

Commissioning the TanDEM-X Ground Segment An Interim Commissioning Phase Perspective

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Topics

- Ground Segment Extensions for TanDEM-X
 - Mission Operations Segment
 - Instrument Operations and Calibration Segment
 - Payload Ground Segment

- TDX Flight Logbook

- First TDX Images and TanDEM DEMs



TanDEM-X Mission

Exciting mission on top of TerraSAR-X:

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

Primary mission goal: consistent high-resolution global world-wide DEM

Fly TSX and TDX in close formation and thus form bistatic SAR interferometer.

Technical challenges

- formation design
- ground-controlled formation maintenance and reconstruction
- collision and mutual illumination avoidance
- high precision reconstruction of interferometric baseline
- „combination“ of two independent (even if „twins“) SAR instruments specifically: independent oscillator frequencies
- global data acquisition and systematic processing into DEMs



TanDEM-X Extensions for Mission Operations Segment / Instrument Operations and Calibration Segment

S-Band Ground Station Weilheim and Others
TT & C

TSX Monitoring & Control System

TDX Monitoring & Control System

Mission Planning
Generation of TSX and TDX Timelines with TerraSAR-X and TanDEM-X Data Takes
Downlink Ressources Handling
Power Thermal Modeling
Sync Horn Selection
Sync Warning Data Takes
Bistatic Data Take Start Time Synchronization
Exclusion Zone Handling

Flight Dynamics
Maintenance of TSX Reference Orbit Attitude and Orbit Products Provision
Maintenance of TDX Helix Formation
Common Maneuver Planning and Execution
Interferometric Baseline Product Provision

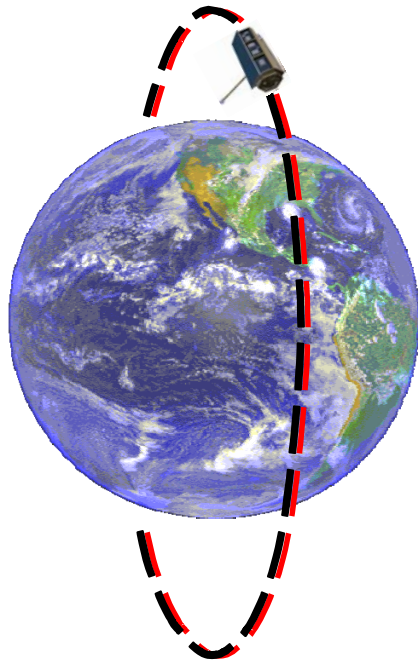
Radar Parameter & Instrument Command Generator
Generation of Data Take Command Sets for TerraSAR-X and TanDEM-X Data Takes
TanDEM System Command Generator
Bistatic Data Take Structure

Instrument Table Generator
Foot Print Data Base
Beam Tables
Instrument Tables
Exclusion Zone Calculation
Oscillator Frequency Offset Determination

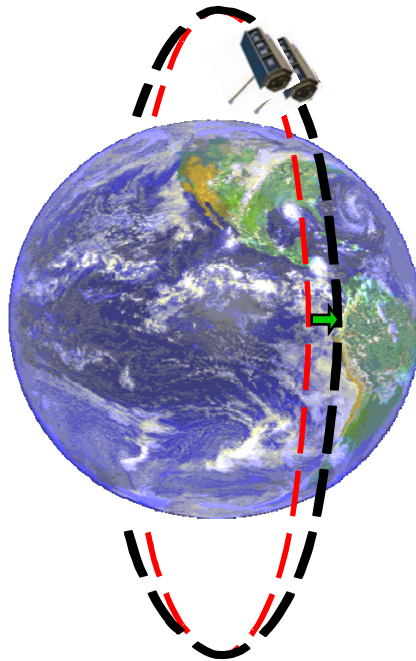
TanDEM-X Acquisition Planner
Long-Term Acquisition Plan
(incl. approximate ressource modeling)
Formation Parameter Calculation
Acquisition Parameter Calculation



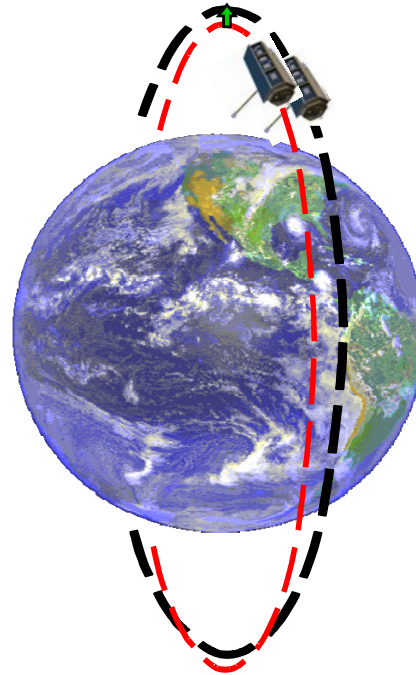
How To Form the TSX – TDX Formation



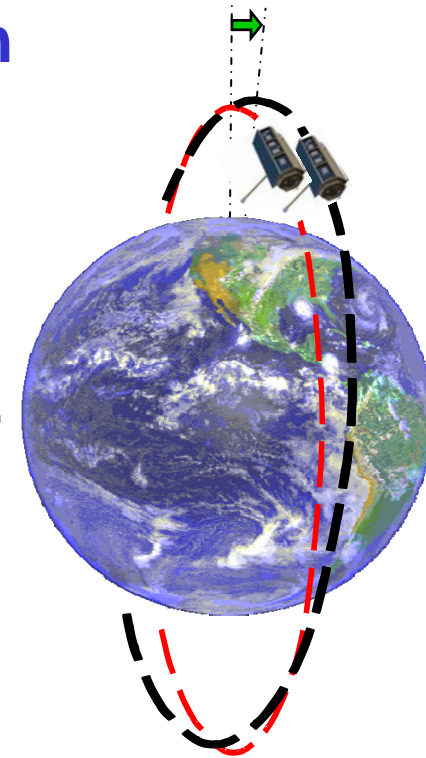
Identical orbits and identical location.



