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ORBIT DESIGN OF A PASSIVE DISTRIBUTED RADAR BASED ON FORMATION FLYING

Abstract

This paper explores the feasibility of a passive distributed radar, realized through a formation of compact satellite receivers flying in Low Earth Orbit (LEO). The cluster is conceived as a rapid-re-configurable system, able to capture the backscattered echoes of existing space-borne SAR satellites moving on higher orbit. Despite the superior performances in applications of SAR interferometry offered by such a distributed radar, the main changeling task is to maintain the transmitter and the receivers in a proper configuration to allow multi-static acquisitions.

The paper firstly analyzes the relative dynamics of the space systems involved, with the receivers imagined as a single deputy-satellite at a completely different altitude from the chief-transmitter (for the receivers altitudes of 300-350 km are considered, while the transmitters generally orbit around 500-800 km). This assumption increases the number of potential "illuminators of opportunity", but makes multi-static acquisitions achievable only at given times, when the along-track separation between the active and passive satellite is below a threshold. Furthermore, the difference in altitude implies different perturbing effects on the satellite trajectories, with the cluster being affected by the aerodynamic drag to a greater extent. Two different solutions are investigated, with the receiver "co-rotating" or "counter-rotating" with the transmitter(s). Then the orbit design is performed by means of simplified mathematical models. They describe the perturbed relative motion during the acquisition time using orbital elements, thus enabling the selection of the deputy orbit from application requirements. Several strategies are discussed both to control and contain the natural drift between the orbit planes produced by the altitude difference. Finally the problem of the formation design is addressed, with emphasis on relative trajectories that both satisfy multi-static observation requirements and minimize control efforts. Again the decisional approach makes use of all the degrees of freedom offered by natural dynamics and the proposed solutions lead to passively safe patterns, highly stable in presence of typical LEO perturbing effects.