Space Debris Detection in Low Earth Orbit with the Sardina Radio Telescope

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Abstract

Space debris are orbiting objects that represent a major threat for space operations. In this work a bistatic radar configuration named BIstatic RAdar for LEo Tracking (BIRALET) is used to detect a set of space debris. Signal-to-Noise Ratios, Doppler shift measures as well as the frequency specters for each debris are presented.

1. Introduction

Space debris are manmade objects, with variable size and shape, orbiting around Earth, including satellite fragments, rocket stages and other objects resulting from human space activities that have stopped their functions [1]. The presence of these objects is an obstacle for manned and unmanned spacecraft maneuvers, increasing the risk of possible collisions and allowing the creation of even new debris [2]. Space debris measurements include space-based and ground based measurements. Ground-based measurements fall in two categories: radar measurements and optical measurements. Radar measurements have been typically used to detect space debris in Low Earth Orbit (LEO) between 200 and 2000 km [3]. In this work, the authors show a set of measures performed with a bistatic radar configuration, named BIRALET for LEO detection of the space debris, using a 4 kW Continuous Wave (CW) signal in P band (410 MHz), generated from the Flight Termination System (FTS), owned by Italian Air Force, and received by the Sardinia Radio Telescope (SRT). A preliminary study was conducted to evaluate the number of detectable debris, using ESA's software Program for Radar and Optical Observation Forecasting (PROOF) 2009, the azimuth and elevation pointing coordinates of the radio telescopes, the altitude and the range of the objects from both transmitter and receiver (using Matlab and Python scripts).

2. Methods

In order to observe the signal sent from FTS and scattered from the debris, the coaxial dual-feed L-P band (0.305-0.410, 1.3-1.8 GHz) receiver of SRT was used [4]. The back end employed for the observations was a Agilent A4446E spectrum analyzer in FFT mode with 100 kHz span, 200 Hz resolution bandwidth and 200 Hz video bandwidth.

3. BIRALET

The bistatic radar configuration used for the observations consists of the FTS as transmitter and the SRT as receiver. The FTS, located in Sardinia (Italy) at the Join Test Range of Salto di Quirra (PISQ), can count on a powerful amplifier capable of supply an averaged and leveled power of 4 kW in the 400-455 MHz bandwidth. The SRT is a 64-mt fully steerable wheel-and-track parabolic antenna, able to observe the sky with high efficiency in the frequency range between 0.3-116 GHz. It is located in Sardinia, about 35 km north from Cagliari. The baseline of the BIRALET is around 40 km.

4. Results and Discussion

The observations started the 17th April 2014. The main goal of the campaign was the detection of a specific set of orbital debris (provided by the Italian Air Force) by means of received SNR and the evaluation of the radar Doppler shift. In table I, the name of the object, the duration of the received echoes, the Doppler frequency and the SNR are shown for each debris.

Table 1. List of the detected debris, with the duration of the received echoes in seconds, the Doppler frequency in kHz and the SNR in dB.

Name	**Duration [s]**	**Doppler frequency [kHz]**	**SNR [dB]**
COSMOS 2237 (I pass.)	0.44	Doppler not measured	39.8
COSMOS 2237 (II pass.)	0.47	-5.2	29.4
HJ-1A (I pass.)	0.30	+6.2	16.4
HJ-1A (II pass.)	0.38	+4.6	15.8
CARTOSAT 2A	0.30	+5.2	11.7

COSMOS 1408	0.51	Doppler not measured	37.2
COSMOS 1375	0.41	+3.4	10.8
VESSELSAT 2	0.39	+5.2	17.4

Figures 1, 2 and 3 show the screenshots of the spectrum analyzer regarding the detection of the debris COSMOS 2237 (second passage), HJ-1A (first passage) and CARTOSAT 2A. The peak of the debris, as well as the carrier and some Radio Frequency Interference (RFI), at higher frequencies, are highlighted.