Rotate orbital plane (i.e. R.A.A.N.)
=> yields horizontal separation at equator crossings (but orbits cross at poles)



Change eccentricity
=> causes different heights of perigee / apogee
=> yields radial separation at poles (= safe formation)

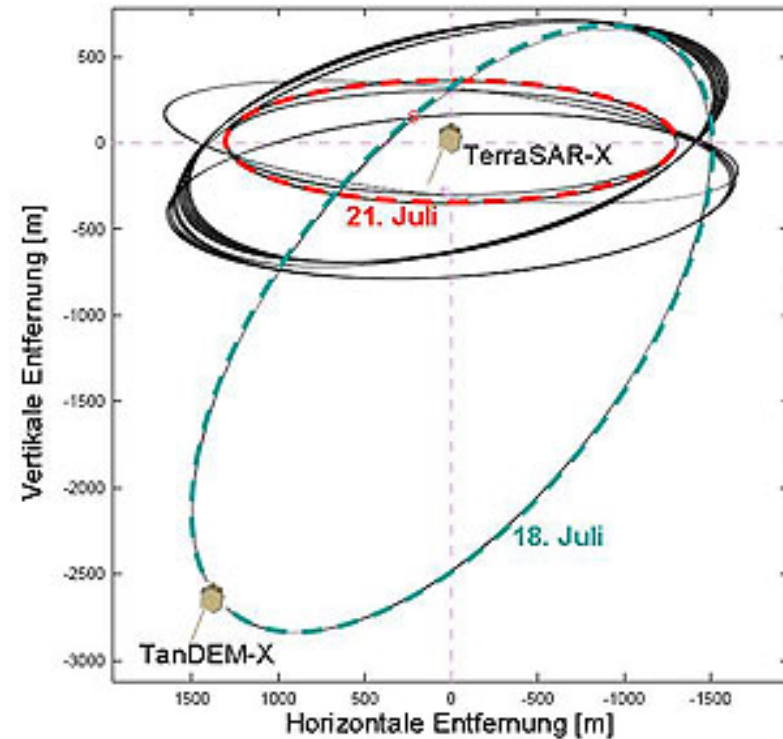


Optionally rotate the argument of perigee
=> yields larger baselines at high latitudes



TDX Flight Logbook – Drift Phase

- June 21: **launch**
TDX follows TSX at 16.000 km distance on June 21
- along-track drift initiated:
630 km per day
- no alignment with
TSX reference orbit yet
- **system data take ordering only**
(accounting for scene „mis-location“)
- June 24 (3.6 day after launch):
data acquisition and processing starts
- July 12 – 20: orbit manoeuvres to stop drift
and to acquire the wide (20 km distance)
formation with TSX



