

## TerraSAR-X and TandDEM-X Missions

Joerg F. Herrmann, Infoterra GmbH

Industry and Science Supporting GMES

CEOS Workshop

Oberpfaffenhofen, 17 October, 2007



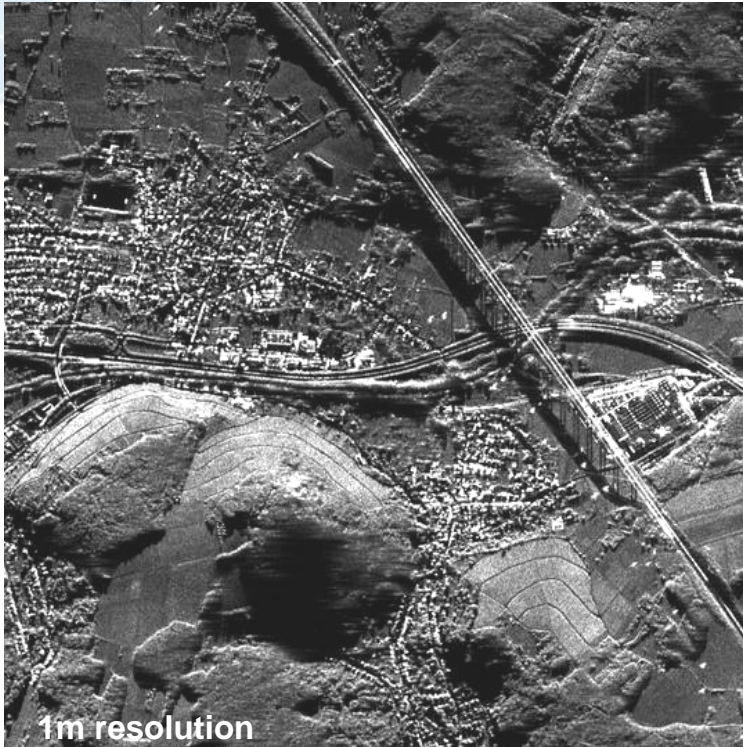
Infoterra GmbH

## TerraSAR-X Launch 15 June 2007

- Successful launch 4:14 h CEST from Baikonur, Kazakhstan
- 1st contact 04:29 h CEST over ground station in Malindi, Kenia
- 1st Images processed June 19th
  - StripMap
  - SpotLight
  - HR SpotLight



# First commercial 1m SAR Satellite Imagery



**TerraSAR-X  
commercial  
offer starts in  
January**

TSX/TDX@CEOS, OP, Oct 2007

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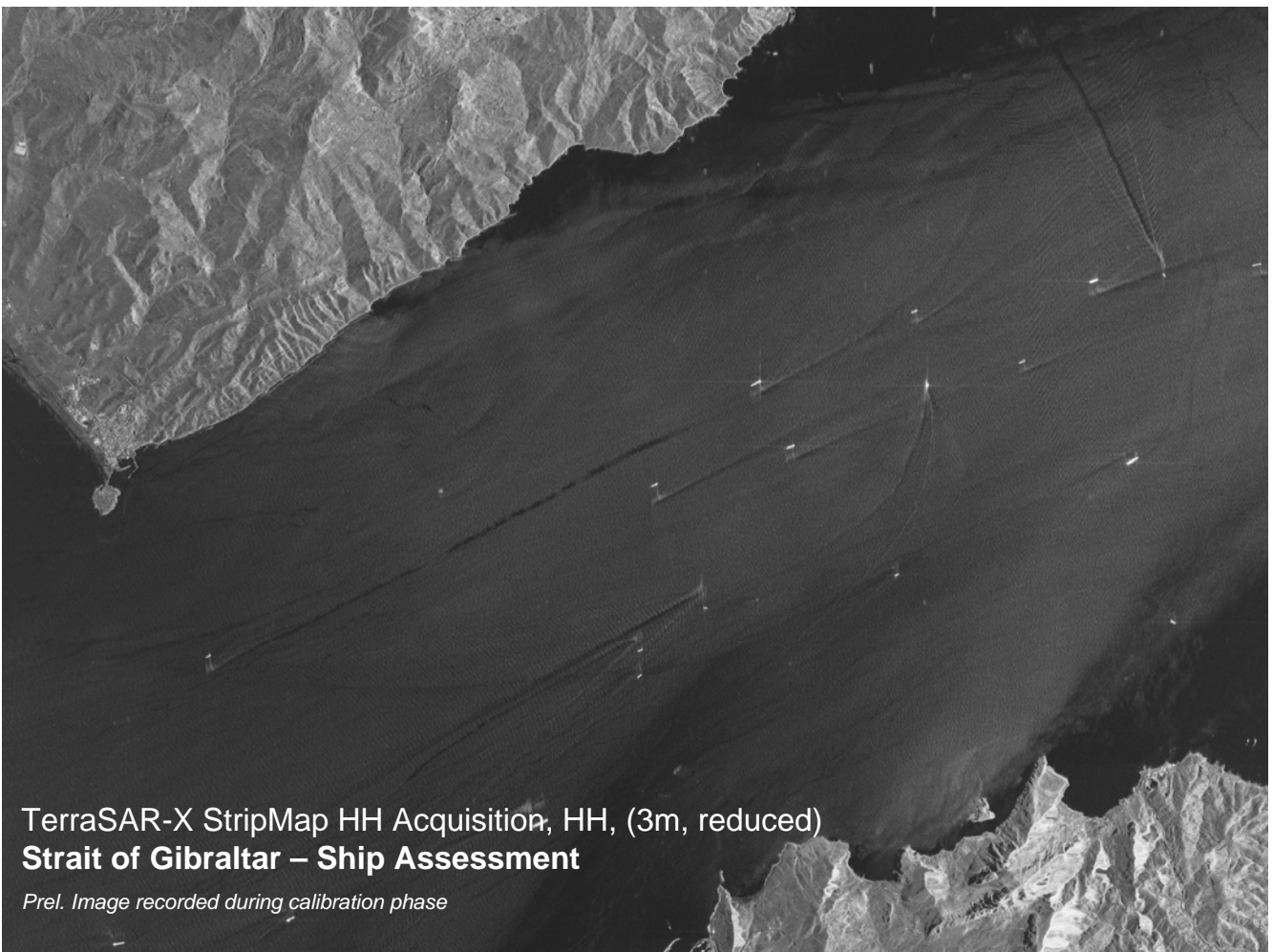
**TerraSAR-X SpotLight Acquisition, HH, (1m reduced)  
Pyramids of Giza, Egypt**

