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FORMATION FLYING L-BAND APERTURE SYNTHESIS: DESIGN CHALLENGES AND INNOVATIVE FORMATION ARCHITECTURE CONCEPT

Abstract

It is well known that global maps of soil moisture and sea surface salinity are required to improve meteorological and climate prediction, as demonstrated by the Soil Moisture and Ocean Salinity (SMOS) satellite flying since 2009. In the context of future L-band missions for land and oceans applications, the spatial resolution should increase from 40 km, as for SMOS, to 1-10 km. Such improvement in the resolution of a radiometer is typically obtained increasing the aperture size: formation flying is envisioned as a potential way to achieve that spatial resolution. This paper presents the results of the formation flying design and trade-off analysis. It shows the selection of the baseline geometry for the Formation Flying L-band Aperture Synthesis (FFLAS) mission concept, proposed by the European Space Agency. FFLAS foresees the use of three SMOS-like satellites, flying in a tight - rigid - formation in the low Earth orbit region. Starting from the scientific mission requirement of the L-band interferometer, an analysis, for possible three satellite planar formation flying architectures, has been carried out in the local orbital frame. For the sake of generality, a yaw angle is introduced to parametrise the possible orientation of the virtual instrument into the local orbital frame. The selection of the proper yaw angle, with respect to the tangential direction, is performed for fuel consumption balancing and optimisation. It also affects the sun-angle in the satellites' body-fixed frame, which is essential for solar panels dimensioning. Furthermore, the selection of the yaw angle is essential to evaluate the along-track and cross-track displacements, influencing the control effort and the inter-satellite collision risk. An established methodology to ensure collision avoidance for neighbouring satellites exploits the eccentricity and inclination separation between the spacecraft. The design investigates the possibility to implement such safety policies with the baseline formation flying geometry. The paper critically presents the outcome of these trade-off analyses. Results are obtained leveraging the Hill-Clohessy-Wiltshire formulation with the relative orbital elements environment, to include the effects of orbital perturbations and to assess the formation safety more straightforwardly.