„Art in Space“ by Ralph Kahle

DT 11 Madagascar

24.06.2010 14:55:44

DT 12 Donez

24.06.2010 15:11:45

DT 13 Livny

24.06.2010 15:12:44

Replay to NSG

24.06.2010 15:13:56

First Images

24.06.2010 15:47

2nd TDX Images Downlink

24.06.2010 16:46:41



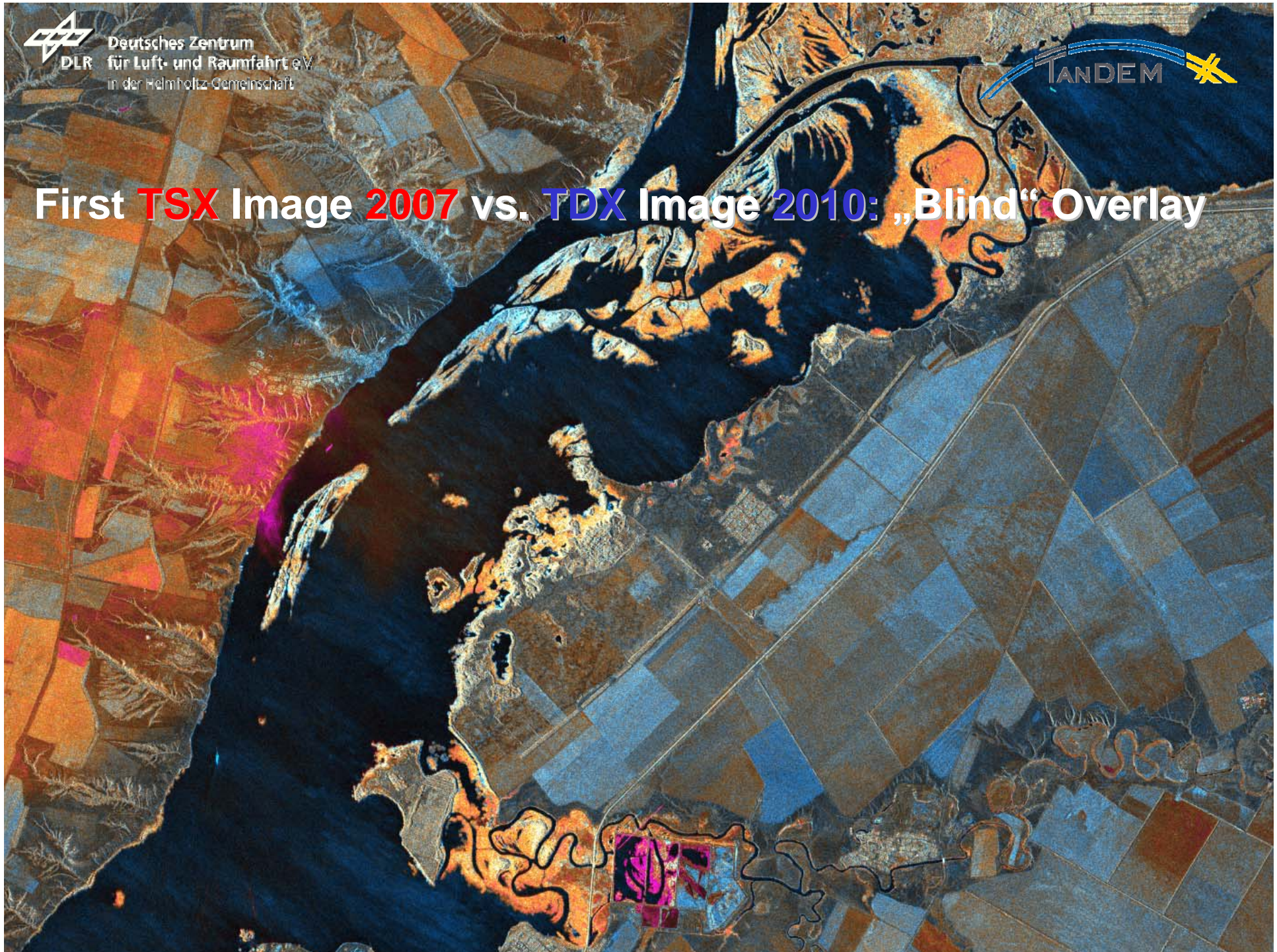


Deutsches Zentrum
für Luft- und Raumfahrt e.V.
in der Helmholtz-Gemeinschaft

TANDEM



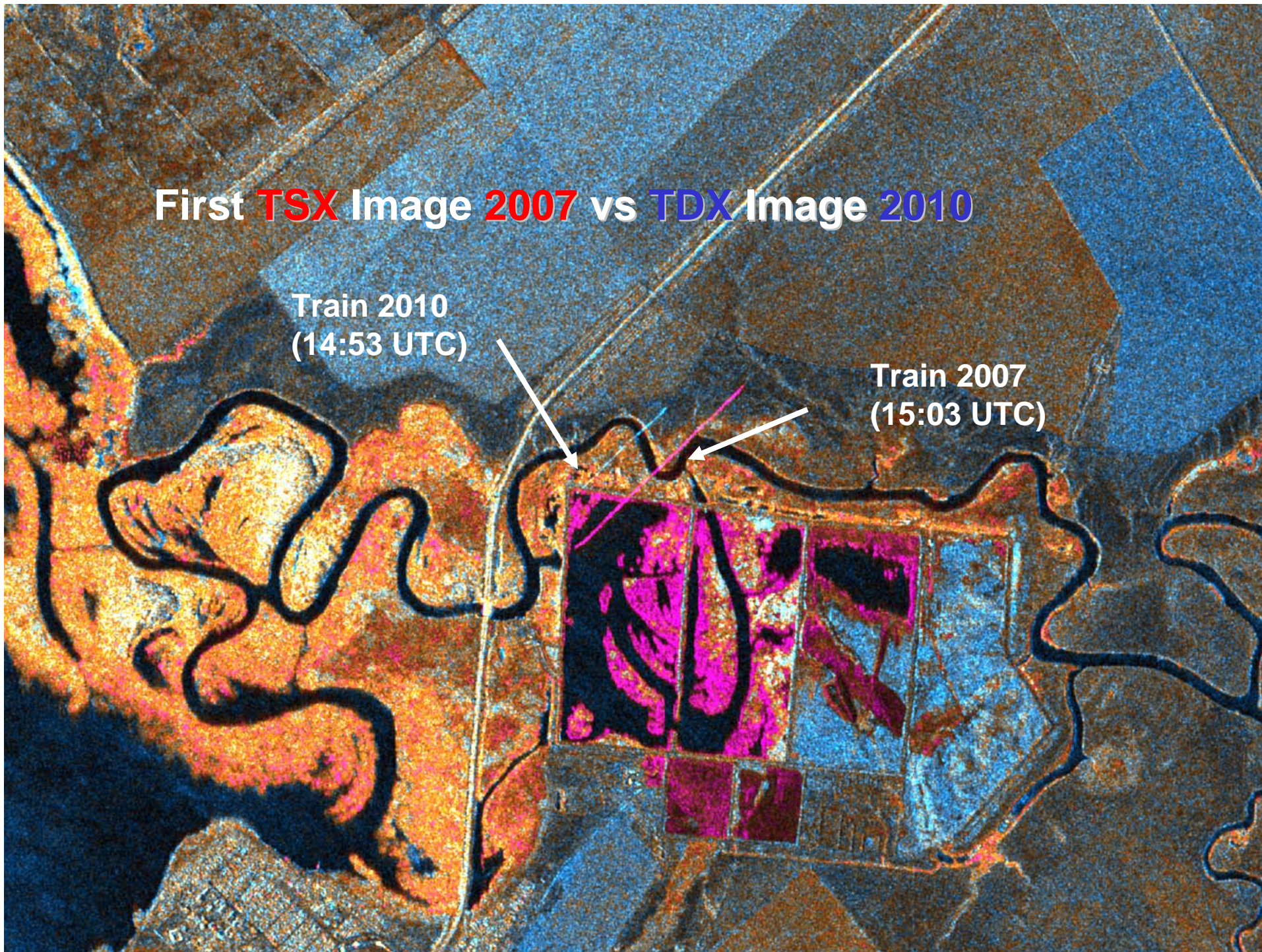
First **TSX** Image **2007** vs. **TDX** Image **2010**: „Blind“ Overlay



First **TSX** Image **2007** vs **TDX** Image **2010**

Train 2010
(14:53 UTC)

Train 2007
(15:03 UTC)





TDX Flight Logbook – Wide Formation (Pursuit Monostatic)

- July 20: wide formation reached
- July 22 (cycle day 1): regular pursuit monostatic TanDEM data taking and processing starts
- from July 22 to beginning of October: TDX follows TSX with 2.6 sec delay
- horizontal separation of 1305 m at equator to yield same ground-track (compensate Earth rotation)
- 300 m radial separation to have sufficient distance in case of unintended approach (safe mode etc.)
- monostatic instrument and formation flying commissioning
- at end:
 - formal review to allow close (bistatic) formation
 - release operational TerraSAR-X mission for both satellites

Payload Ground Segment Extension for TanDEM-X



NSG Receiving Station
X-Band Data Reception
S-Band Uplink / Downlink

**TerraSAR-X
Transcription System**
Data Take Decryption
Data Take Assembly

**TerraSAR Multi-Mode SAR
Processor (TMSP)**
Data Take Screening
L0 Product Generation & Archiving
L1b User Product Generation

**TerraSAR-X Order and
Production Control /
Delivery Product Generator**

**User Services
(EOWEB)**

**Product Library
Catalogue & Archive**



**TanDEM Ground
Station Network**
X-Band Data Reception
S-Band Uplink / Downlink
Station Monitoring and Control

TanDEM Transcription / Screening
Data Take Decryption / Data Quality Screening

TanDEM Ingestion System
Data Take Ingestion / L0 Product Archiving

Integrated TanDEM Processing System
Interferometric Quality Pre-Check
L0 precise screening
Raw DEM Generation
CoSSC Generation

