29th IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (B4)
Interactive Presentations - 29th IAA SYMPOSIUM ON SMALL SATELLITE MISSIONS (IP)

Author: Mr. Thomas Timmons
University of Glasgow, United Kingdom

Dr. James Beeley
University of Glasgow, United Kingdom
Dr. Gilles BAILET
University of Glasgow, United Kingdom
Prof. Colin R. McInnes
University of Glasgow, United Kingdom

EXPERIMENTAL TESTING OF RANGE-BASED RELATIVE POSITIONING STRATEGIES FOR A SWARM OF CENTIMETRE-SCALE FEMTOSPACECRAFT

Abstract

Ongoing miniaturisation through consumer technology now makes it possible to fabricate active femtospacecraft with inertial measurement units, attitude determination and control, radio communications and a suite of sensors packaged on a centimetre-scale printed circuit board. The extension of femtospacecraft technology to a networked swarm dispersed from a carrier platform could facilitate massively parallel distributed multi-point sensing. Applications include improved investigation of planetary atmospheres, space weather monitoring, magnetospheric characterisation, gravity field mapping and distributed sparse aperture interferometry.

For such applications, in-orbit relative navigation would be a key enabling technology. Determining the location of femtospacecraft relative to one another within a large network would be essential in adding value to data collected, and in enabling femto-spacecraft to operate in proximity to one another; for example, by using differential air drag to maintain the swarm spatial structure.

In this paper, we present the results of an experimental test campaign to implement range-based positioning algorithms for a femtospacecraft swarm, using coarse range-only estimates approximated by received signal strength indications (RSSI). These parameters are shared within centralised and distributed network configurations. The paper builds on prior work developing and simulating algorithmic approaches using combinations of optimisation and trilateration-based methods to achieve relative positioning with coarse range estimates.

A series of experiments and procedures are detailed for the implementation of real-time relative positioning, scaling from static tests to demonstrations with one-to-one scaling of the kinematics reflecting the dispersal of a femto-spacecraft swarm from a carrier spacecraft in low Earth orbit. The development of suitable path loss models required to use RSSI as a range approximation is detailed, along with real-time measurement filtering and localisation techniques. Distributed sensing strategies for combining measurements gathered over a large volume of space are also explored. Finally, recommendations for in-orbit implementation are made, based on the experimental results obtained.