FIRST EXPERIMENTAL RESULTS OF BISTATIC SAR WITH SABRINA-X AND TERRASAR

Paco Lopez-Dekker, Antoni Broquetas, Jordi J. Mallorqui, Juan Carlos Merlano, Sergi Duque, Mario Fortes, Xavi Costa, Jose A. Garcia-Molina

Remote Sensing Lab (RSLab)
Dept. Signal Theory and Communications
Universitat Politècnica de Catalunya (UPC), Barcelona Spain
{mallorqui@tsc.upc.edu}

1. INTRODUCTION

As Synthetic Aperture Radar (SAR) and associated research areas such as InSAR or Pol-SAR are developing into maturity, bistatic systems are emerging as a new research field. Bistatic systems open the possibility to explore alternative geometries and different scattering mechanisms. Some of the upcoming systems, such as the future Tandem-X mission, can be described as quasi-monostatic, with the receiver and the transmitter close to each other in almost parallel orbits. While these systems present important technological challenges, there are few new theoretical aspects involved. In contrast, if the receiver and the transmitter follow independent trajectories or are located far apart completely, new scenarios arise. Besides the geometry-related issues in the design of bistatic systems, there are a number of synchronization-related challenges. For example, the need for independent reference oscillators on transmit and receive dramatically increases the impact of oscillator phase noise. All oscillator phase noise components of at least two frequency sources contribute to the phase noise while in a monostatic radar only high-frequency oscillator phase noise contributions were relevant. In explicitly designed bistatic radars, it is usual to derive all frequencies from a common reference, for example, by using GPS disciplined sources. A different approach is to record the relative phase offsets between the oscillators, as it will be done in the future TanDEM-X mission, which requires a two-way dedicated link. Once these offsets are known, they can be corrected in the data processing. However, if the receiver uses a non-cooperative source of opportunity, none of these strategies can be applied directly.

During the last year, the Remote Sensing Laboratory (RSlab) of the Universitat Politècnica de Catalunya (UPC) has been developing a C-band receiver for a ground-based bistatic-SAR system using the European Space Agency's (ESA) ERS-2 and ENVISAT as transmitters of opportunity that has been named SABRINA (SAR Bistatic Receiver for INterferometric Applications) [1]. The system is intended to provide an experimental platform with which to study most aspects of the bistatic-SAR systems, including scattering phenomena, raw data processing, hardware related aspects with a particular emphasis on those linked to synchronization [2], interferometry and polarimetry. SABRINA has been able to produce Digital Elevation Models (DEM) of the city of Barcelona]3][4]. The bistatic backscattering acquisition geometry increases the ground-range resolution of the images with respect the orbital monostatic case, as it depends on the transmitter and receiver incidence angles. This aspect is particularly interesting in urban areas were improved resolutions allow a better discrimination of the targets present in the scene. On the contrary, the azimuth resolution is reduced by a factor of $\sqrt{2}$, as the reduction of the Doppler bandwidth is partially compensated by the wider azimuth beamwidth of the one-way radiation pattern.

2. SABRINA-X

The bistatic receiver SABRINA was originally designed to work with transmitters at C-band and it has been recently updated to X-band to allow the acquisition of data from TerraSAR-X. In addition to the modifications of the antennas and RF front-end to the new band, one of the main challenges has been the accommodation of the large bandwidth to the off-the-shelf high-speed digitizer. For instance ERS and ENVISAT signals have bandwidths of around 16 MHz while with TerraSAR it rises up to 150 MHz. In order to simplify the acquisitions in C-band the different channels are sampled directly at IF and the

I&Q demodulation is done digitally during the post-processing. With TerraSAR the demodulation is done by hardware and the available bandwidth filtered to 100 MHz to avoid aliasing in the digitisation step. Another consequence of the higher sampling rate is a dramatic reduction of the sampling window, from 7,6 seconds for ERS/ENVISAT to around 1,5 seconds for TerraSAR. Thus, the prediction of the satellite's time of pass has to be done with the highest precision possible using the available two-line Keplerian element (TLE) sets and information directly provided by DLR.

3. EXPERIMENTAL RESULTS

Different experiments are going to be done in the next months to test SABRINA-X with TerraSAR in the urban area of Barcelona. The high resolution bistatic images generated will be compared with those obtained with ERS and ENVISAT. The highest resolution should allow relating the different scattering centers present in the image with the different structures of the scenario. The available ground-truth should allow identifying which kind of human-made structures can behave as bistatic permanent or coherent scatters. The classical canonical targets, which are the traditional source of monostatic permanent scatters in urban areas, should not have identical behavior in bistatic geometries. The existence or not of such targets is still an open issue when working with bistatic geometries.

4. REFERENCES

[1] J. Sanz-Marcos, P. Lopez-Dekker, J.J. Mallorqui, A. Aguasca, P. Prats, "SABRINA: A SAR Bistatic Receiver for Interferometric Applications", *IEEE Geoscience and Remote Sensing Letters*, Volume 4, Issue 2, April 2007, Page(s):307 – 311

[2] P. Lopez-Dekker, J.J. Mallorqui, P. Serra-Morales, J. Sanz-Marcos, "Phase Synchronization and Doppler Centroid Estimation in Fixed Receiver Bistatic SAR Systems", *IEEE Transactions on Geoscience and Remote Sensing*, Volume 46, Issue 11, Part 1, Nov. 2008 Page(s):3459 – 3471

[3] P. Lopez-Dekker, J.C. Merlano, S. Duque, J. Sanz-Marcos, A. Aguasca, J.J. Mallorqui, "Bistatic SAR interferometry using ENVISAT and a ground based receiver: Experimental results", *IEEE International Geoscience and Remote Sensing Symposium 2007 (IGARSS-07)*, Page(s): 107-110

[4] S. Duque, P. Lopez-Dekker, J.J. Mallorqui, J.C. Merlano, "Forward and Backward Bistatic Interferometry", *IEEE International Geoscience and Remote Sensing Symposium 2008 (IGARSS-08)*, in press.