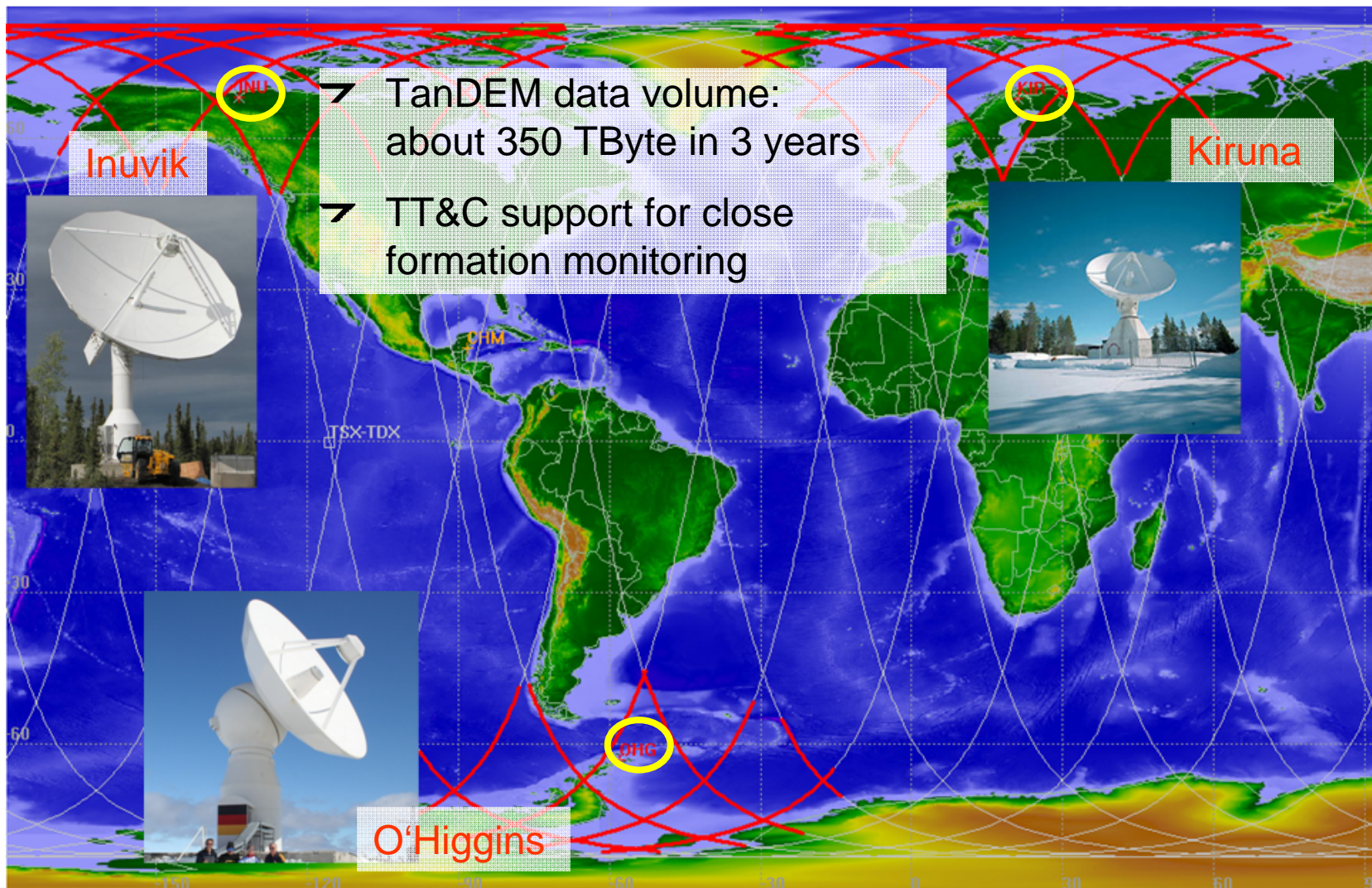
**DEM Mosaicking and Calibration
Processing System**

**TanDEM-X Acquisition Production
Control**





TanDEM Ground Station Network Commissioning





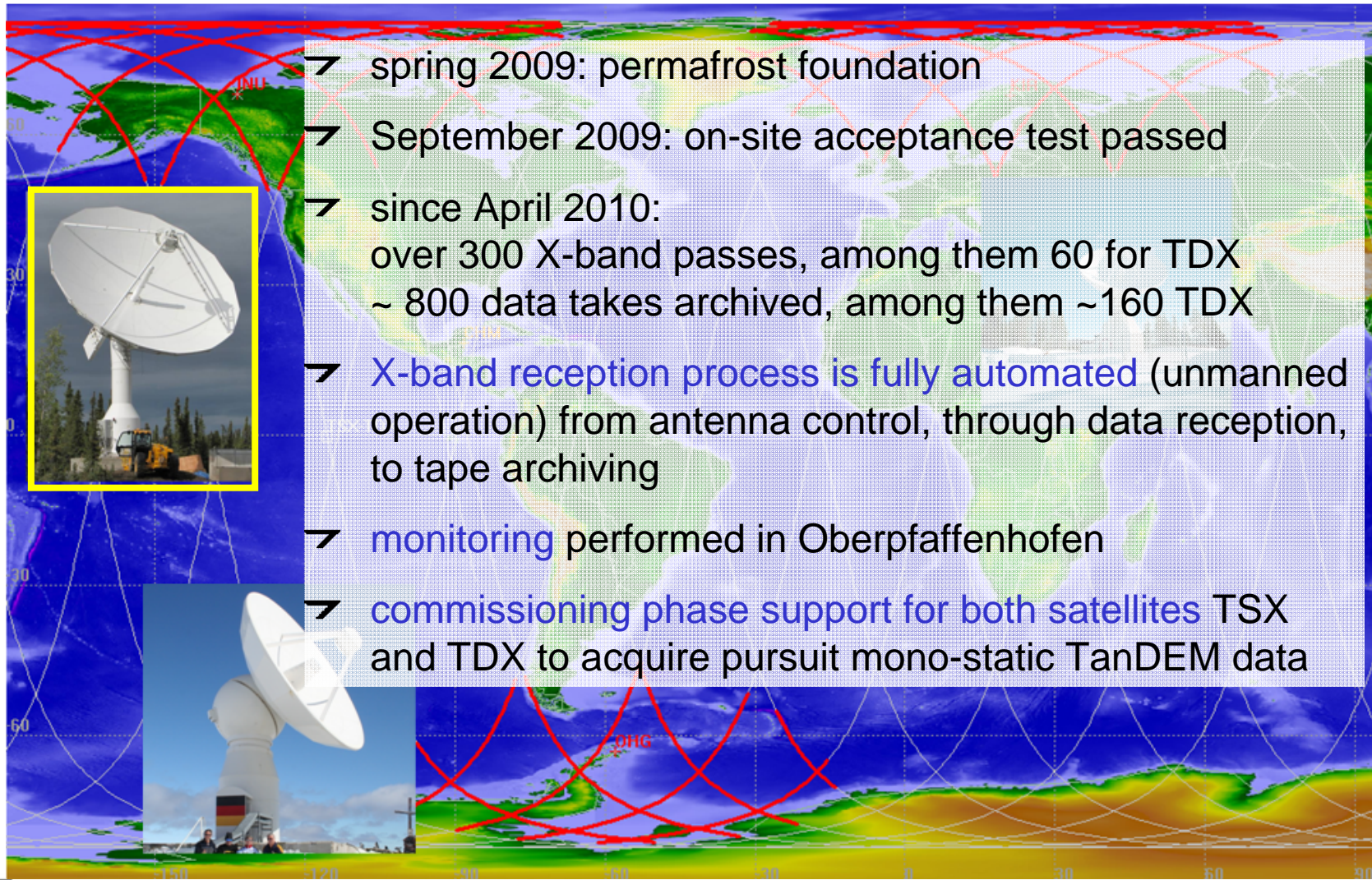
DLR's German Antarctic Receiving Station O'Higgins

