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Space Debris Detection, Tracking and Characterization (1)

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INVESTIGATION OF THE RADAR PARAMETER SUBSPACE FOR DIFFERENT BEAM-PARK SIMULATIONS WITH THE TIRA SYSTEM

Abstract

Objects larger than about 10 cm can be tracked and catalogued from ground-based sensors such as radars and telescopes. Radar systems are ideally suited for observing low altitude orbits since they can be operated at any time and in all weather conditions. Smaller debris and objects orbiting on highly elliptical orbits are quite challenging to detect and regularly track from ground. In order to get insight into the current statistical distribution of these challenging objects, random sample observations are conducted. Results from these observations deliver also sampling points for validating and calibrating space debris population models such as the Meteoroid and Space-Debris Terrestrial Environment Reference (MASTER) model of the European Space Agency (ESA). Since 2000, the Inter-Agency Space Debris Coordination Committee (IADC) has been coordinating low altitude campaigns, also called Beam Park Experiments (BPEs), using primarily radars. During a BPE, the radar antenna is pointed in a given direction and data are collected for 24 hours continuously. Fraunhofer FHR has participated in these space debris measurement campaigns with the Tracking and Imaging Radar (TIRA) system since 1993. A question was raised whether new signal processing techniques could be applied to process the BPE data acquired with the TIRA system and what would be the resulting improvement in terms of detection performance and parameter estimation. In order to answer this question, the expected variations of the observables (range, radial velocity, radial acceleration and azimuth and elevation angles) over the acquisition time have to be investigated first. In other words, it is necessary to analyze how the Keplerian parameter space, describing the object orbits, maps into the measured radar parameter subspace. To conduct this analysis, the software "SpaceView" developed by Fraunhofer FHR was used. Two different simulations with a duration of 11 days were performed, corresponding to an East-pointing configuration and a South-pointing configuration. Space-Track Two Line Element (TLE) catalogue was taken as input population, which was assumed to be representative of the space debris population. The simulated observables for the objects crossing the antenna beam were computed during their pass using a sampling frequency similar

to the radar pulse repetition frequency. By exploiting the so generated beam crossing list, the potential of new signal processing schemes can be assessed. This paper will present the results of the simulations and will discuss the locations of the challenging objects in the Keplerian space.