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DESIGN APPROACH TO QUANTIFY INTER-GROUND STATION DISTANCES BY DOPPLER BASED RANGING EXPERIMENT FOR SMALL SATELLITE MISSIONS

Abstract

Determining the orbital location of spacecrafts is one the most important aspects for a space mission. Post launch, the information about the satellite position is required to perform certain attitude and determination control commands that could be relevant for a number of other on-board scientific endeavors. With the rapid increase of mission possibilities with small satellites precise orbit determination has become more prominent.

Small satellites are usually located by means of estimating their orbital presence using the Two Line Element (TLE) method that defines the orbital parameters. These can then be propagated to predict the satellite location at different epochs. While TLEs can be instrumental towards satellite position they suffer from diverging error propagation with successive epochs. Additional location modules can be used onboard the satellite however they take up essential real estate and may be power-hungry. Thus it is required that the current practices are modified in order to better estimate the satellite's location. Mapping the doppler shift of incoming data streams from the satellite telemetry can provide essential information related to its location therefore extending the possibility of ranging.

Our research focuses on estimating the satellite orbital location by utilizing the doppler-shift occurring in the downlink to different ground stations. The experiment is designed similar to the concept of a reverse global positioning system. The approach uses multiple ground stations (GSs), considerably within the same window of reception for the incoming telemetry. Each GS will be equipped with external time and frequency markers and are time-synchronized using the GPS. The number of precise time and frequency markers generator modules will inject the signal to the GS receiver input together with the received signal from satellite. The signal markers will be recorded at each participating GS and time of arrival and frequency will be calculated for each received packet. Coordinates of the satellite then be triangulated via correlating signals of multiple GSs, which could then be used to estimate the orbit by effective use of Kalman-filters. By this approach we look forward to quantifying a near-optimal distance required between GSs to have a decent accuracy in orbit-determination.

The approach advances the use of telemetry in order to precisely locate the satellite. While this technology is widely used to estimate location for larger spacecrafts, the application for the same, with optimal ground station distancing, shall contribute to future small satellite missions in the earth orbit and possibly further as well.