- since Oct. 2008:
operational X-band data reception for TerraSAR-X background mission
- since Nov. 2008:
routine 24h/7d TT&C support during Antarctic summer
- after TDX Separation (June 21, 02:29 UTC):
First Acquisition Combined Troll / O'Higgins Pass (UTC 02: 53)
- LEOP and Check-Out: 9 to 10 TT&C Passes per day
- thus: OHG **already successfully commissioned** for TDX as well





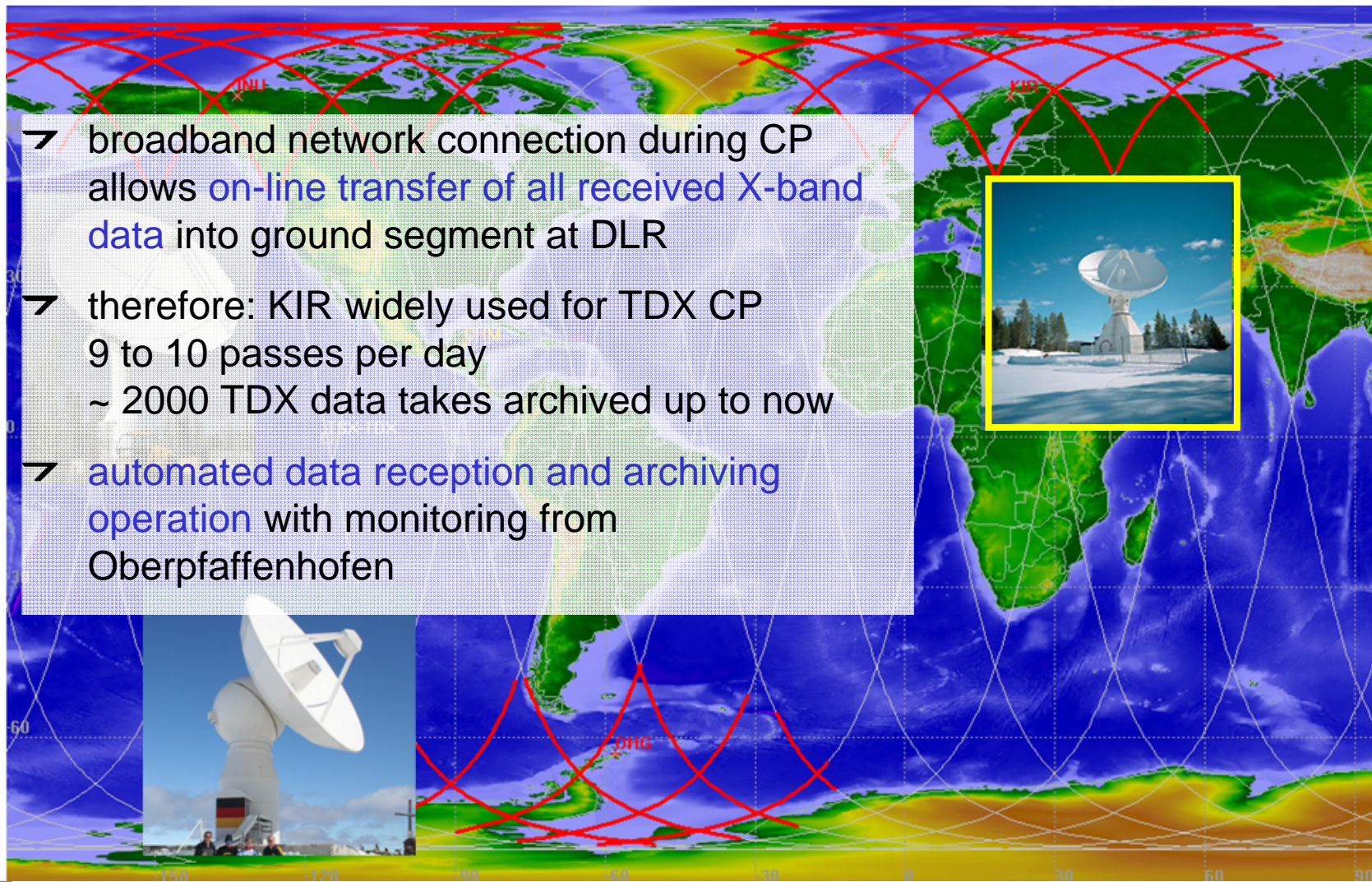
DLR's Inuvik Satellite Station in Canada

