TerraSAR-X
Status and
Future Plans

Dr. Stefan Knabe
SeaSAR, 25. January 2010
Company Profile

Status TerraSAR-X Program

Outlook TanDEM-X Program

TerraSAR-X2 „Second Generation“ Planning Status

TerraSAR-X Ship Detection Service

TerraSAR-X Maritime Application Examples
Spot Infoterra Group within Astrium and EADS

Airbus
Military Transport Aircraft
Eurocopter
Astrium
Turnover 2007: €3.5 billion
Staff 2007: 12,000*
Defence & Security Systems

Astrium Satellites
Astrium Services
Space Transportation

Telecommunications
Secure Satcom Systems
Earth Observation
Navigation

France, Germany, UK, Spain, Netherlands

Commercial in Confidence
Spot Infoterra Group: Key Facts & Figures

The Earth observation division of Astrium Services

- an international network of partners & customers
- staff: +800 staff (2008), located in 13 countries
TerraSAR-X - Status

- TerraSAR-X - Innovative SAR (Radar) satellite offering variable image acquisition modes
  - X-Band SAR System
  - Spatial resolution: up to 1 meter
  - Large area coverage up to 100 km swath width
  - Multi-polarization Image acquisition: single, dual, quad pol
  - Flexible, short-term programming and near-real-time data delivery capacity

- Public private partnership (PPP) agreed in 2002
  - EADS Astrium GmbH: satellite construction
  - German Aerospace Centre (DLR): satellite operations, exclusive scientific data rights
  - Infoterra GmbH: exclusive commercial data rights
**TerraSAR-X Imaging Modes**

<table>
<thead>
<tr>
<th>Mode</th>
<th>Spatial resolution</th>
<th>Scene Size</th>
<th>Polarization</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ScanSAR Mode</strong></td>
<td>18.5 m</td>
<td>100 x 150 (- 1.659) km</td>
<td>single pol</td>
</tr>
<tr>
<td><strong>StripMap Mode</strong></td>
<td>3.3 m (single pol)</td>
<td>30 to 50 (- 1.659) km</td>
<td>single, dual pol</td>
</tr>
<tr>
<td><strong>SpotLight Mode</strong></td>
<td>1.1 m (single pol)</td>
<td>10 km x 5 km</td>
<td>single, dual pol</td>
</tr>
</tbody>
</table>
Current and Near Future Ground Receiving Stations

TSX & TDX DRS

Commercial in Confidence
TerraSAR - Program with long term Continuity

2007  2010  2014  2019

TerraSAR-X1 (PPP) Imagery, Monitoring, DEM
TanDEM-X (PPP) Global DEM, Imagery

Second Generation
- New Technology
- More detail (0.5 m, polarization)
- Formation (TDX2), constellation
- Payload enhancement (AIS, TIR)
- Systeme response time reduction
- Service subscription

TerraSAR-X2 (commercial)

TerraSAR-3 (PPP)
TanDEM-X (TDX)

* TerraSAR add-on for Digital Elevation Measurements *
TanDEM-X Mission overview

- TanDEM-X Space Segment consists of TerraSAR-X Satellite (TSX) and the nearly identical TanDEM-X Satellite (TDX)
- Radar interferometer, flying in a very precise formation
- Objective of TanDEM-X mission:
  - acquisition of a global DEM according to HRTI-3 standard
  - generation of local DEM with HRTI-4 like quality
- Public-Private Partnership between DLR and Astrium GmbH
- Commercial and scientific use
- Launch TSX was June 2007, launch TDX within the first half of 2010
- Mission duration > 5 years
### NGA Standards for Digital Elevation Models

<table>
<thead>
<tr>
<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 90 m x 90 m</td>
<td>&lt; 30 m</td>
<td>&lt; 20 m</td>
</tr>
<tr>
<td>DTED-2 30 m x 30 m</td>
<td>&lt; 18 m</td>
<td>&lt; 12 m</td>
</tr>
<tr>
<td>HRTI-3 12 m x 12 m</td>
<td>&lt; 10 m</td>
<td>&lt; 2 m</td>
</tr>
<tr>
<td>HRTI-4 6 m x 6 m</td>
<td>&lt; 5 m</td>
<td>&lt; 0.8 m</td>
</tr>
</tbody>
</table>

*Definition of 90% point-to-point errors:*

- *Absolute height error:* The maximum height difference between the elevation model and the true terrain.
- *Relative height error:* The maximum height difference divided by the distance between the points, expressed as a percentage.

![Diagram showing absolute and relative height errors](image)
Ausblick - TerraSAR-X / TanDEM Höhenmodelle

![Graph showing various elevation model methods and their coverage in mio km².](image)

- **TanDEM**
- **TanDEM--XX**
- **TerraSAR**
- **TerraSAR--XX**
- **SRTM-X**
- **ERS Tandem**
- **SPOT 5 HRS (Ref3D)**
- **SRTM-C (restricted)**
- **SRTM-C (free)**
- **USGS GTOPO30**
- **Airborne LIDAR**
- **Airborne SAR**
- **Photogrammetry**
- **HR Satellites**
- **Aster**

**DTED/HRTI Level**

- Nation-wide (0)
- Continental (50)
- Global (150)

**Coverage in Mio km²**

- 0 (nation-wide)
- 50 (continental)
- 100 (global)
- 150 (global)
TanDEM-X - Secondary Mission Goals

**Pol-InSAR**
- fully polarimetric

**Digital Beamforming**
- 4 phase centres:
  - high resolution
  - wide swath imaging
  - ambiguity suppression

**Along-Track Interferometry**
- HELIX formation:
  - short along track baseline,
  - vanishing cross track baseline
  - sensitive to slow and fast movements

