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# THE MULTIBEAM RADAR SENSOR BIRALES: PERFORMANCE ASSESSMENT FOR SPACE SURVEILLANCE AND TRACKING

**Abstract**

Near-Earth space has become progressively more crowded in active and inactive spacecraft and debris.

Consequently, an international effort is being devoted to improving the performance of optical and radar sensors for space objects monitoring. The aim of this work is to present and assess the performance of the novel multibeam BIstatic RAdar for LEo Survey (BIRALES) sensor within the European Space Surveillance and Tracking (SST) Framework.

BIRALES sensor uses the "Radio Frequency Transmitter" (RFT) of the Italian Joint Test Range of Salto di Quirra (Sardinia, Italy) as transmitter and part of the Northern Cross (NC) radiotelescope (Medicina, Italy) as a multibeam receiver. The RFT is a powerful amplifier able to supply a maximum power of 10 kW in the bandwidth 410-415 MHz. The NC is made of two perpendicular arms: the East-West arm is a 564 m long single cylindrical antenna, whereas the North-South arm is made of 64 parallel antennas. Eight antennas of this arm have been refurbished (through the H2020 SST framework funds) to mount four receivers each, which allow its field of view (FoV) to be divided in 24 independent beams. When an object transits inside the antenna FoV, the beams are illuminated by the reflected radio wave. Consequently, besides the classical range, Doppler shift and Signal-to-Noise Ratio (SNR) measurements, the illumination sequence provides an estimate of the object transit direction and the associated angular deviation profiles with respect to the receiver pointing direction, with a higher level of detail with respect to a single-beam system.

The data received from BIRALES are provided as input to a tailored orbit determination (OD) algorithm, aimed at computing an estimate of the orbital parameters of the observed object. The OD process is divided in two phases. First, the angular profiles are estimated starting from the SNR data available from each beam. Then, the object state corresponding to the first observation epoch is estimated by matching the generated orbital trajectory with the measurements. The considered measurements are the slant range, Doppler shift and the estimated angular profiles.

The first part of this work illustrates the OD results achieved with numerical simulations. The sensor performance is assessed considering known and unknown objects, single and repeated passages and different sensor configurations. For all cases, the effect of measurement noise on each single measurement is investigated. The second part illustrates the results achieved during real observation campaigns after calibration of the measurements model.