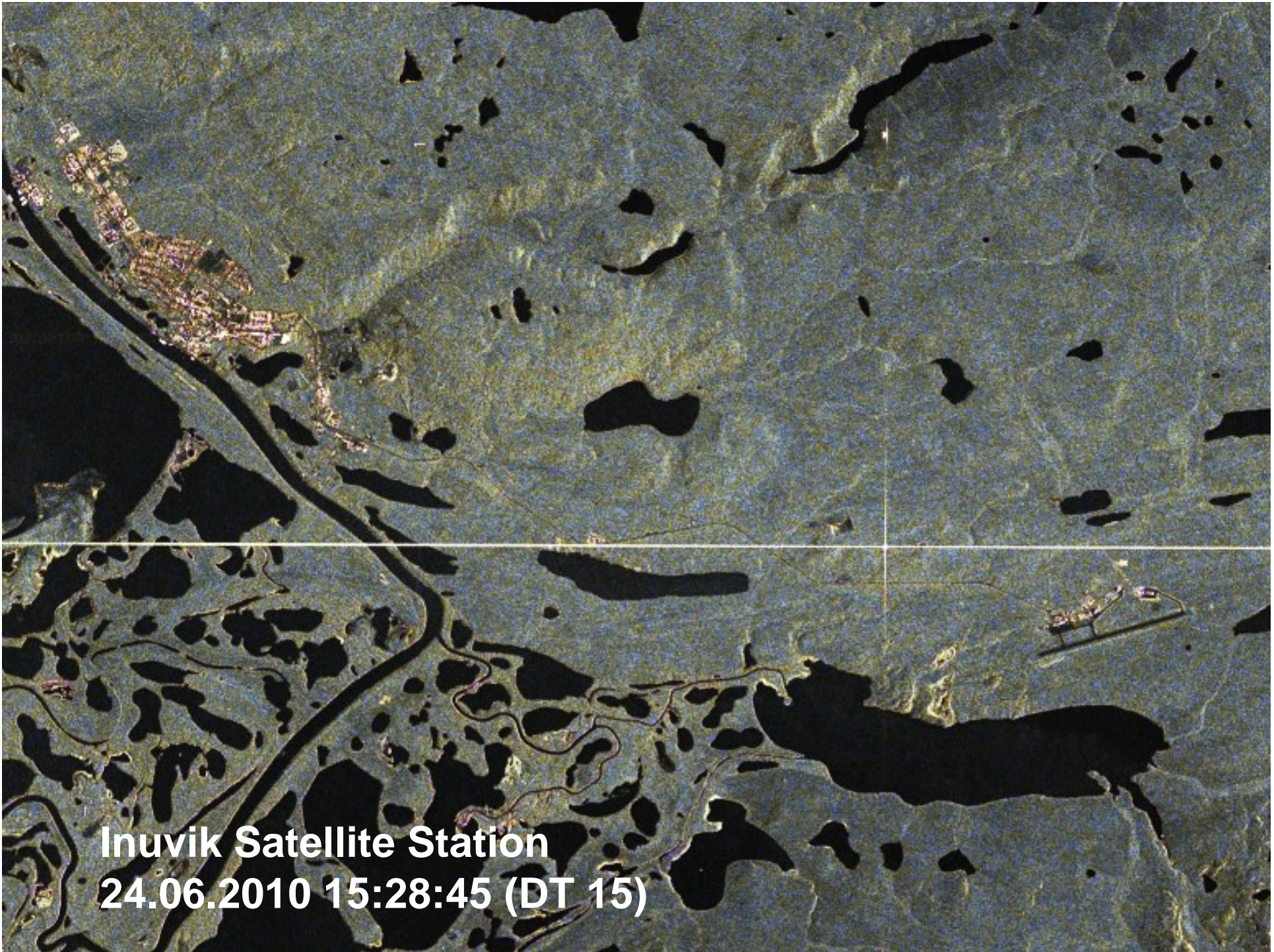


- spring 2009: permafrost foundation
- September 2009: on-site acceptance test passed
- since April 2010:
over 300 X-band passes, among them 60 for TDX
~ 800 data takes archived, among them ~160 TDX
- X-band reception process is fully automated (unmanned operation) from antenna control, through data reception, to tape archiving
- monitoring performed in Oberpfaffenhofen
- commissioning phase support for both satellites TSX and TDX to acquire pursuit mono-static TanDEM data

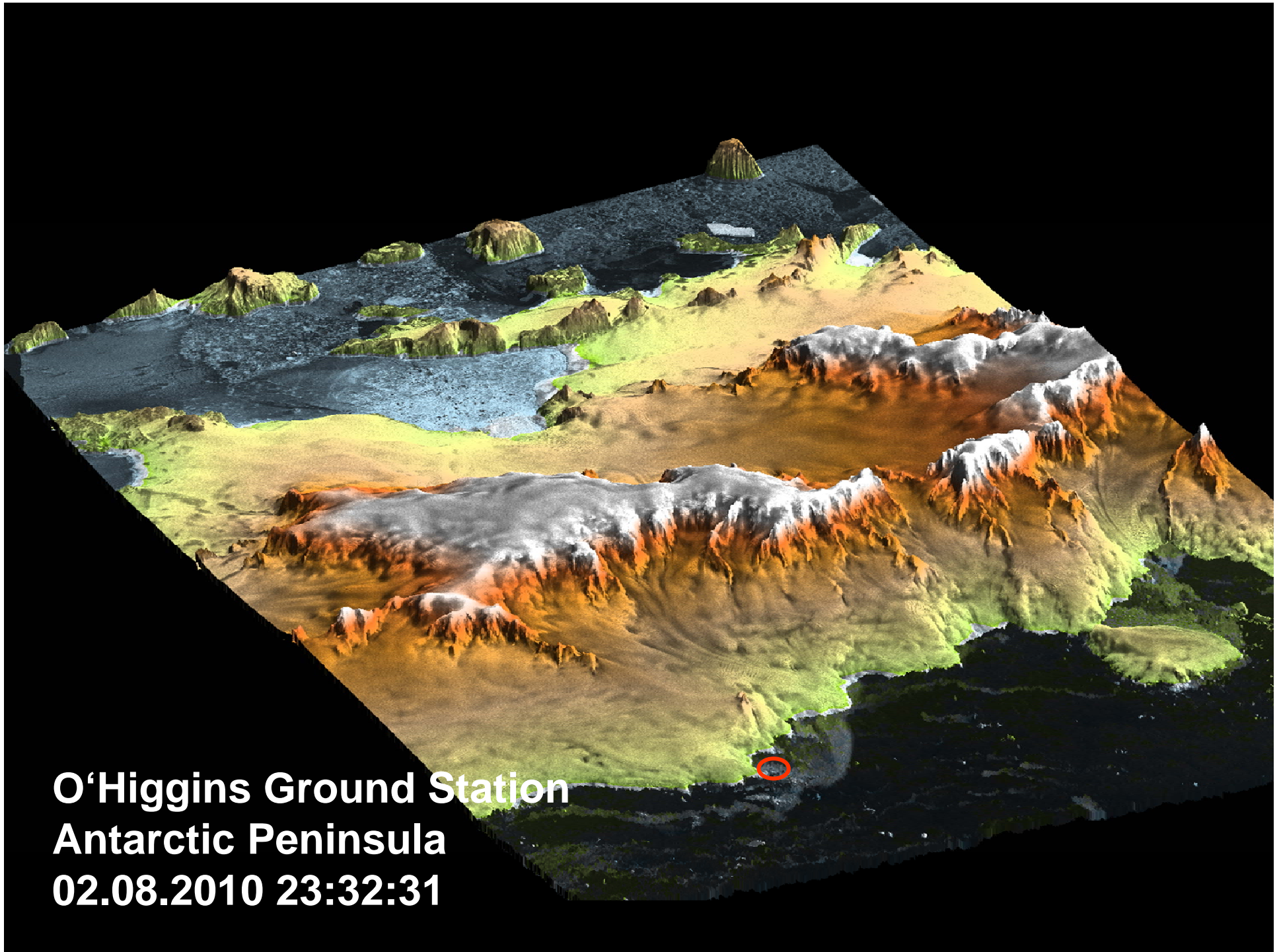


Partner Ground Station SSC ESRANGE Kiruna





Inuvik Satellite Station
24.06.2010 15:28:45 (DT 15)



O'Higgins Ground Station
Antarctic Peninsula
02.08.2010 23:32:31



Data Quality Screening at Ground Stations Fast Quality Assessment and Commanding Feedback

Replay of TanDEM data take pair:

separate for TSX and TDX channel and possibly in portions to different ground stations.