**Bistatic Observations**
- bistatic angle:
  - New image parameters
  - Bistatic Doppler
  - Multiple shadows
TerraSAR-X2
( TSX2 )
TerraSAR-X Second Generation (TSX2)

- **Commercial program**
  - Infoterra: lead and Service Segment
  - Astrium: Space Segment (satellite and launch)
  - DLR: Ground Segment, system procurement, QA

- **Implementation Study finished (Phase 0: 4-11/2009)**
  - Trade-off of options
  - Confirm costs, risks, schedules
  - Demonstrate performance improvements

- **Feasibility Study start in 2010 (Phase: A)**
- **Launch envisaged for 2014**
TSX2 Major Improvements vs. TSX1

- **SpotLight resolution 0.5 m (design focus)**
- **Increased, flexible swath width**
  - StripMap: 10 – 40 km @ 1 – 4 m (optional design focus)
  - ScanSAR / TopSAR: 50 – 500 km @ 5 – 50 m
- **Polarization without szene size reduction**
- **Quicker system response time (Near Real Time) with**
  - Polar stations (X + S-band as of 2010)
  - Increased down link rate (up to 800 Mbps)
  - Mission planning, downlink, up to each orbit
- **Ideal constellation scenario:**
  - 2 x TSX2 (InSAR / Mapping)
  - + 4x TSX2 (Monitoring)
TSX2 Key SAR Performance Figures

TerraSAR-X2

- Two simultaneous receive chains
  - Full dual-pol standard for all acquisition modes
  - Quad-pol capability inherent

- good product quality at 600 MHz

- Optimized for High Resolution Spot Light
  - 0.5m @ 10 x 10 km @ VV+VH or HH+HV

- Wide set of Strip Map options
  - 1 m @  10 km
  - 2 m @  20 km
  - 3 m @  30 km
  - 4 m @  40 km

- Wide set of Top SAR / Scan SAR options
  - 5 m @  50 km
  - 10 m @ 100 km
  - 16 m @ 160 km
  - 30 m @ 300 km
  - 50 m @ 500 km
TSX2 Additional Payload

**Thermal Infrared Sensor**
- High spatial resolution: 10 m
- Reveals thermal signatures within the SAR image
- Enables automated guidance/search in SAR image analysis
- SAR provides the resolution, TIR provides additional signatures

**AIS Receiver**
- SAR image acquisition at the same time as AIS reception
- No external AIS-source or time sync. needed
- Ideally merged with SAR vessel detection information: quick and reliable tactical overview
TSX2 SpotLight Simulation: 0.5 m, 3-Pol.

Courtesy DLR-HR (F-SAR, 600Mhz, 0.5m, „3-Pol“, SLC)
TSX2 TIR simulation: 7.6 m, uncalibrated
TerraSAR-X Ship Detection Service
Maritime Surveillance – Increasing Information Need

- **Maritime traffic control (incl. illegal trafficking),**
  strong increase of ship traffic due to globalisation

- **Boarder control,** extension to and beyond 200 mile zone
  - custom control (smuggling)
  - illegal immigration

- **Homeland security,** increasing terrorist attacks

- **Illegal fishing** (e.g. new EC Fishery Control Directive)

- **Environmental Pollution Control:** Oil damping

- **Northern Sea Routes safety,** increasing shipping & resources exploitation activities in the Arctic enabled by climate change

- ....
**Scope**

- Situational awareness for Exclusive Economic Zone (200 nm zone, approx. 370 km), open sea monitoring beyond coastal Radar range (30 to 40 km), early warning towards in-coming traffic / threats

- Ship detection information to be integrated into customer’s situational awareness centre
  - Integration in Coastal Surveillance and Vessel Traffic Management Systems: complementary information source to coastal Radar, AIS / LRIT / VMS, etc. to provide full situational awareness picture
  - Support to tactical planning of sea-based / airborne interception operations

**Service Concept**

- Centralized, modular Maritime Surveillance Services providing information to varying European and national stakeholders (mainly public authorities) ➔ Opportunity to share costs

- Fully automatic TSX ship detection processors directly implemented in Direct Receiving Station (DRS) to enable NRT information delivery

- Multi-mission concept: integration of main satellite sensors to comply with high monitoring frequency requirements
Ship Detection Product Example

Display of ship detection product incl. AIS overlay (kml-file) on Google Earth basis:
- red circle: SAR based ship location
- green arrow: AIS information
- Grey arrows: coastal Radar

Location: North Sea, German Bight, Helgoland
Radar Oil Spill Detection Module

Eastern Crimea (Ukraine) - Oil Spills

TerraSAR-X
StripMap Acquisition

Location of Crimea:

Satellite Information
Sensor: TerraSAR-X
Imaging Mode: StripMap
Ground Range Resolution: 16m
Polarization: HH+VV
Pass Direction: Descending
Acquisition Date: 2005-11-16
Acquisition Time: 03:52:00 to 03:52:14 UTC
Product Type: Geoencoded (Rectified)
Resolution Mode: Spatially Reshaped

Map Projection
Geographic: Universal Transverse Mercator

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© Copyright by Infoterra GmbH, 2010 © Commercial in Confidence
Dr. Stefan Knabe
Product Manager Maritime Services
Infoterra GmbH
Claude-Dornier Str.
D-88090 Immenstaad
Germany
T: +49 7545 8 3177
E: stefan.knabe@infoterra-global.com