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INVESTIGATION OF MULTIPLE-SATELLITE FORMATION CONFIGURATIONS FOR SINGLE-PASS SYNTHETIC APERTURE RADAR INTERFEROMETRY

Abstract

In the context of future synthetic aperture radar (SAR) missions, the need for more accurate digital elevation models (DEMs) calls for novel satellite formation concepts. Since 2010, the TanDEM-X mission has provided accurate DEMs using two spacecraft flying a helix formation. This configuration consists of one daughter spacecraft orbiting the mother satellite, creating a slowly varying across-track baseline for interferometry. The TanDEM-X mission provided a DEM with an unprecedented 12 m horizontal resolution and 2 m height accuracy. Building upon these findings, this work investigates various formation configurations, including those with fixed baselines when small separations (< 100 m) are involved, which are of interest for interferometry at high frequencies, e.g., Ka-band. Additionally, configurations with more than two spacecraft are explored to evaluate the potential of achieving multiple baselines in a single pass. Starting from a preliminary analysis of the control effort to maintain a fixed baseline under a continuous control scheme, this work examines novel formation geometries in combination with interferometry and power requirements to propose design strategies for future SAR missions. It combines the requirements on the delta-velocity budget with the platform power demand, to assess the power needed by the electric thrusters to maintain two different formation configurations: the classical helix and the fixed-baselines relative trajectories. This analysis is performed parametrically upon the spacecraft separation and the orbit altitude, including the main external perturbations, such as the Earth's oblateness and the atmospheric drag. Furthermore, it conducts a parametric analysis of the antenna power requirement, as a function of the orbit height and the instrument duty cycle. This information, combined with the delta-velocity budget and power demand, is essential for identifying optimal combinations of orbit altitude, spacecraft separation, and antenna parameters for different operational scenarios. The results of this work offer a tool for identifying the most suitable orbital and interferometric parameters based on the specific application needs.