TANDEM-X COMMISSIONING PHASE STATUS

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1. INTRODUCTION

TanDEM-X [1] is an Earth Observation mission, result of the cooperation of the German Aerospace Center (DLR) and EADS Astrium GmbH, consisting of two twin synthetic aperture radar (SAR) satellites, TerraSAR-X (TSX) and TanDEM-X (TDX). TSX has been operative since 2007, and TDX has been launched on the first half of 2010. Both satellites fly in a versatile, configurable and closely controlled helix orbit formation in order to acquire single-pass cross-track interferometric SAR (InSAR) images of the Earth with the optimal performance. The goal is to generate a global highly accurate digital elevation model (DEM) with 12 m resolution, 10 m absolute- and 2 m relative-height accuracy. This has to be achieved over the whole Earth's land surface within 4 years after launch.

In order to assure the accurate completion of this DEM product, TDX has to undertake a precise commissioning phase in a tight time schedule. The commissioning phase activities range from the monostatic calibration (analogue to the one performed for TSX) to the commissioning of bistatic aspects like the innovative flight formation, the collision avoidance strategy, the upgraded mission planning and ground station network, the synchronization performance, the baseline calibration and the illumination risk handling.

The paper describes the status of this challenging commissioning phase and a detailed description of the main phases and activities.

2. CHALLENGES

2.1. Mission Schedule

The TSX satellite was launched in June 2007. Since its successful commissioning phase, where the instrument was accurately calibrated, TSX has remained very stable and reliable [2]. However, the warranted life time is limited. For acquiring the TanDEM-X DEM with the specified quality, at least two to three years of combined operation are required. Difficult terrain like mountainous areas needs to be acquired three or even four times to minimize shadowing and layover effects and phase unwrapping errors. In order to start as soon as possible with the nominal DEM acquisition, the TDX commissioning phase has to be performed as fast as possible.

2.2. Complexity

The combination of the TerraSAR-X and TanDEM-X mission objectives increases the complexity of the system. Apart from acquiring the InSAR images for the DEM acquisition, the TerraSAR-X customers should not be disturbed. This is only possible by implementing a new mission planning concept to distribute the TerraSAR-X mission acquisition equally on both satellites. The SAR processing chain has also been extended to include an additional branch for interferometric processing [3], comprising bistatic and pursuit monostatic operation modes. The duration of the maintenance phases for activating the TanDEM-X functionalities have to be minimized.

2.3. Collision Avoidance

For the first time two satellites are operated at a nominal distance of a few hundred meters only. Safety is ensured by flying in a so-called "helix formation", where TSX and TDX have slightly different orbital planes [4].

2.4. Exclusion Zones

The helix formation results in one satellite turning around the other with one orbit periodicity. This means that there is a risk of mutual illumination during radar activities, when one satellite is in the direction of the main beam of the neighbor SAR antenna, which could cause damage to the electronic equipment. Therefore, a three-step fail-safe concept has been implemented to disable the transmission during this risky illumination periods.

2.5. TerraSAR-X Experience

The experience gained during the TSX commissioning and two years of operation and its proven long term stability allows us to face the TanDEM-X challenges with reasonable optimism.

3. COMMISSIONING PHASE PLAN

The commissioning phase can be divided into three main phases, as shown in Fig. 1.

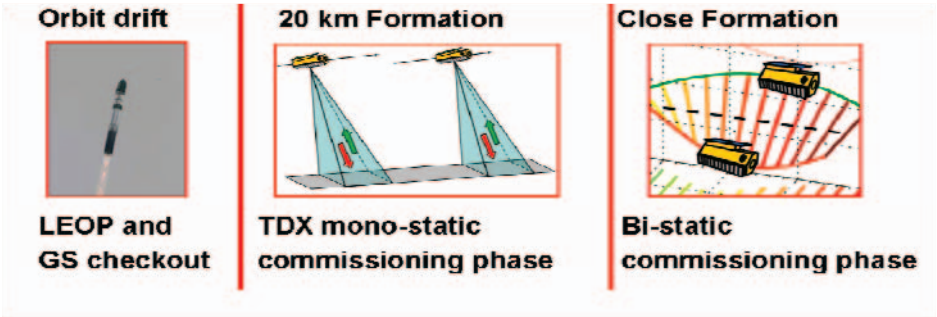

Figure 1: Three phases of the commissioning phase

The duration of the first phase is dependant on the launch date and lasts approx. between 20 to 30 days. Initial part is the Launch and Early Orbit Phase (LEOP) that includes the satellite checkout after launch, the release of the antenna boom for data downlink and the test of the S/C systems. In addition, all ground systems run through

