IAF SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (B2)
Interactive Presentations - IAF SPACE COMMUNICATIONS AND NAVIGATION SYMPOSIUM (IPB)

Author: Mr. Calum Turner
AstroAgency, United Kingdom

Dr. Raj Thilak Rajan
Technical University of Delft, The Netherlands

PERFORMANCE BOUNDS FOR COOPERATIVE LOCALISATION IN STARLINK

Abstract

Large satellite constellations in Low Earth Orbit (LEO) have the potential to revolutionise worldwide internet access. The concomitant potential of these large constellations to impact space sustainability, however, has prompted concern from space actors as well as provoking concern in the ground-based astronomy community. Increasing the positional accuracy of the orbital state of satellites in mega-constellations improves space situational awareness, reducing the need for collision avoidance manoeuvres and allowing astronomers to prepare better observational mitigation strategies. Current state-of-the-art solutions rely on Earth-based ground segments or onboard Global Navigation Satellite Systems (GNSS) hardware to precisely localise satellites. These methods can be augmented by cooperative navigation within the satellite network using existing inter-satellite links.

In this paper, we present a model of Phase 1 of Starlink, one of the more well-studied large constellations in LEO, and investigate the potential of cooperative localisation using time-of-arrival measurements from the optical inter-satellite links in the constellation.

We establish the achievable performance of cooperative localisation between 1584 Starlink satellites and 87 ground stations by calculating the theoretical lower bounds on the accuracy of the position estimation e.g., Cramér-Rao Bound (CRB) over the course of one orbit at 573 simulated time steps. Our results show that the standard deviation for localising the Starlink satellites has a value of 10.15 m and varies between a maximum of 36.5 m and a minimum of approximately 2m. This result is determined primarily by the geometry of the constellation and the characteristics of the inter-satellite links. We discuss our results and lay out options for more sophisticated modelling and investigations for improved position accuracy of large satellite constellations.