*Pref. Image recorded during calibration phase*



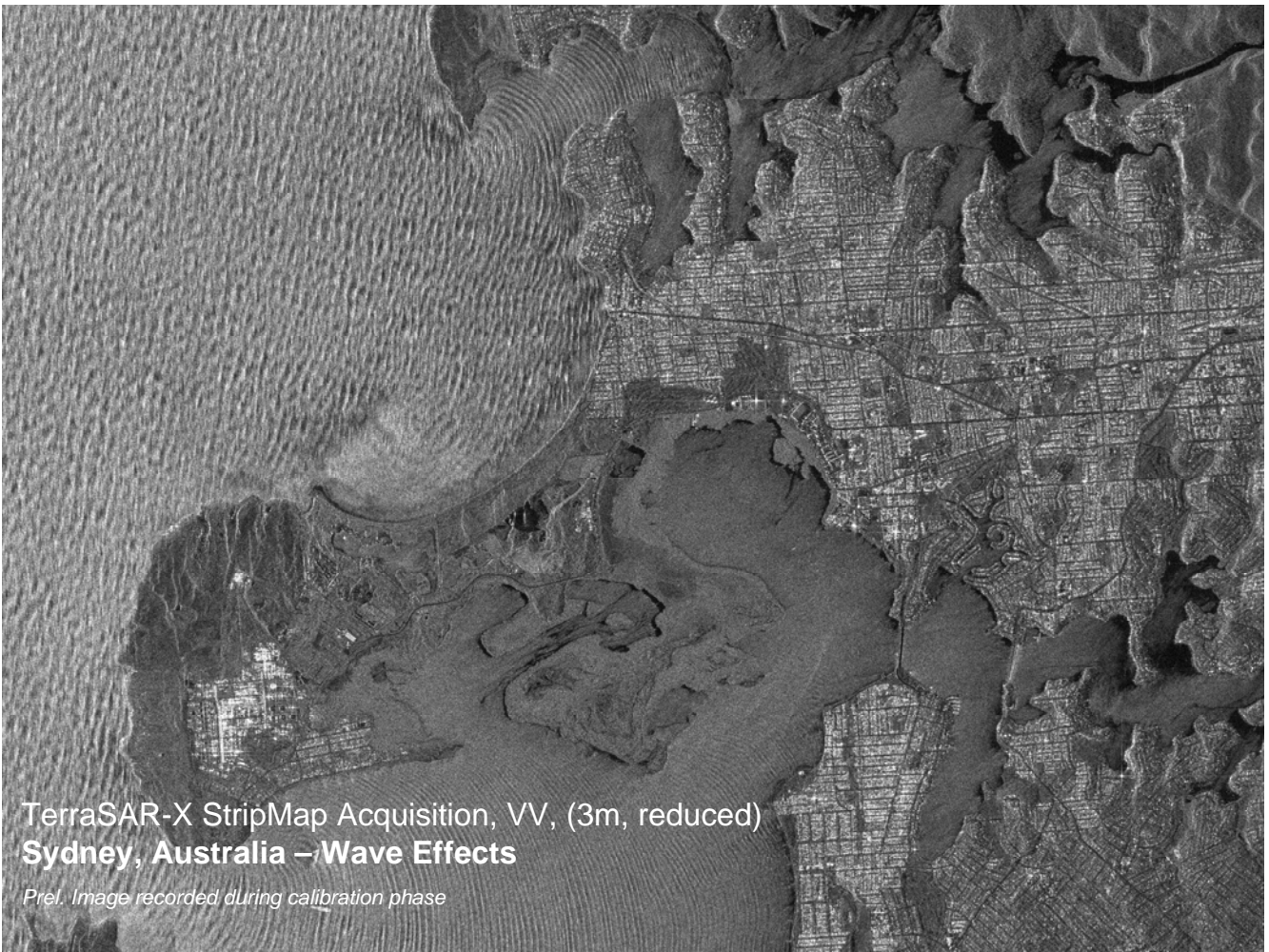
**TerraSAR-X StripMap Acquisition (3m res) of  
Berlin City Center, Germany**

