TERRASAR-X DUAL RECEIVE ANTENNA MODE - CHANNEL RECONSTRUCTION AND IMPACT ON THE GMTI PERFORMANCE -

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1. INTRODUCTION

Synthetic aperture radar with multiple channels separated in along-track direction allows for GMTI such as detection of road traffic [1]. With TerraSAR-X two receive channels separated in along-track direction can either be realized through switching between the fore and aft antenna halves from pulse to pulse, or with the dual receive antenna (DRA) mode [2]. While the switching in the single channel switched aperture mode is implemented by alternately applying attenuation to the fore and aft antenna halves, in the DRA mode the signals of the fore and aft antenna halves are combined by a hybrid coupler generating the sum and difference channel data. By use of the redundant receiver unit both channels are sampled separately. Fore and aft channel signals have to be reconstructed in the signal processing step.

In this paper a method for an adaptive fore and aft channel reconstruction based on calibration pulses and calibration beams is presented. The imbalances related to the TerraSAR-X hardware implementation of the DRA mode are modeled into the transfer functions of the data acquisition and the processing in order to analyze the quality of signal reconstruction and draw conclusions on the impact on the ground moving target indication (GMTI) performance of this two-channel mode. The theoretical results derived are validated with experimental data and GMTI results are shown.

2. DUAL RECEIVE ANTENNA MODE, FORE AND AFT CHANNEL RECONSTRUCTION

The proposed method compares the recorded sum and difference channel calibration pulses for various calibration beams to the sum and difference channel signals one would have expected. By this, we can formulate complex deviation factors. The deviation factors allow us to determine the true hardware transformation matrix.

2.1. Calibration pulses

There are three types of calibration pulses which differ in the section of the hardware they characterize: The transmit (Tx) calibration pulses are sent through the transmit hardware of the system and are the same for both channels. The receive (Rx) calibration pulses are sent through the receive hardware and characterize the fore and aft channel receive hardware before the hybrid coupler, the hybrid coupler, as well as the cables after the hybrid coupler. The third type of calibration pulses are the central electronics (CE) calibration pulses which characterize the common section of the calibration paths where the transmit as well as the receive calibration pulses run through.

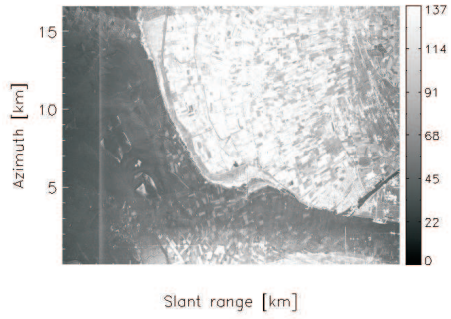
2.2. Calibration beams

Various calibration beams are available in order to generate different fore/aft channel calibration vectors. The calibration beams used for the DRA mode fore and aft channel reconstruction are the following:
CalDRA: Here the calibration pulses sent through the fore channel receive hardware of the system are phase shifted by $+45^\circ$, while the pulses sent through the aft channel hardware are phase shifted by -45°.
FORE: For this calibration beam there is no phase shift between the pulses sent through the fore respectively aft channel receive hardware. Instead, an amplitude weighting of $-20\,dB$ is applied to the pulse which is sent through the aft channel receive hardware.

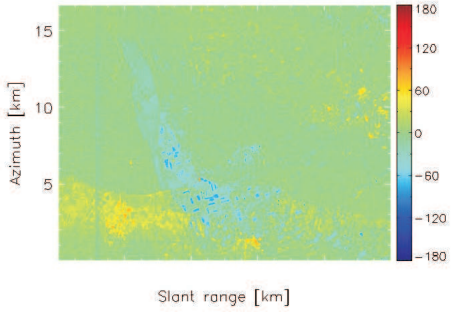
3. DUAL RECEIVE ANTENNA MODE FOR GMTI

3.1. Along-track interferometry

In Fig. 1 an example SAR image of a reconstructed fore channel can be seen on the left, while the ATI image of the reconstructed fore and aft channel signals is shown on the right. The images show the mouth of the Elbe river in northern Germany. In both images azimuth ambiguities are visible in the water of the mouth of the Elbe river (Germany). While in the SAR image the azimuth ambiguities appear as unexpected images of fields in the water, in the ATI image the azimuth ambiguities are characterized due to their phase offset being different from zero. As well one can identfy some potential moving targets in the Elbe.



(a) SAR image



(a) ATI phases

Fig. 1. Left: SAR image of reconstructed fore channel. Right: ATI phase of reconstructed fore and aft channel SAR images. The images show the mouth of the Elbe river.

3.2. Impact on the GMTI performance

Space-based GMTI demands for high precision calibration of the radar instrument, and in the case of the TerraSAR-X DRA mode for high precision fore and aft channel reconstruction. In order to fulfill this requirement an adaptive method is presented which estimates the true receive hardware transfer function. The impact of limited knowledge about the true receive hardware function on the performance of some common GMTI measures is studied via error propagation. The theoretical and simulation results are validated by experimental data results.

4. REFERENCES

[1] H. Runge, S. Suchandt, A. Kotenkov, H. Breit, M. Vonavka, and U. Balss, "Space borne SAR traffic monitoring," in *Proc. International Radar Symposium (IRS)*, Cologne, Germany, 2007.

[2] M. Suess, S. Riegger, W. Pitz, and R. R. Werninghaus, "TerraSAR-X - design and performance," Ulm, Germany, 2004, Proc. European Conference on Synthetic Aperture Radar (EUSAR).