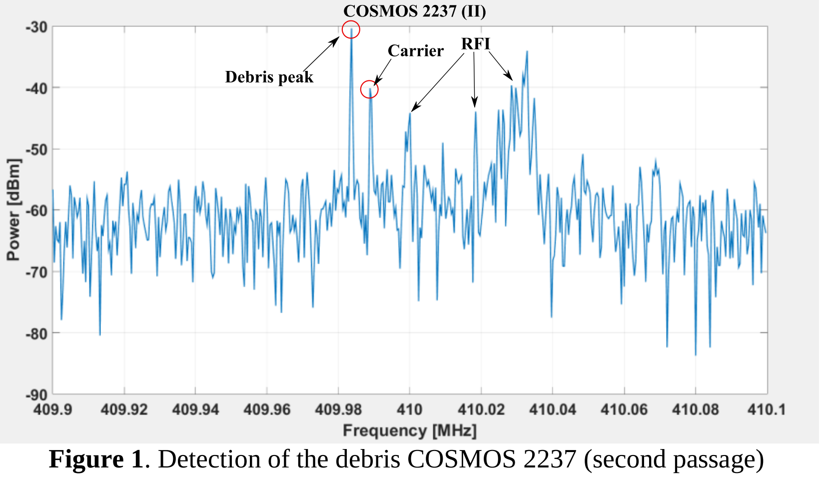

Figure 1. Detection of the debris COSMOS 2237 (second passage)

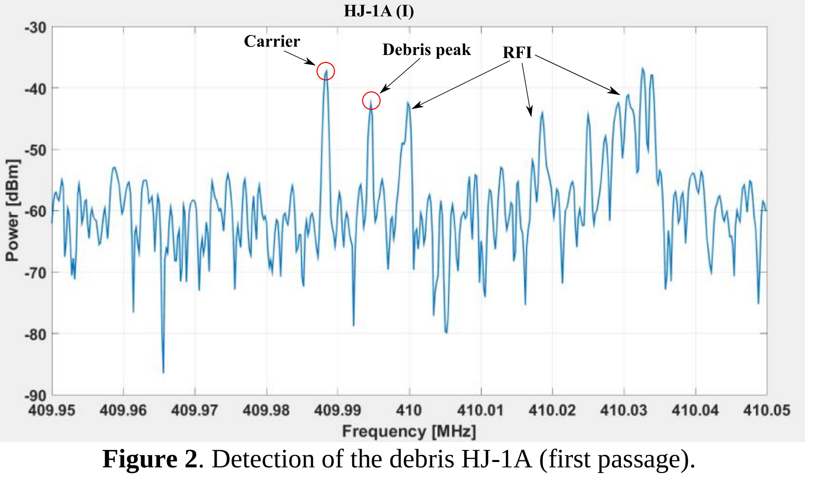

Figure 2. Detection of the debris HJ-1A (first passage).

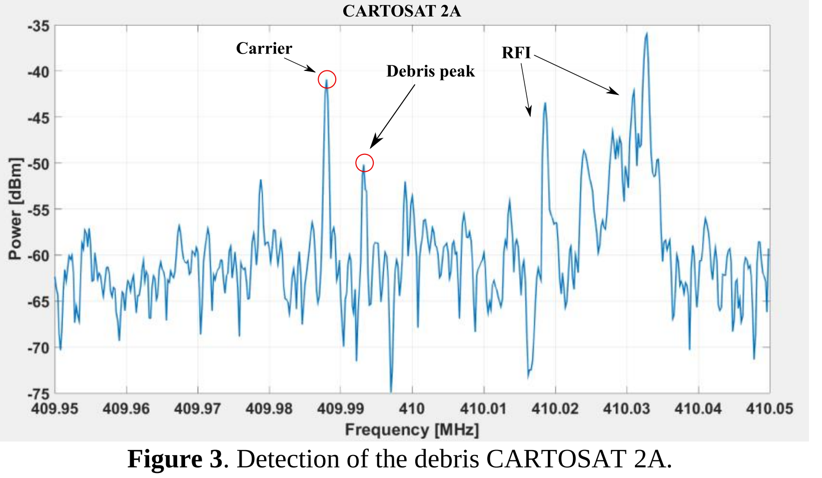

Figure 3. Detection of the debris CARTOSAT 2A.

It is pretty clear, both from table I and figures 1 and 2, that every debris in the list was successfully detected. However, for two specific debris (COSMOS 2237 first passage and COSMOS 1408) the authors were unable to measure the Doppler frequency. The reason is that the Doppler shift was small, if compared with the minimum resolution bandwidth of the spectrum analyzer.

5. Conclusion

In this work a set of measures to detect space debris in Low Earth Orbit with the SRT has been performed. The authors showed the level of Signal-to-Noise ratio received by the SRT, the duration of the scattered echoes and the Doppler shift. Although every debris in the list has been detected, we were unable to measure the Doppler frequency for each one. This may depend on the back end used in the signal acquisition chain.

6. References

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