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TRAJECTORY OPTIMISATION FOR THE ESA SWM MISSION TO SUN-EARTH L5

Abstract

Space wether events affect directly both manned and unmanned spaceflight missions. In order to determine the influence of such events, observations of the solar phenomena away from Earth and/or near Earth are mandatory. The Sun-Earth equilateral Lagrange point L5 (SEL5) is a perfect candidate for an observation post of the solar space weather mission due to the constant dynamical and envionmental conditions a spacecraft would face in that position. For these reasons, SEL5 is selected for the ESA Space Weather Mission to belaunched in 2023. This paper presents the mission analysis of ESA SWM, exploring interplanetary transfer to SEL5 as a phasing trajectory of 60 degrees in the Earth orbit around the Sun. Different set of trajectories can be investigated depending on the desired duration of the transfer: longer transfers required less propellant since longer time for the phasing is allowed. In order to optimise the amount of v required for the mission, several operational orbits have been considered. Transfer orbits to SEL5 present some inclination with respect to the ecliptic. Therefore, having SEL5 as the final target during the transfer requires for the injection manoeuvre to perform the inclination plane change to keep the spacecraft in the ecliptic plane. It is possible to reduce this injection manoeuvre if some inclination with respect to the ecliptic is allowed for the operational orbit. This implies the spacecraft would be virtually orbiting the SEL5 in its way around the Sun. The number of possible solutions for this set of operational orbits is extremelly high since small variation of any orbital parameter would lead to orbits that are not exactly at SEL5 but close enough to allow constant observations during a 10 years mission. Besides, the amont of v is directly related to the final operational orbit considered, requiring to fully optimise both the operational orbit and the transfer trajectory together in order to find an optimal solution. In this context, a two step optimisation algorithm has been developed: during the first step, a stable operational orbit is considered. Then, for each selected operational orbit, the transfer trajectory is optimised in order to assess the total v required for the mission. With this information, a global optimisation process based on a multi-objective genetic algorithm is used to find the optima for the mission.