ESA study contract summary page

ESA CONTRACT No 18575/04/D/HK(SC)	SUBJECT: Small-size Space Depris Data Collection with EISCAT Radar Facilities	CONTRACTOR: EISCAT

ABSTRACT

The present study is the third in a series of our ESA contracts since 2000 to develop, implement, and apply a method of using the EISCAT ionospheric research radars, located in northern Norway near Tromsø (site latitude 69.5º, radar wavelength 32 cm) and in Longyearbyen on Svalbard (78.1º, 60 cm), to measure space debris simultaneously with the standard ionospheric measurements. In the present contract, the emphasis has been in performing a significant number of debris measurements. We have accumulated about 10 000 debris events during more than 800 hours of measurements in 2004 and 2005.

A basic aim through this series of studies has been to be able to conduct the debris measurements in a “piggy-backed” mode, without interfering with the standard EISCAT measurements. We utilize the radar's analog signal and the frequency reference, but otherwise place no requirements whatsoever on the host’s resources or operations. Especially, we take both the radar transmission schemes and the antenna pointing directions as given, and optimize their use for our purposes. We use a special digital receiver back-end, connected in parallel with the standard EISCAT receiver at some point in the analog signal path. For increased detection sensitivity, we implement coherent pulse-to-pulse integration by computing the radar ambiguity function from a segment of measured transmission and reception that typically covers coherently a few tens of interpulse periods, 0.2-0.3 seconds. At the Tromsø radar, 0.2 s coherent integration gives 50% probability of detection of a 2.5 cm sphere at 1000 km range. At the Svalbard radar, the corresponding minimum detectable diameter is 2.9 cm. At the Tromsø system, typical integrated detection rate over LEO is 15-20 events per hour, on Svalbard, about twice as much.

Even though we have been able to obtain good sensitivity and reasonable event rates, there are inevitably limitations with our approach. Partly these are due to using radars that have been designed for beam-filling soft targets rather than small hard targets, partly due to the inherent difficulty of coherent integration, and partly due to the piggy-backed nature of our measurements. First, even though it seems that the coherent integration increases detection sensitivity somewhat, it is very difficult to get quantitative control on the integration loss, especially in the common EISCAT case of multi-frequency transmission. Second, none of the EISCAT antennas is equipped with a monopulse feed, so the target’s path across the radar beam is not known, and only a lower bound for the radar cross section can be estimated. An unknown proportion of the events represents side-lobe detections. Third, the dominant pointing directions in EISCAT are towards south at about 70-80 degrees elevation, which makes it difficult to estimate Doppler-inclination.

In spite of the limitations, EISCAT space debris measurements, summarized in this report and available in detail on the accompanying CD, taken with two wavelengths, at two high latitude locations, in long continuous measurements (weeks), sometimes with multiple pointing directions, present an interesting check of the debris models in LEO. Some further work, however, remains to be done before quantitative comparison to the models, such as ESA’s MASTER model, can be made with confidence. For instance, it seems desirable to re-detect the debris events with non-coherent pulse-to-pulse integration, a process which would be entirely possible since we routinely save the raw data of all the events.

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