections (CME) and solar flares, can cause magnetic and radiation storms that disrupt services such as radio communication and satellite operation, among others. It is therefore essential to monitor and predict space weather activity to provide a timely warning service on the occurrence of those events. Currently this service uses data from science missions including SOHO and ACE at the Sun-Earth L1 libration point, both of which are well beyond their design lifetimes. The European Space Agency, under the Space Situation Awareness program, is looking at an operational Enhanced Space Weather Monitoring Systemto maintain the capability at L1, and potentially enhance it with a second spacecraft away from the Sun-Earth line (ASEL) to provide a different view of the solar disc and more accurate estimates of CME propagation speed and direction.

Observational requirements put some constraints on the locations of the spacecraft: measurements of the interplanetary magnetic field and solar wind before they encounter the Earth's magnetospheremust be made within 60 Earth radii from the Sun-Earth line, which restricts the orbit selection for the L1 spacecraft, while the ASEL spacecraft must be located at least 30 degrees away from the Sun-Earth line. The mission design is first investigated assuming separate launches for the two spacecraft. A small amplitude Lissajous orbit that meets the requirements is selected as the nominal orbit for the L1 spacecraft. Low energy transfer trajectories from low Earth orbit to the L1 orbit are generated in a high fidelity model via an optimization process using manifold theory. Various orbits are examined for the ASEL spacecraft including heliocentric drifting orbits, horseshoe orbits and L5 orbits. Trade-offs are made considering transfer durations, orbit insertion costs, departure conditions and drift rates with respect to the Sun and the Earth. The drift rate illustrates how fast the spacecraft leaves the vicinity of its nominal region. Finally a dual launch option is considered, where both spacecraft are sent to the L1 region. Transfer strategies using L1 unstable manifold trajectories are investigated for the second spacecraft to reach its nominal orbit (L5 or horseshoe orbits). Although this option increases the transfer duration for the ASEL spacecraft, it allows the use of one single mid-size launcher and reduces the overall cost of the mission considerably.