TanDEM-X Mission Concept & Status

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TanDEM-X
TerraSAR-X add-on for Digital Elevation Measurements

- Acquisition of a global DEM
- Demonstration of innovative techniques (formation flying, bistatic acquisition)
Global TanDEM-X DEM

- Single-Pass Across-Track Interferometry
- Coherent processing of data acquired with two independent radar instruments
- Correlate multiple acquisitions with different baselines / look angles
- Raw DEM mosaicking on continent level
- Final product available 4 years after launch
## Standards for Digital Elevation Models

<table>
<thead>
<tr>
<th></th>
<th>Spatial Resolution</th>
<th>Absolute Vertical Accuracy (90%)</th>
<th>Relative Vertical Accuracy (point-to-point in 1° cell, 90%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DTED-1</td>
<td>90 m x 90 m</td>
<td>&lt; 30 m</td>
<td>&lt; 20 m</td>
</tr>
<tr>
<td>DTED-2</td>
<td>30 m x 30 m</td>
<td>&lt; 18 m</td>
<td>&lt; 12 m</td>
</tr>
<tr>
<td><strong>TanDEM-X</strong></td>
<td>12 m x 12 m</td>
<td>&lt; 10 m</td>
<td>&lt; 2 m</td>
</tr>
<tr>
<td><strong>Level-4</strong></td>
<td>6 m x 6 m</td>
<td>&lt; 5 m</td>
<td>&lt; 0.8 m</td>
</tr>
</tbody>
</table>

**Coverage in Mio. km²**

**Relative Vertical Accuracy**

- 10 m
- 2 m
- 100 km

**DTED/HRTI Level**

- Airborne LIDAR
- Airborne SAR
- Photogrammetry
- HR Satellites
- SRTM-C (restricted)
- SRTM-X
- ERS Tandum
- SPOT 5 HRS
- SRTM-C (free)
- USGS GTOPOS

**Standards for Digital Elevation Models**
HELIX satellite formation enables safe operation

- horizontal cross-track separation at equator by different ascending nodes
- vertical (radial) separation at poles by orbits with different eccentricity vectors
HELIX - Formation
Exclusion Zones

Definition of exclusion zones for TSX & TDX based on beam table.
Different exclusion zones in case of left-looking operation!

TSX

D E M

standard TSX beams

possible beams & sidelobes

TDX

exclusion zones (example)

“TSX may not transmit in asc. orbit”

“TDX may not transmit in desc. orbit”
Bistatic Operation - Synchronisation

- Bi-static operation of TSX-1 and TDX-1 requires synchronisation of independent oscillators
- Phase referencing by exchange of pulses via synchronization link
- Necessary hardware modifications already implemented on TSX-1
- Leap PRIs compensate drift of Echo Window
- Complex instrument commanding
- Continuous in-flight characterisation of oscillator drift
- Additional “pre-processing” steps in SAR Processor
Joint TerraSAR-X/TanDEM-X Mission Planning

- Both missions TerraSAR-X and TanDEM-X share a common space segment.
- TanDEM-X DEM Orders are planned well in advance.
- TerraSAR-X Order can be of short notice (6 hours before uplink).
- Priority concept allows TerraSAR-X high-priority orders to replace or cut even a TanDEM-X DEM Order.
- Re-ordering mechanism are available for failed or skipped TanDEM-X orders.
- Using the space segment beyond specifications is possible due to extended resource management (power & battery degradation, thermal, downlink).
**Data rate**
Can be slightly influenced by selection of radar parameters (PRF, BAQ).

**Ground Station Network**
Additional downlink opportunities are used for peak load orbits.

**Ground Coverage**
- Left-looking acquisitions required for Antarctica
- Selection of elevation beams at higher latitudes.

**On-board Mass Memory**
Less memory on TSX-1 → dump TSX-1 first.

**DEM Calibration/Mosaicking**
- Sufficient overlap between acquisitions
- Long datatakes favoured
- Crossing orbits.

**Height Error**
Expected height error calculated for every acquisition.

**Phase Unwrapping**
Additional acquisitions with different imaging geometry for difficult terrain.

**Access Time**
No blocking of geographical positions for multiple repeat cycles.
### General Outline of the Data Acquisition Plan

**Data Acquisition 3 (+?) Years**

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 months</td>
<td>Commissioning Phase</td>
</tr>
<tr>
<td></td>
<td>1st global DEM acquisition with small baselines + scientific radar data products</td>
</tr>
<tr>
<td>1 year</td>
<td>2nd global DEM acquisition with larger baselines + scientific radar data products</td>
</tr>
<tr>
<td>1 year</td>
<td>DEM data takes for difficult terrain with different viewing geometry + scientific radar data products</td>
</tr>
<tr>
<td>6 months</td>
<td>scientific radar data products + customized DEMs with large interferometric baselines</td>
</tr>
<tr>
<td>≥ 1 months</td>
<td></td>
</tr>
</tbody>
</table>
Capabilities of TanDEM-X

- Cross-track baselines (0 km to several km)
- Along-track baselines (0 km to several 100 km)
- Interferometric modes (bistatic, alternating, simultaneous)
- SAR modes (Stripmap, Spotlight, ...)
- Bandwidth / resolution (100/150/300 MHz)
- Incident angles (20° ... 55°)
- Polarisations (single, dual, quad)
- Split antenna (4 receive channels)

TanDEM-X is a highly flexible sensor which enables multiple powerful imaging modes

### Cross-Track Interferometry
- Digital Elevation Models
- Spatial Coherence (forest, ...)
- Double DInSAR (change maps, ..)
- High Resolution SAR Images

### Along-Track Interferometry
- Large Scale Velocity Fields (ocean currents, ice drift, ...)
- Moving Object Detection
- Temporal Coherence Maps

### New Techniques
- 4 Phase Center MTI (traffic, ...)
- PolInSAR (vegetation height, ...)
- Digital Beamforming (HRWS, ...)
- Bistatic Imaging (classification, ..)
## TanDEM-X Products

### DEM products:
- **Intermediate TanDEM-X DEM**: TanDEM-X DEM of first global acquisition only
- **TanDEM-X DEM**: *TanDEM-X Nominal DEM*; better than HREGP specification
- **FDEMs**: DEMs processed to finer pixel spacing; has a higher random height error
- **HDEMs**: experimental high resolution DEM with additional acquisitions; regional size only; better than HRE08 specification

### SAR products:
- **experimental products** from operational TanDEM-X modes (co-registered complex images – “CoSSCs”)
- **TerraSAR-X mission basic products** from TanDEM-X raw data sets
- „byproduct“ of operational DEM processing chain: archive of *CoSSCs from all acquisitions* for DEM generation (multi-temporal global coverage)

* TerraSAR-X basic product performance parameter specification does not apply
Status & Outlook

- The TanDEM-X Ground Segment successfully passed the Operational Readiness Review (last Review Milestone before launch).

- The launch of TDX-1 has been shifted to the first half of 2010 due to an electrical problem detected on TDX-1.

- TanDEM-X science webpage will be open from beginning 2010 for proposal submission [http://tandem-x.science.dlr.de](http://tandem-x.science.dlr.de)

- Preparation of activities on-going for LEOP and Commissioning Phase.
Time for Questions?