IAF EARTH OBSERVATION SYMPOSIUM (B1)
Interactive Presentations - IAF EARTH OBSERVATION SYMPOSIUM (IP)

Author: Mr. Ahmed Kiyoshi Sugihara El Maghraby
University of Southampton, United Kingdom, asem1g14@soton.ac.uk

Dr. Angelo Grubisic
University of Southampton, United Kingdom, A.Grubisic@soton.ac.uk
Dr. Camilla Colombo
Politecnico di Milano, Italy, camilla.colombo@polimi.it
Dr. Adrian Tatnall
University of Southampton, United Kingdom, art4@soton.ac.uk

COUPLED ORBITAL AND RADIOMETRIC PERFORMANCE SIMULATION OF THE FORMATION FLIGHT INTERFEROMETRIC RADIOMETER FOR GEOSTATIONARY ATMOSPHERIC SOUNDING

Abstract

The availability of frequent measurements of global 3D atmospheric temperature and humidity fields is critical for Global Numerical Weather Prediction and Now-Casting. This can be made via passive microwave atmospheric sounding at the resonance frequencies of water and oxygen, and in the vision to provide these measurements in real-time, the capability to sound the atmosphere from the geostationary orbit has long been desired. The major challenge is the large aperture required – the diffraction limit dictates that an aperture in excess of 10 m is required to achieve useful spatial resolution.

While several mission concepts for this purpose are now being developed using aperture synthesis techniques: GeoSTAR (NASA), GAS (ESA) and GIMS (China), we have recently proposed a novel technique using formation-flying satellites to further extend the achievable spatial resolution by synthesising extremely large apertures that are beyond that achievable using single satellites.

The concept requires that the relative positions of these satellites are known to very high accuracy down to 1% of a wavelength, and are maintained to within a few wavelengths from their nominal positions. At the oxygen's 53 GHz resonance frequency, these correspond respectively to the knowledge of the position at a few tens of microns' accuracy, and its control to within a few centimetres.

Past studies have identified the effect of the errors present in the position measurements on the performance of the instrument, and the feedback control technique required to maintain the formation flight geometry at this accuracy. Based on these findings, we present the end-to-end simulation results of the proposed formation flight interferometer. First, we numerically propagate the satellite trajectories under the relevant perturbation forces at the geostationary orbit. The satellite formation is maintained with feedback control taking into account sensor and thruster imperfections, using the models of existing systems. The propagation results are then used to quantify the radiometric performance of the concept.

We find that the current state of the art of inter-satellite relative position sensing and precision thruster systems satisfy the requirements, achieving 61.3 μm accuracy in inter-satellite position sensing. This contributes to a loss in radiometric accuracy of 0.03 K in the recovered brightness temperature. With this result, a formation of a single full-sized satellite with nine nano-satellites synthesises an effective aperture of 14.4 m, achieving 16.7 km spatial resolution from the geostationary orbit, with the expected constellation total mass of less than 1,000 kg.