pre-defined checkout procedures. Beginning with the LEOP (which takes approx. 7 days), TDX drifts towards TSX in order to reach a 20 km along track separation at the end of the first phase.

During the second phase, the monostatic commissioning phase, TDX is commissioned for acquiring nominal TerraSAR-X-mission datatakes. This includes the instrument calibration and the product verification on the TDX as well as acquisitions in pursuit monostatic mode.

In the last phase, where the mean along track distance is reduced to 0 and the helix formation with typical cross track distances of 200 m are set, the calibration, verification and validation of the bistatic aspects are performed. Here, the first bistatic acquisitions are acquired. After this phase the operational DEM acquisition starts.

4. ACTIVITIES AND PHASES

4.1. LEOP and Ground Segment Checkout

The ground stations (satellite tracking) and their running systems (transcription and processing systems) have to be checked out. Also the mission planning system, which mainly comprises the verification of the power thermal model, the splitting of replays, parallel SAR acquisitions and the data dump and test of the left looking mode, has to undertake a checkout process. The verification of the orbit and attitude products should verify their required accuracy. Once this is working, the instrument will be activated for the first time. The first performance parameters of the instrument have to be analyzed and first initial acquisitions will be performed.

Finally, the complete chain from ordering to the generation of the processed image has to be checked out.

4.2. Monostatic Commissioning Phase

With an along-track distance of 20 km, the behavior of both satellites in the formation is studied before entering into close formation. The SAR instrument calibration is the main driver for the duration of this phase. A defined number of acquisitions over the ground targets at the DLR calibration field in southern Germany [2] are required for an accurate calibration. To achieve the same accuracy as obtained for TSX, two cycles for geometrical and pointing calibration are required. Using a precise antenna model, the absolute calibration can be reduced to only three cycles. The verification of the SAR performance is important to ensure the product quality. Here, the Noise Equivalent Sigma Zero (NESZ), the Signal-to-Noise Ratio (SNR) and the ambiguities are evaluated. These verifications are repeated during the bistatic phase.

All SAR products have to be verified to assess the product quality and compliance with the specification.

As both satellites comprise independent local oscillators and with the differences affecting the height accuracy of the DEM, synchronization between both oscillators is required. This is done by exchanging special synchronization pulses through the X-band horn antennas of a dedicated synchronization link. The performance of this synchronization link has to be verified with special data takes.

Using different test sites, the baseline between both satellites is evaluated in order to eliminate constant offsets.

4.3. Bistatic Commissioning Phase

The commanding of bistatic acquisitions is a new task for TanDEM-X. Therefore, adjustment and optimization is required in order to correctly set parameters like the receiver gain, the echo windows, pulse repetition frequency... Also the systematic height error models to correct the raw DEMs have to be verified.

The TanDEM-X Interferometric Processor, which generates the interferometric SAR images, performs the co-registration and phase unwrapping and provides raw DEMs, has to be operationally verified.

The raw DEMs are then calibrated in height and mosaicked by the DEM Calibration and Mosaicking processor. This is the driver in this phase. In order to gain experience in calibration and mosaicking, larger areas at test sites all over the world are used for acquiring test DEMs. In order to acquire four parallel images, four repeat cycles are needed.

5. CONCLUSION

The commissioning phase planning provides an overview on the tasks to be performed during the TanDEM-X commissioning phase. The main challenges are the tight schedule, the close formation flight and the extension of an operational running system. The three phases are packed with different verification tasks and calibration activities. However, with the experience gained with TSX and its high stability, a successful TanDEM-X commissioning phase is foreseen.

6. ACKNOWLEDGEMENT

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7. REFERENCES

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