*Prel. Image recorded during calibration phase*



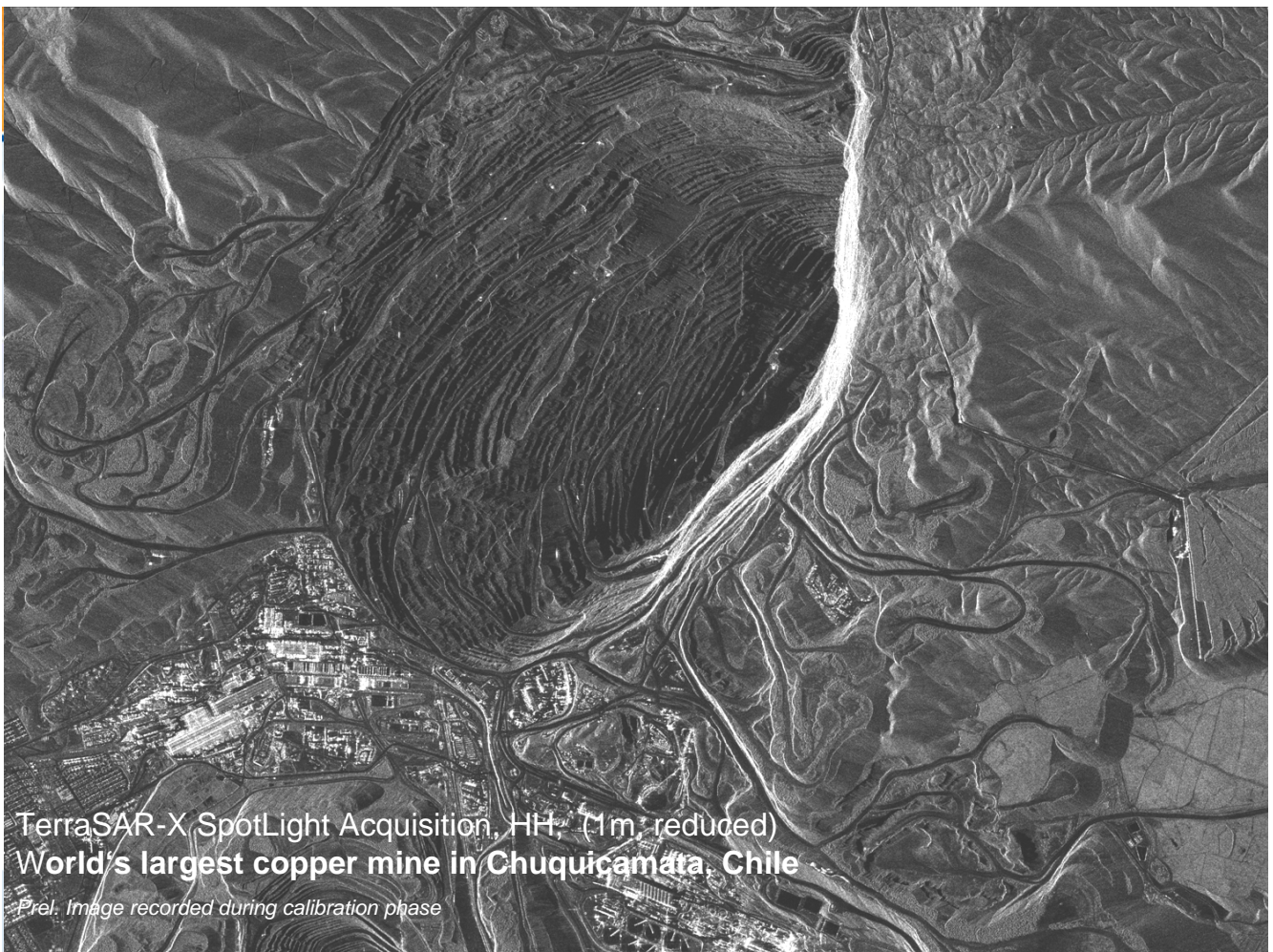
**TerraSAR-X StripMap HH Acquisition, HH, (3m, reduced)  
Strait of Gibraltar – Ship Assessment**

