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A NOVEL FEMTOSATELLITE SENSOR ARRAY FOR DECONVOLVING TIME AND SPACE MEASUREMENTS OF TRANSIENT PHENOMENON IN EARTH ORBIT

Abstract

Distributed sensing arrays made from free-flying femtosatellite sensors in orbit are a promising new capability for space science. Despite only being capable of lower quality measurements due to hardware and size limitations, femtosatellites have been shown to be excellent candidates for such applications thanks to the possibility of massive parallel sampling that compensates for sensor performance [1]. Taking many simultaneous measurements over large volumes of space is a capability that is ideally suited for deconvolving space and time in measurements of transient phenomena. Examples of scientific interest include global sampling of rapidly evolving phenomena, such as space weather events that result in short-term morphological changes to the Earth's magnetosphere [2].

In this paper, a strategy to measure changes in a generic scalar or vector field using massively parallel sensors implemented in a femtosatellite swarm is investigated. A data processing method is then presented to show how the swarm's dataset can then be used to reconstruct the field independently in time and space. As an example, a mission concept to take global measurements of the magnetic field in low Earth orbit is described. Mission requirements are derived from scientific objectives and hardware constraints. The femtosatellite swarm properties required for such a task are defined and sized to meet the reliability objectives, and sensing accuracy desired. At the individual satellite level, a concept of operations is presented that demonstrates how a non-magnetic redundant attitude determination sensor can be used to subtract attitude measurements from the on-board magnetometer, resulting in measurements of magnetic field variation. Finally, mission analysis is carried out to determine the predicted lifetime, and deployment timescales for the mission, which are then compared to space weather warning times and event duration.

[1] T. Timmons, J. Beeley, G. Bailet, and C. McInnes, "Massively Parallel In-Situ Sensing using Femto-spacecraft Clouds," in *72nd International Astronautical Congress*, Dubai, 2021.

[2] T.Pulkkinen, "Space Weather: Terrestrial Perspective," *Living Reviews in Solar Physics*, vol.4, no.1, 2007.