Therefore: Direct SAR data quality screening at station with immediate online delivery of quality summary annotation (no mass data) to DLR

- received data quality and completeness (partial replay extent)
- raw data statistics
- baseband Doppler estimates
- sync pulse analysis

As soon as all quality summary annotations for 1 TanDEM pair are complete at DLR:

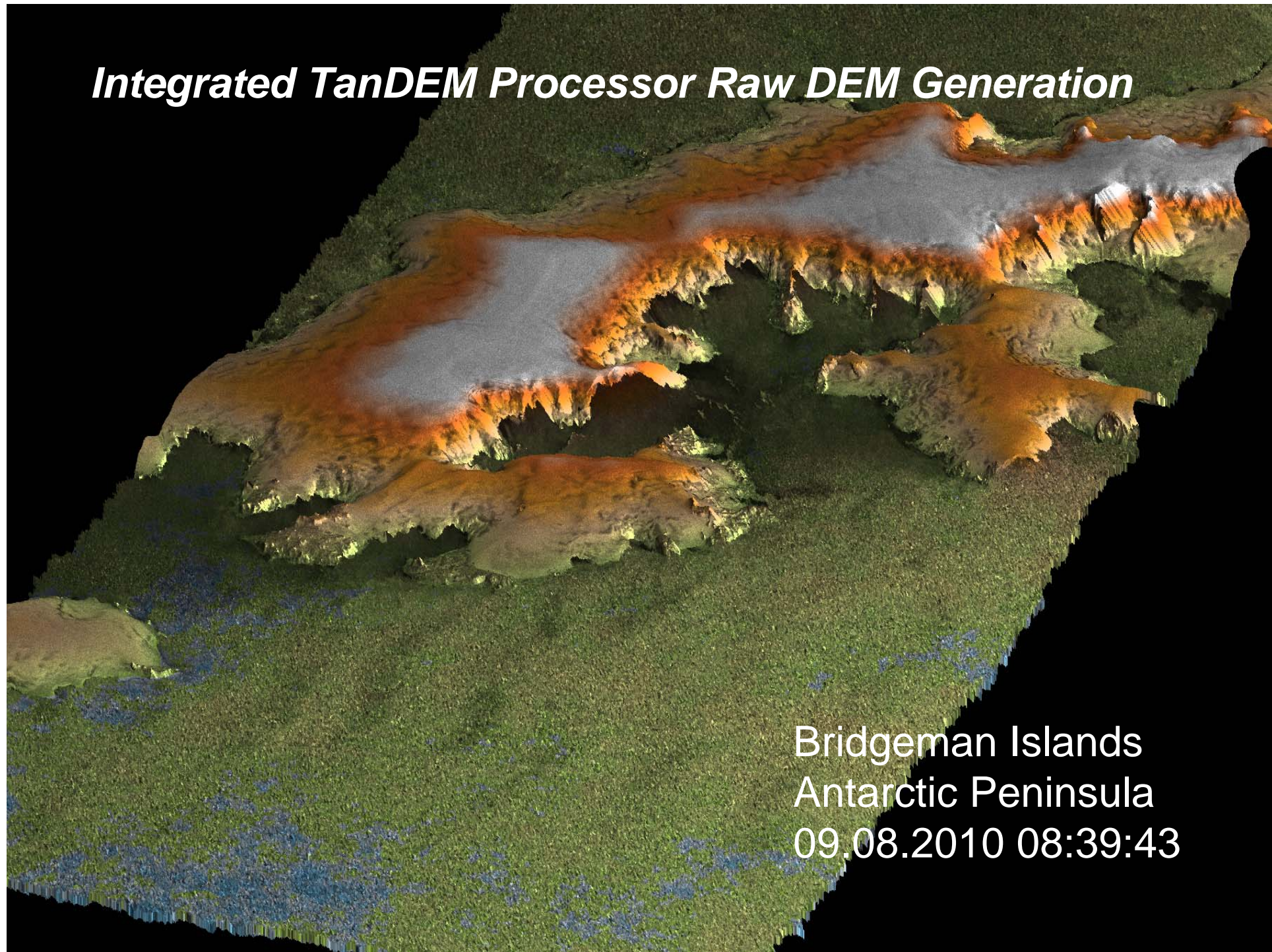
Interferometric quality pre-check performed by ITP

- common illumination check
- common geographical coverage check
- sync pulse evaluation

