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Author: Mr. Andreas Hornig
AerospaceResearch.net, Germany

Prof. Dieter Fritsch
Institute for Photogrammetry (IFP), University of Stuttgart, Germany

CUBESAT POSITIONING PERFORMANCE COMPARISON BETWEEN ON-BOARD GNSS, ACTIVE 1-WAY RANGING AND TDOA METHODS BY THE DISTRIBUTED GROUND STATION NETWORK, AND THE RESULTING TIME FROM RIDESHARE LAUNCH TO IDENTIFICATION - AN OPERATOR'S SELECTION HELP

Abstract

The new launchers and rideshare missions allow mass deployments of hundreds of small- and cubesats with each single launch. The deployment sequence forms a literal "train-of-satellites" of differently spaced objects that poses a challenge for the Space Surveillance Networks to track and identify the different satellites. This is due to the sheer number of objects that are indistinguishable close together at the beginning and then disperse differently. Analysis of different missions (SpaceX's Rideshare, ISRO's PSLV, Rocketlab's Electron) show that it takes NORAD/SpaceTrack up to a few months to identify each object and match it to its mission. The fastest matches are within days and those are sats that have on-board GNSS receivers, where the operators share their orbit knowledge to STM systems. This timescale poses a risk to all in the shared-medium called orbit and also makes the operators wait until their paid operations can start.

Different methods for positioning by measurement and orbit determination exist and require minimum distances between objects and several ways for identification. On-board GNSS receivers provide meter-level accuracy fastly within few orbits, so that proximity to neighboring satellites is not the limiting factor, but it requires down-links to transfer the data via the operator's groundstation system to the STM. External measurements of the RF-signal at any groundstation would only require any beacon format with a tx-timestamp, but the timestamp needs to be with adequate precision of sub-microseconds accuracy towards the International Atomic Time reference. This one-way method is still challenging for cubesat communications electronics and a microseconds accuracy results in a km-range accuracy of positioning and also needs more orbits for extended measurements. TDOA/TOA methods from any RF-signal provide similar results as the one-way method but requires more stations that receive the same signal. The small dimensions of the target satellites are often beyond the methods like laser-ranging or radar that are available.

This paper describes the methods used for the Distributed Ground Station Network (DGSN) and the performance in positioning and time-until identification. This is put into context of other tracking services and compared so that the operator has a foundation to select the adequate method and service for their mission. The DGSN project was started within the SmallSat-Design-Studies at the Institute of Space Systems (IRS). It was part of several annual Google and ESA Summer-of-Code campaigns. It is a PhD-research topic at the Institute for Photogrammetry (IFP) at the University of Stuttgart.