*Prel. Image recorded during calibration phase*



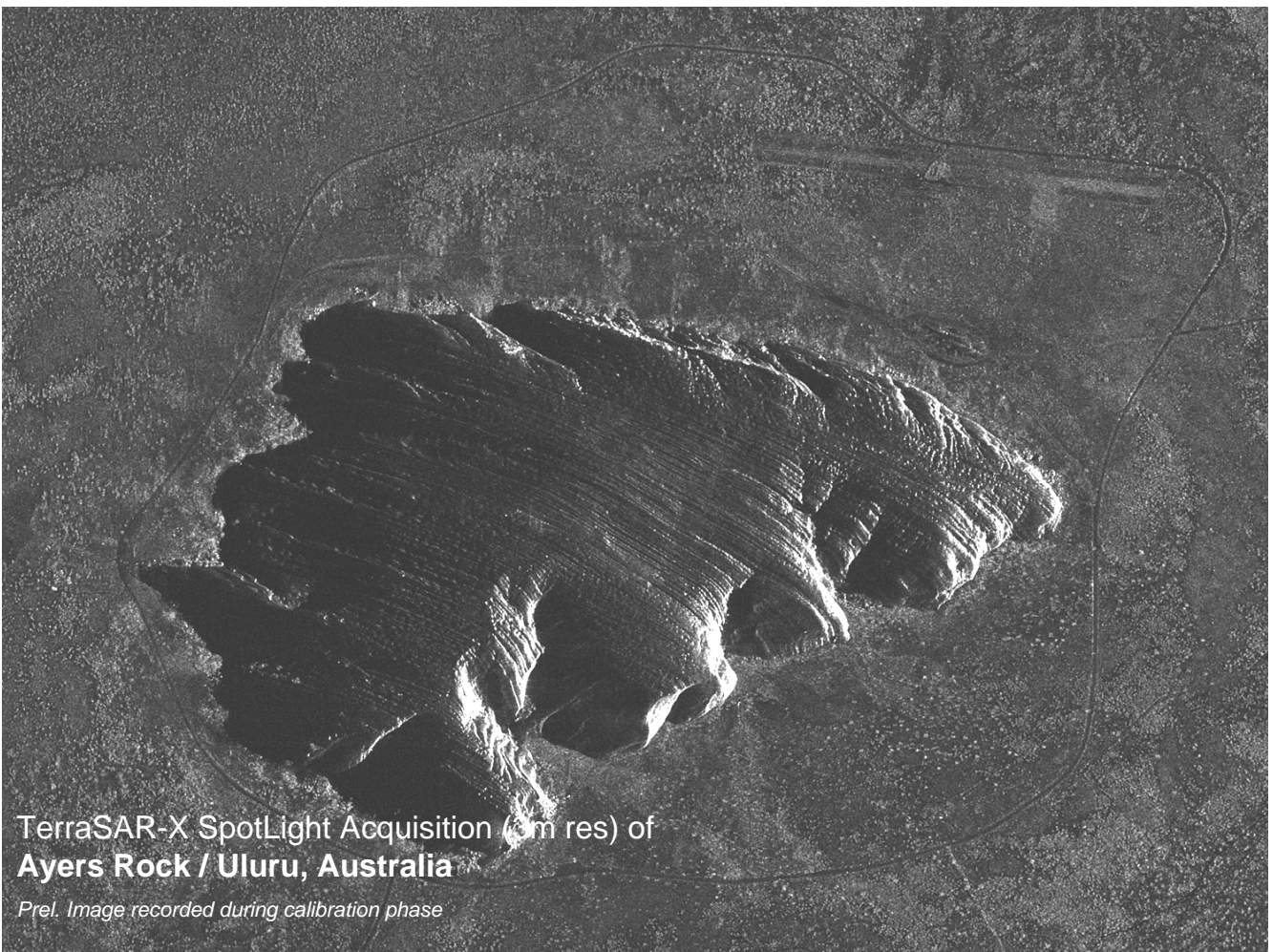
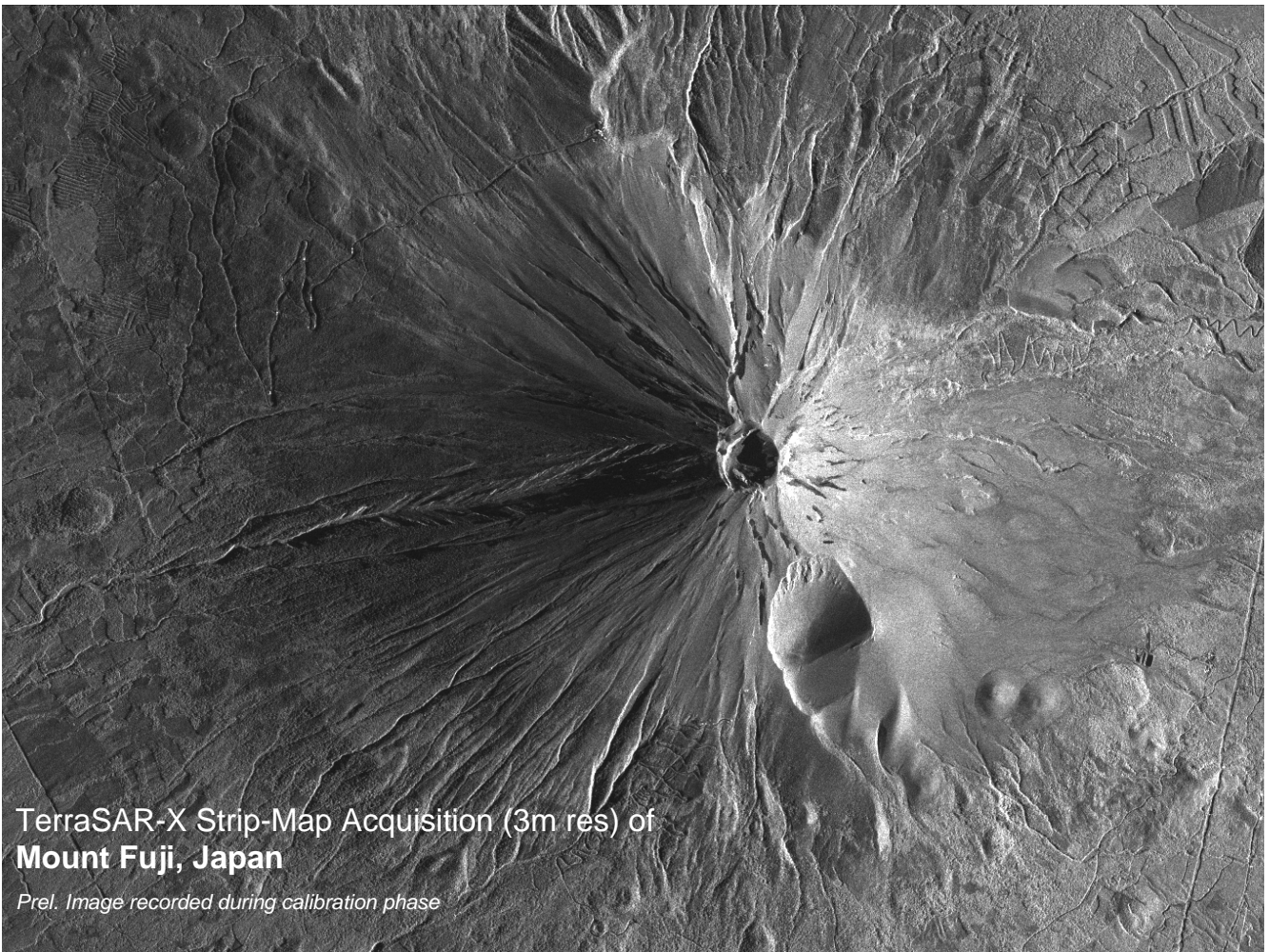
**TerraSAR-X StripMap Acquisition, VV, (3m, reduced)**  
**Sydney, Australia –Wave Effects**

*Prel. Image recorded during calibration phase*



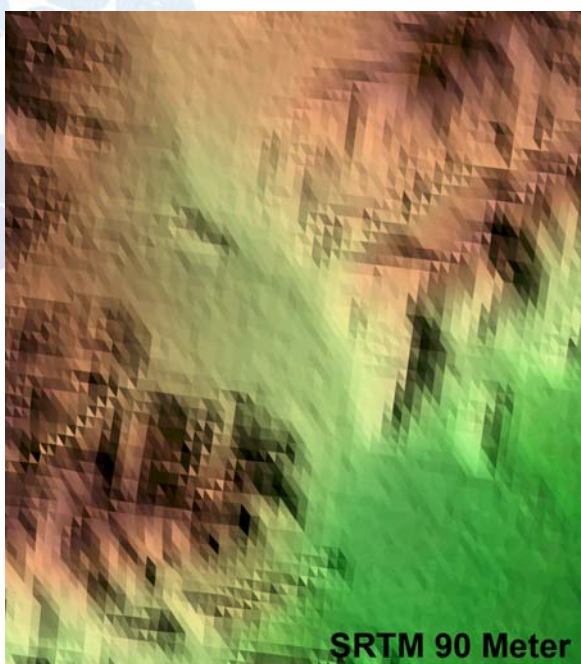
**TerraSAR-X SpotLight Acquisition, HH, (1m, reduced)**  
**World's largest copper mine in Chuquibambilla, Chile**