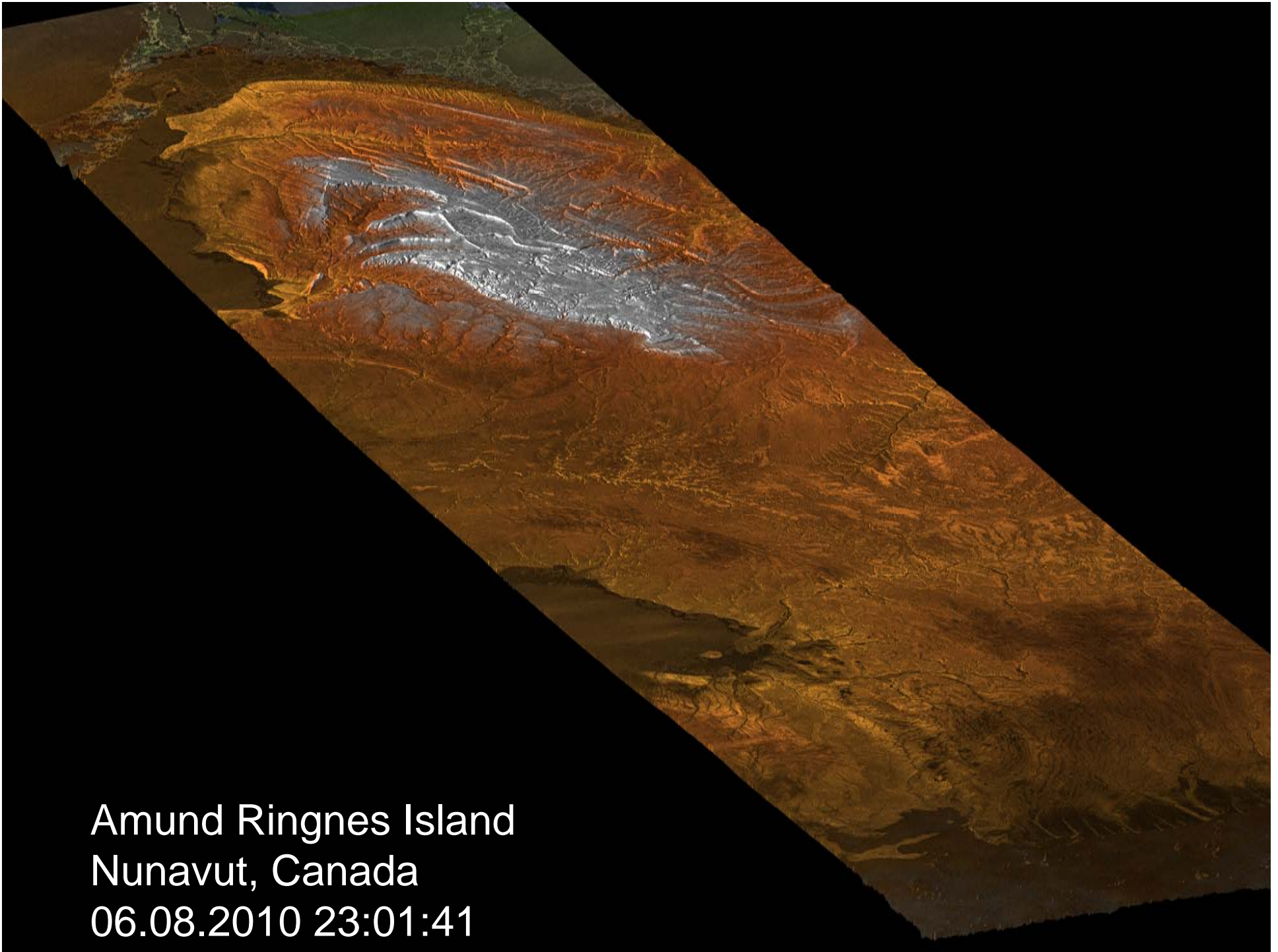
Thus: Immediate feedback for

- possibly (immediate) reordering of data takes
- long-term acquisition planning
- instrument commanding

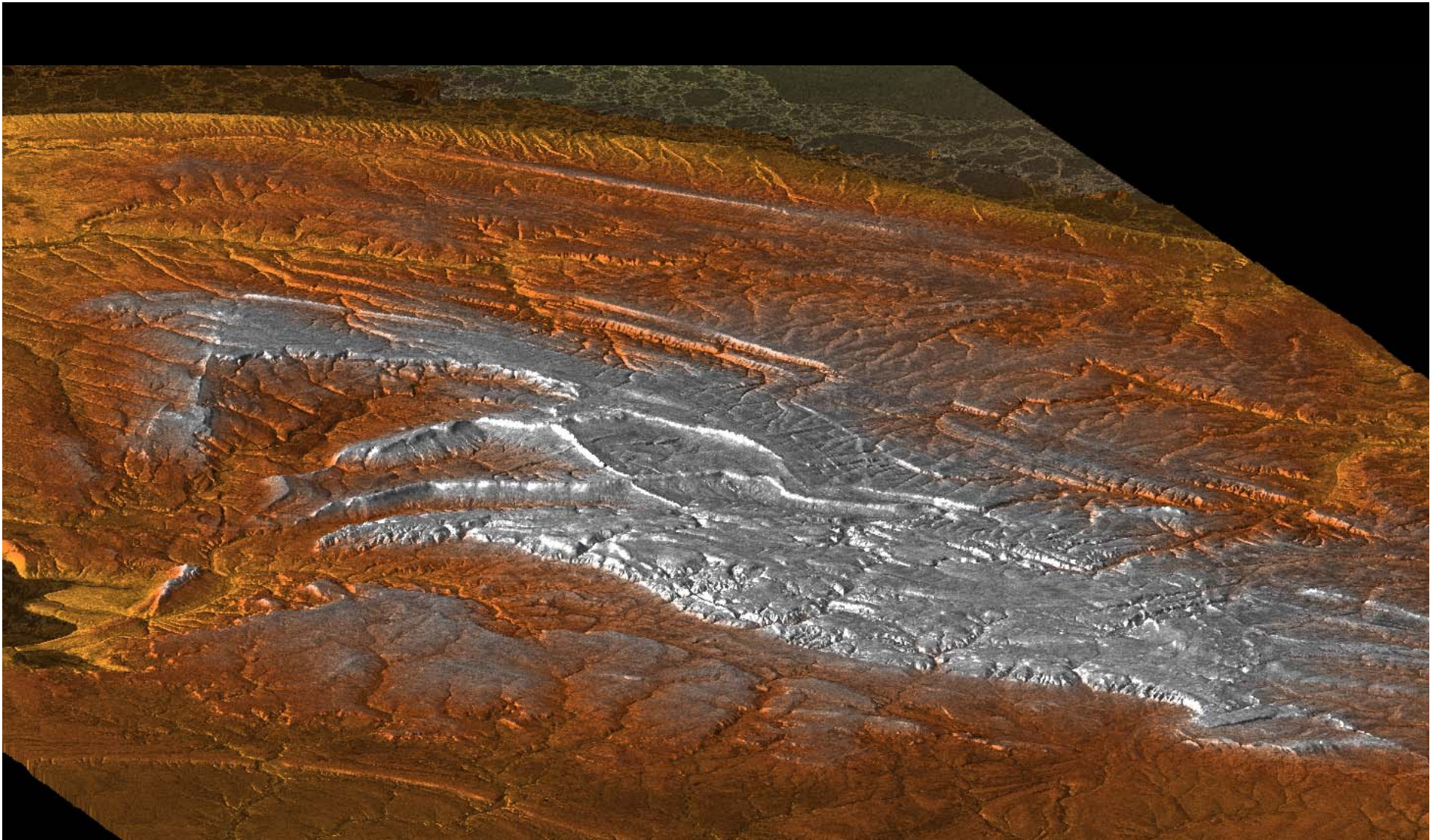
Integrated TanDEM Processor Raw DEM Generation



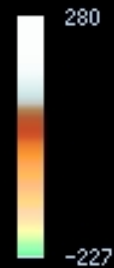
Bridgeman Islands
Antarctic Peninsula
09.08.2010 08:39:43



Amund Ringnes Island
Nunavut, Canada
06.08.2010 23:01:41



Amund Ringnes Island
Arctis, Canada
06.08.2010 23:01:41





TDX Flight Logbook – To Be Continued Bistatic Commissioning Phase (Close Formation)

- from October until end of year
- zero (+/- 800 m) along-track separation
- 400 m radial / 362 m horizontal separation
- daily formation maintenance maneuvers by TDX (cold-gas)
- bistatic TanDEM commissioning
- routine TerraSAR-X mission using both satellites



Conclusions and Outlook

- TDX data taking and processing started only 3.6 days after launch.
- TanDEM data taking and raw DEM generation started at day 1 of the first pursuit monostatic cycle.
- TanDEM-X ground segment is already in very good shape for systematic DEM data acquisition and raw DEM processing.
- Further ground segment extensions planned for near future, e.g. for DEM production monitoring, acquisition and processing of experimental data takes, etc.
- **Transition into close formation and bistatic commissioning promises to become a new thrilling experience.**

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(Förderkennzeichen 50 EE 0601)



**Tandem-X
Mission Blog
at
<http://www.dlr.de/>**



UTC 176/11:14:13
MET 804/08:44:45

