DEVELOPMENT AND EXPERIMENTS OF A PASSIVE SAR RECEIVER SYSTEM IN A BISTATIC SPACEBORNE/STATIONARY CONFIGURATION

Holger Nies[1], Florian Behner[1], Simon Reuter[1], Otmar Loffeld[1], Dietmar Matthes[2], Joachim Schiller[2]

[1]Center for Sensorsystems (ZESS)
University of Siegen
Siegen, Germany

[2]Fraunhofer Institute for High Frequency
Physics and Radar Techniques (FHR)
Wachtberg, Germany

1. INTRODUCTION

This paper demonstrates the first experiment in bistatic SAR using a stationary receiver and TerraSAR-X as transmitter operating in the high resolution spotlight mode. We intend to record the direct satellite signal and backscattered signal from the scene with a stationary SAR receiver, mounted on roofs of high buildings, or on bridges looking into valleys, etc. After evaluating the bistatic geometry an overview of the hardware setup and a short performance analysis is given in the final paper. First processed results are presented from data taken in a number of experiments performed in summer and fall 2009.

2. DESCRIPTION OF THE SYSTEM AND THE EXPERIMENTS

To develop efficient algorithms for bistatic SAR focusing, there is a need for test data sets. Therefore it was decided to build up an own affordable sensor system to perform bistatic SAR experiments. Because of the high operating cost of a moving sensor platform, a stationary receiver is desired. The system was originally designed using the TerraSAR-X satellite as illuminating platform. The high bandwidth of the transmitter of 300MHz and the sliding spotlight SAR mode permits the acquisition of SAR data with less than 1m resolution. To preserve high flexibility, the system was not limited to this signal source. By changing some components this system enables also acquiring parasitic bistatic SAR data of different kinds of moving radar transmitters with a different center frequency or bandwidth. Due to the passive nature of the used radar principle the system is named HITCHHIKER. The receiver unit consist of a 2 channel system with an adequate data rate and flexible PRF (Digitizer plus two channel frontend for the demodulation from X-band to intermediate frequency, IQ demodulation is done later with digital signal processing). There are three main components of our system: the RF-frontend, the digitizer and the control computer. The RF-frontend is equipped with low noise amplifiers, mixers, bandpass and lowpass filters to convert the received signal in an appropriate way for feeding in our

digitizer. Controlled by the computer, the digitizer samples the signal at intermediate frequency. The maximum sample rate is 8GS/s with 10 bit quantization. The memory capacity is 2GS in total.

The first antenna points towards TerraSAR-X for recording the direct signal and triggering the recording for channel two. This means the recording is not done continuously, but rather pulse by pulse. The second antenna is directed towards the scene, orthogonal to the flight trajectory of the spacecraft. Additionally to the SAR data also the timestamps of the individual pulses are recorded, so that we are able to add the range migration term related to the satellite's trajectory and the position of the trigger antenna.

Several experiments have been carried out to get a stack of raw data to verify the bistatic processing algorithms. To evaluate the quality of the acquired data, a QuickLook processor was developed. This frequency domain processor, uses correlation with the direct channel in fast time and a dechirping approach in slow time. Range defocusing is corrected by an autofocus. The processed image is available within 6 minutes after acquisition end on the control computer. No positional information is needed.

3. RESULTS

In September 2009 the first experiments were done using TerraSAR-X as transmitter in 300MHz high resolution sliding spotlight mode.

Figure 1: a) Bistatic radar image of a factory obtained with our receiver system b) Monostatic image from TerraSAR-X c) Optical image of the same scene (google earth)

In these experiments the receiver was placed on top of the building Adolf Reichwein at the campus of the University of Siegen. The transmitter was operating in right looking mode. The satellite was on the ascending

orbit path thus the scene was located east of the receiver position, while the transmitter's incidence angle measured 54°. Polarization was VV. The total scene extension was about 3 km×8 km. In Figure 1a a detail of the bistatic SAR-image shows a factory 700m east of the receiver position; the resolution in this case was around 0.5m. For comparison an optical view on the scene was added. The result was processed using a modified time domain processor using the signals of both receiving channels.

The final paper will give more processing results of different scenes and a comparison of the time domain result with the QuickLook processor and with then monostatic image of TerraSAR-X. Furthermore it will contain more details regarding the used system and a short performance analysis of the bistatic configuration.

4. REFERENCES

[1] J. Sanz-Marcos, P.; Lopez-Dekker, J. J. Mallorqui, A. Aguasca, and P. Prats, "SABRINA: A SAR bistatic receiver for interferometric applications" IEEE Geosci. Remote Sens. Lett., vol. 4, no. 2, pp. 307–311, Apr. 2007.

[2] S.V. Baumgartner, M. Rodriguez-Cassola, A. Nottensteiner, R. Horn, R. Scheiber, M. Schwerdt, U. Steinbrecher, R. Metzig, M. Limbach, J. Mittermeyer, G. Krieger, A. Moreira, "Bistatic Experiment Using TerraSAR-X and DLR's new F-SAR System", EUSAR 2008, Proceedings, vol1., pp. 57-60, Jun. 2008

[3] H. Fiedler, G. Krieger, F. Jochim, Marc Kirschner and A. Moreira, "Analysis of bistatic configurations for spaceborne SAR interferometry" Proceedings of EUSAR, 2002.