*Prel. Image recorded during calibration phase*

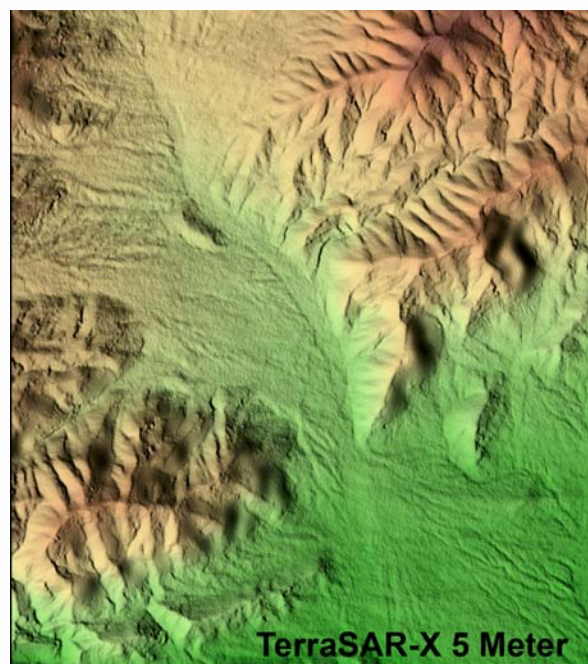




## TerraSAR-X Dual Pass Interferometry – Las Vegas



**SRTM 90 Meter**



**TerraSAR-X 5 Meter**

Credit: DLR; date: July 7, 2007; original resolution: 1 metre (reduced image); mode: SpotLight Mode; polarisation: VV

# Content

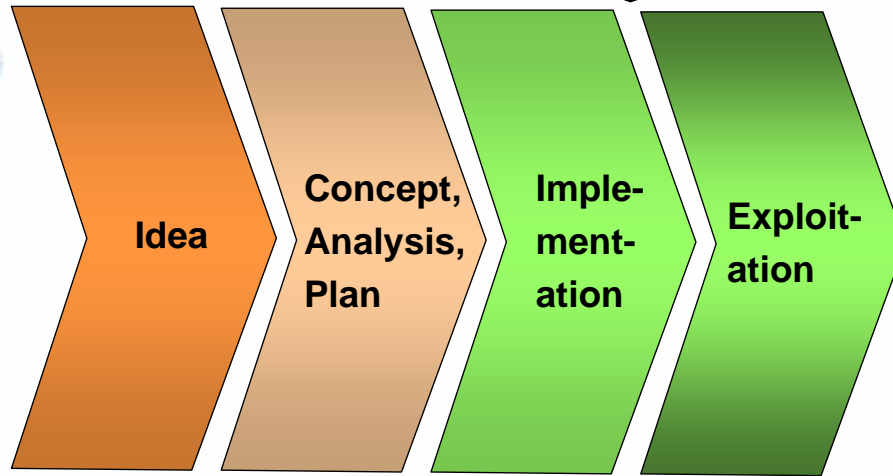
- Commercialization
- TerraSAR Program
- System
- Infoterra
- Services
- GMES

# Commercialisation of Remote Sensing in Germany

- First attempts made in early 1990s
- Government: make commercial use of many years of technology developments
- Industry: government/industry risk sharing
- Policy Drivers
  - Economically viable co-funding scheme with clear rights and duties (sustainable service)
  - Share benefits and risks 50/50
  - Legal rules to avoid political business risks

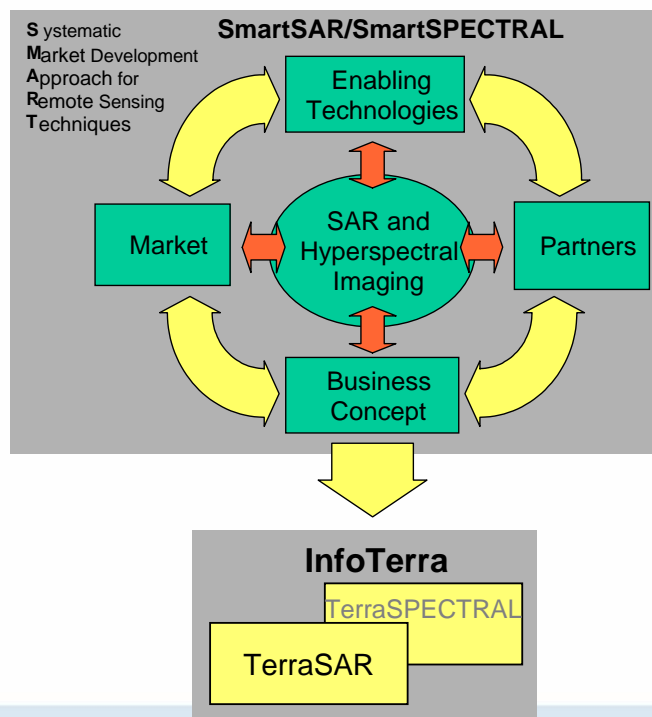
# Start-up Phases

1997



**Motivation**    **Broad**    **Start-up**    **Growth**  
**Competence,**    **Capital**    **Capital**  
**Seed Capital**

