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SPACE OBSERVATION BY AUSTRALIA TELESCOPE COMPACT ARRAY: PERFORMANCE CHARACTERISATION USING GPS SATELLITE OBSERVATION

Abstract

The increasing congestion of resident space objects (RSOs) demands more sensors to provide observational data for cataloguing in the context of Space Situational Awareness (SSA) and Space Traffic Management (STM). In addition to the expanding network of dedicated optical and Radio Frequency (RF) sensors, radio telescopes, which are mainly being used for scientific astronomical observation, offer a largely untapped opportunity for delivering SSA data products.

Australia Telescope Compact Array (ATCA) is an array of six twenty-two metre Cassegrain reflector antennas located at the Paul Wild Observatory near Narrabri in New South Wales (NSW), Australia. ATCA is primarily used for astronomical observations as a stand-alone interferometer or as part of a larger VLBI network with existing receivers covering bands within 1 – 115GHz. To study the performance of ATCA correlator array in interferometry mode for space observations and establish an operational SSA mode a system model and a sensitivity model are required.

In this work, we consider interferometric observation of Medium Earth Orbit (MEO) objects and describe a system model for observations required for orbit determination. In particular, we develop a signal and system model for estimating Direction of Arrival (DOA) based on Multiple Signal Classification (MUSIC) parameter estimation technique. We use the correlator's output and adopt interferometry equations to re-focus the interferometer on a grid of ranges near the location of interest to establish the measurement vector containing the unknown parameters.

Interferometric observations of Global Positioning System (GPS) satellites are used to evaluate the system model by comparison with a precise ground truth. In each observation, we use the most recent Two-Line Element (TLE) published by North American Aerospace Defence Command (NORAD) to track and estimate a more precise position vector in J2000 Earth-cantered Inertial (ECI) frame. Then, we transform the precise GPS location data points published by US National Geospatial-Intelligence Agency (NGA) from International Terrestrial Reference and Frame (ITRF) to the ECI frame and compare them with the estimated position vectors. Finally, we report the measurement quality in terms of estimation error and bias and provide insights into future capabilities of ATCA.