TAXI: A VERSATILE PROCESSING CHAIN FOR EXPERIMENTAL TANDEM-X PRODUCT EVALUATION

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1. INTRODUCTION

TanDEM-X is a high-resolution interferometric mission with the main goal of providing a global digital elevation model (DEM) of the Earth surface through single-pass X-band interferograms. It is, moreover, the first genuinely bistatic SAR mission, and, independently of its usual quasi-monostatic configuration, includes many of the peculiarities of bistatic SAR. An experimental, versatile, and flexible interferometric chain has been developed for the scientific exploitation of TanDEM-X data, which we have named TAXI (TAndem-X Interferometric processor).

TanDEM-X is the first bistatic SAR mission in space [1]. The main objective of the mission is to act as a single-pass interferometric system capable of provising very high resolution 3D information. Bistatic SARs offer increased performance at an increased operational cost. Its uniqueness, coupled with the flexibility of the TerraSAR-X satellite, allows one to develop a large amount of novel and challenging experiments to take advantage of its capabilities. To this aim, a flexible interferometric chain is being developed at DLR-HR to exploit the scientific data gathered during the mission. The paper addresses the particular characteristics of this processing chain, especially focussed on its bistatic and interferometric branches. The TanDEM-X baseline model and its expected cofigurations are presented. A block diagram of the interesting branches is shown, followed by a discussion on the selected synchronisation approach, imaging modes and processing kernels. The paper also tests the developed chain with actual bistatic data of the TanDEM-X mission.

2. TANDEM-X BASELINE MODEL

The TanDEM-X baseline expressed in the local coordinates of the TerraSAR-X satellite can be approximated as

$$\Delta x(t) = \Delta x_0 + 2 \cdot A \cdot \sin[\phi_{\mathrm{lat}}(t) + \alpha] \quad , \tag{1}$$

$$\Delta y(t) = -B \cdot \cos[\phi_{\mathrm{lat}}(t)] \quad , \tag{2}$$

$$\Delta z(t) = -A \cdot \cos[\phi_{\mathrm{lat}}(t) + \alpha] \quad , \tag{3}$$

where Δx_0 is a constant along-track offset, A is the maximum variation of the along-track offset, B is the maximum variation of the horizontal across-track offset, ϕ_{lat} is the argument of latitude, and α is a constant angle representing the decoupling of

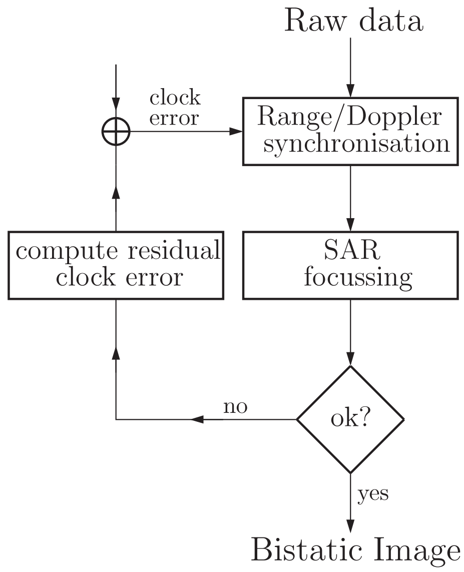

Fig. 1. Block diagram of the bistatic part of the TanDEM-X interferometric processor.

the instant at which the maximum along-track offset and maximum across-track offset are reached. The x-axis of the local coordinates coincides with TerraSAR-X velocity vector, the z-axis is defined by the radial vector of the satellite position, being the y-axis the one to complete the coordinate axes. The baseline draws respective ellipses on the xy and xz planes, so that if the projections of the satellites on the xz plane are close, their respective projections on the xy plane are far, and *vice versa*. The baseline also changes mildly within an acquisition.

3. TANDEM-X DURING THE COMISSIONING PHASE

The main goal of the mission is the generation of the global DEM following the HRTI-3 standard. The mission works on a tight schedule and, therefore, the baselines between the end of the commissioning phase until the beginning of mission's third year are usually not easily modifiable. From the third year onwards, the more demanding experiments and configurations are foreseen. An accelerated TerraSAR-X-like commisioning phase has been designed for the TanDEM satellite, before any bistatic operation is undergone. During this time, TerraSAR and TanDEM satellites approach each other in orther to prepare the close flying formation. Bistatic acquisitions with large along-track baselines (about 20 km) are foreseen during this commissioning phase to test the bistatic capabilities of the system.

4. PROCESSING APPROACH

The structure of the TanDEM-X interferometric processor consists of a monostatic and a bistatic branch. The information needed for the interferometric processing is already computed in both monostatic and bistatic processing steps. Fig. 1 shows the block diagram of the bistatic branch of the TanDEM-X interferometric processor. Its basic structure consists of a synchronisation and a focussing part. Further details on each of these blocks are given in subsequent Sections.

5. BISTATIC DATA SYNCHRONISATION

TanDEM-X is a cooperative system. During the acqusitions, the TerraSAR and TanDEM satellites exchange transmitting pulses along their direct path for synchronisation purposes. An evaluation of these pulses provides information on the differential clock error, namely the frequency offset and the phase noise. This information is used for bistatic synchronisation, a crucial step before focussing. Due to the particularities of the large baseline configurations, a significant decrease in the signal-to-noise ratio of these synchronisation pulses is expected and therefore a further automatic algorithm is foreseen.

6. IMAGING MODES AND FOCUSSING KERNELS

The standard imaging modes of TerraSAR-X are stripmap, sliding spotlight, and scanSAR, while TOPS is operated by DLR Microwaves and Radar Institute (DLR-HR) as an experimental mode [2]. Due to the usually quasi-monostatic configurations of TanDEM-X, analogous imaging modes extended to the bistatic case can be thought of. The focussing kernels of the monostatic part are based on the chirp scaling approach. The so-called extended chirp scaling (ECS) [3] is used for the stripmap configurations, whereas the other monostatic modes, which demand a special azimuth focussing approach, further use the common kernel of the baseband azimuth scaling (BAS) [2]. A dual-solution approach is used for the bistatic kernels. One option is to tune the monostatic processing functions so that they are matched to the bistatic configuration and then use the regular monostatic kernels, i.e. still using the hyperbolic approximation with an effective velocity [4]. Another one is to generate actual bistatic processing functions using a numerical approach [5].

7. EXPERIMENTAL RESULTS

In the final version of the paper, this section will include results with TerraSAR-X/TanDEM-X data.

8. SUMMARY

The experimental TanDEM-X processing chain will be presented. Its architecture and capabilities will also be addressed, with special focus on the purely bistatic characteristics of the system. The processing chain will be tested with monostatic and bistatic data acquired during the TanDEM-X commissioning phase.

9. REFERENCES

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