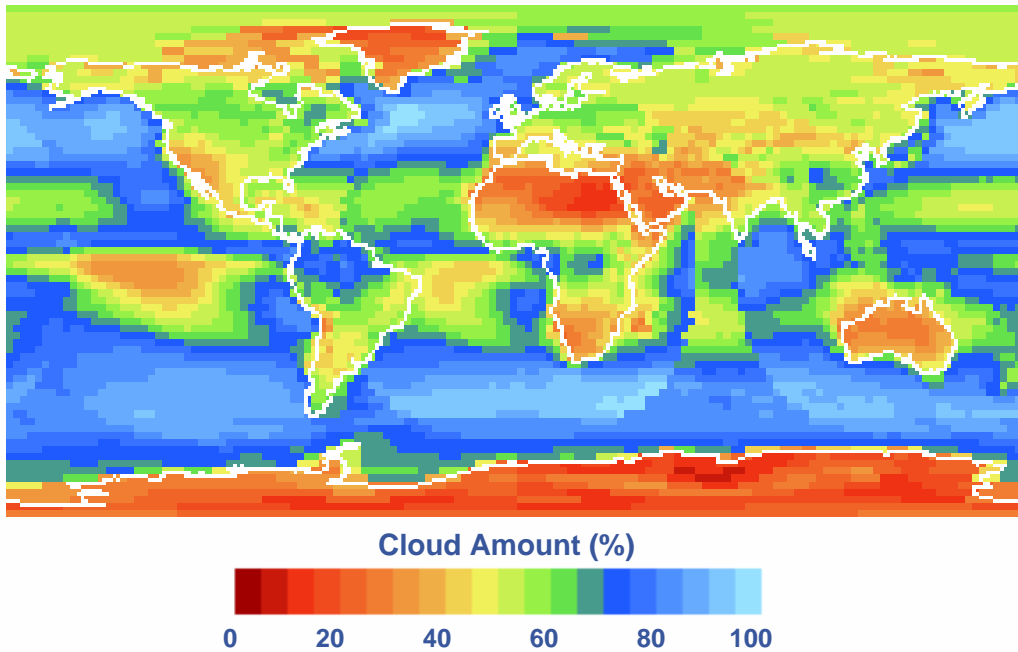
# Commercialisation Systematics





## Regional Advantage/Complementarity of Radar

### World-wide Cloud Cover Prevalence (8 year mean average)



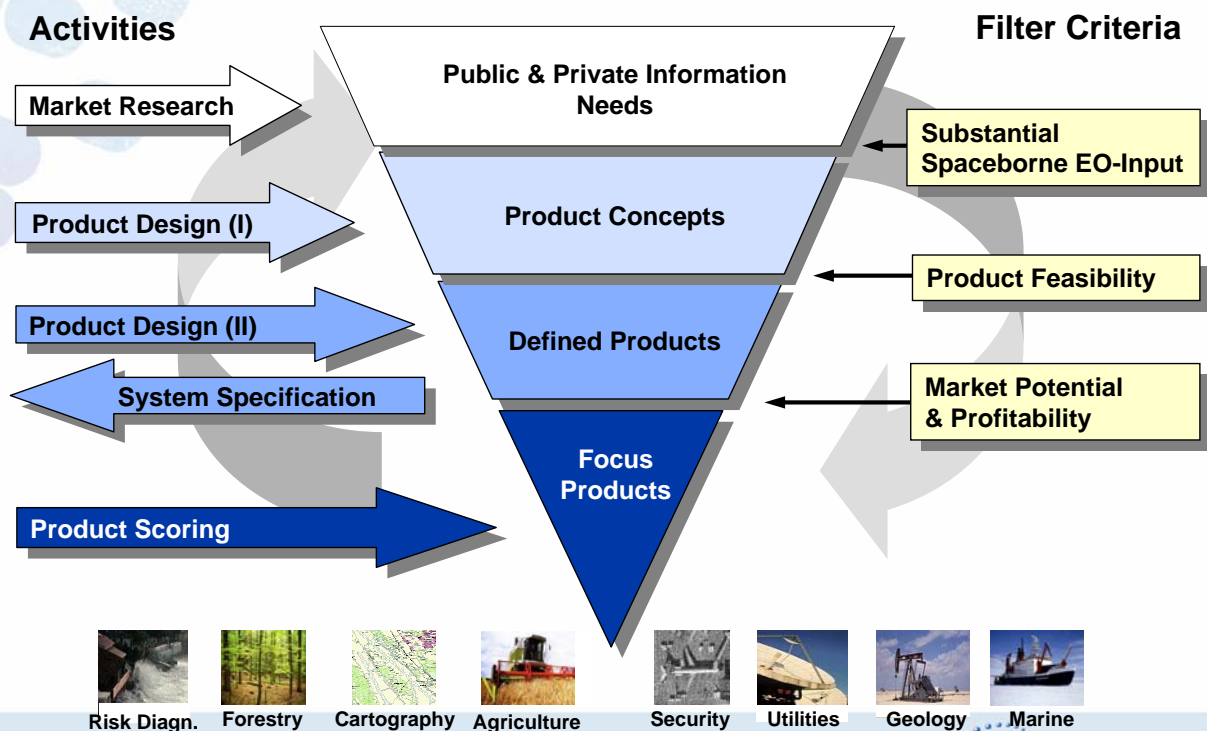
## Radar Remote Sensing to be up-to-date



# TerraSAR-X Program

- **Market-derived system using innovative technology**
  - 1 meter resolution
  - Novel acquisition flexibility
  - Large area coverage
- **Public private partnership (PPP) agreed in 2002**
  - EADS Astrium GmbH
  - German Aerospace Centre (DLR agency)
- **Exclusive commercial data rights with Infoterra GmbH, in turn for industry investments (TSX1 and TSX2); now extended by TanDEM-X (TDX)**

# Market-derived System



## TerraSAR-X PPP Features

- **Public-Private Partnership (PPP)**
- **First system (S/C, launch, ground and service segment) fully funded including 5 years of operation**
  - 25% EADS Astrium / Infoterra
  - 75% DLR
- **Infoterra commercialize data service and obligation for service continuity:  
finance TerraSAR-X2 (resulting in 50/50 shared cost)**
- **System collection capacity shared 50/50 between science and commercial**

## Roles of PPP operating Partners

### Infoterra GmbH

- **TerraSAR-X service for all national and international non-scientific requests (private and government)**
- **Products and services world-wide**
- **Reception stations world-wide**
- **Commercial tasking through DLR with priority**

### DLR

- **Satellite and instrument operation**
- **Basic SAR Products**
- **Provide data to science community for research and development (AO process)**

## Data Rights for TSX1 and TDX

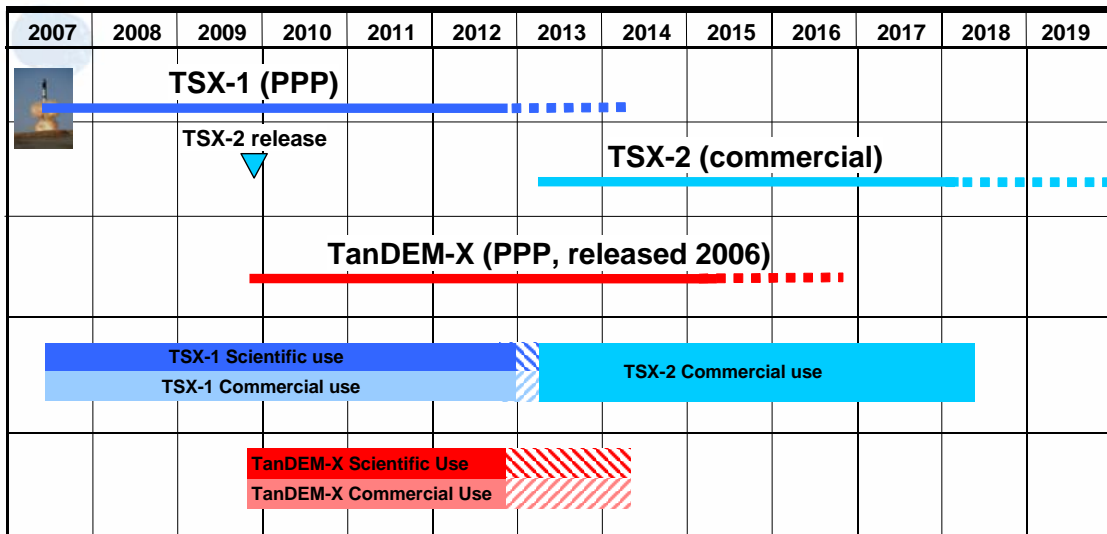
- **Ownership rights with German government (DLR)**
  - No product exclusivity for Third Parties
  - Data copies from foreign stations to DLR
- **World wide exclusive commercial exploitation rights with Infoterra GmbH**
  - Customers and partners hold sub-licenses for data use and re-sale to end-user
  - Exclusivity can be granted for sales into market regions or segments

## German Data Security Policy

- **Avoid threats or hazards for security**
- **Guarantee positive control over “high quality” satellites**
- **Support commercialization by defining reliable and transparent policies**
- **Sensitivity check based on “Geomatrix”:**
  - end-user
  - observation area
  - resolution
  - delivery time
- **Implications: delay, degradation, or non-delivery**
- **Infoterra and DLR enforce compliance under government control**

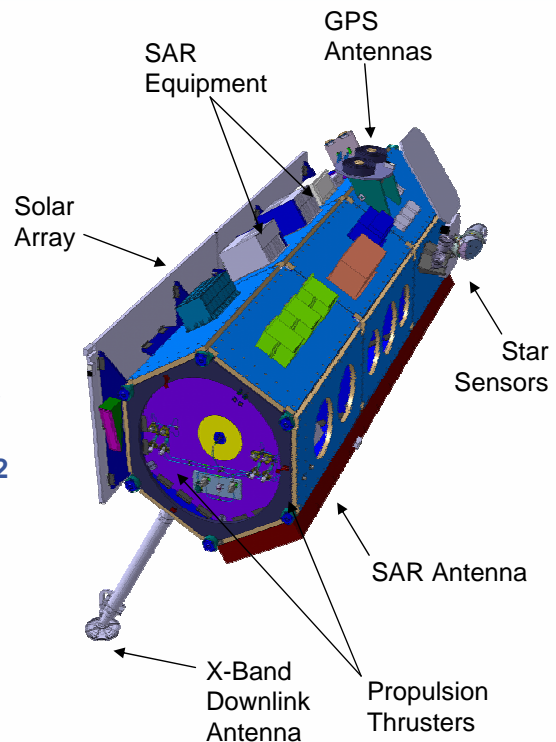
# TerraSAR-X Outlook – Obligation to Service Continuity

## Infoterra GmbH pursues Service Continuity

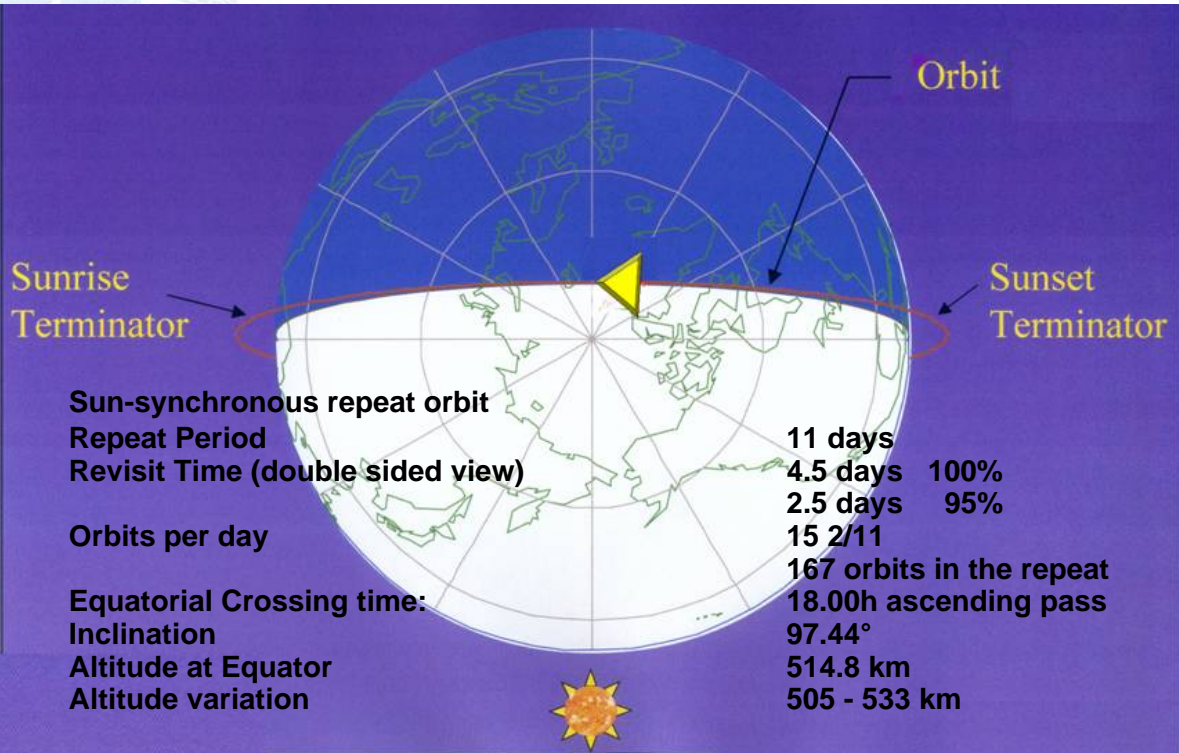


## TerraSAR-X Characteristics

- Orbit SS Dusk Dawn 515 km (6/18h)
- Planned Mission Life 5.5 years
- Launcher Dnepr-1 (97%)
- Launch Mass: 1350 kg
- Average Power: 800 W
- Pointing Accuracy 60 arcsec
- Left- and Right Looking Operation
- Dual-Band GPS Receiver for cm-range post-processing position knowledge
- 256 Gbit EOL Solid State Mass Memory (up to 250 scenes 5x10 km @ 1m)
- Data compression BAQ 8:6, 8:4, 8:3, 8:2
- 300 Mbit/s TDES-encrypted SAR data Downlink in X-Band
- Fully one-failure tolerant design
- Reliability:
  - 0.81 after 5.5 years
  - 0.72 after 7 years



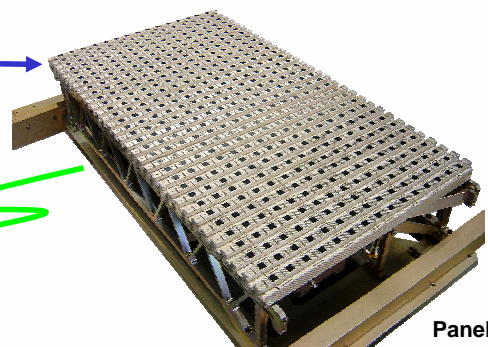
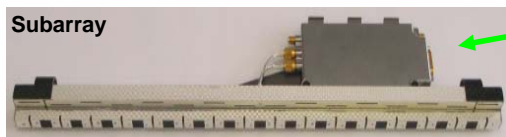
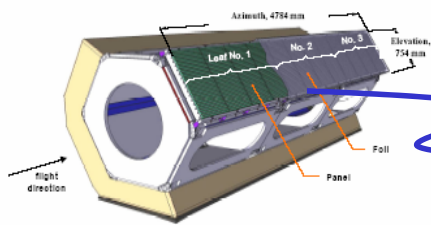
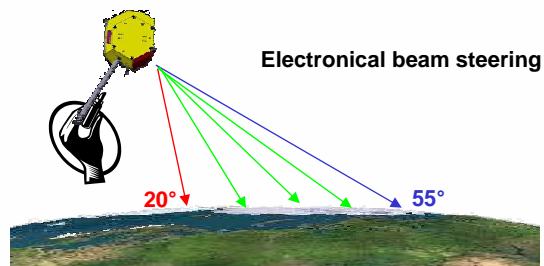
# TerraSAR-X Orbit



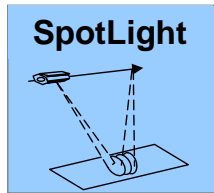
# Active SAR Antenna

Antenna composed of:

- 3 Leafs à 4 panels
- 32 subarrays per panel
- 384 T/R Modules



# Geometric Resolution

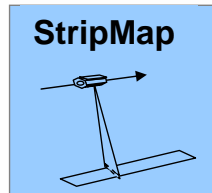


**SpotLight**



**res.: << 1 m**

identification of tanks possible (T72, Leo,...)

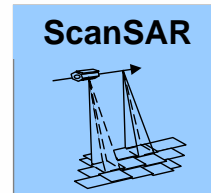


**StripMap**

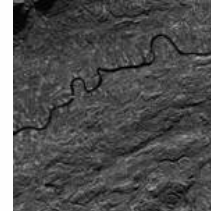


**res.: 1.0 m**

recognition of airplanes (Transport, Fighter,...)

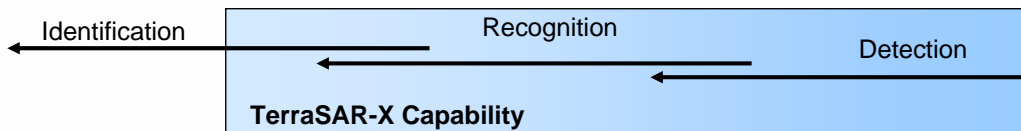


**ScanSAR**

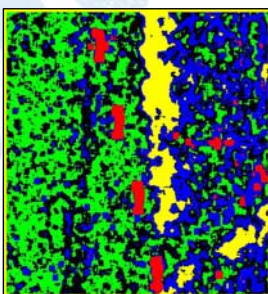


**res.: 16.0 m**

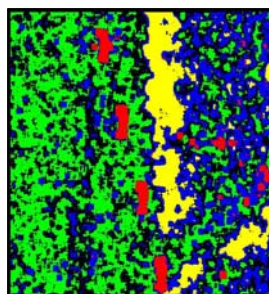
detection of coarse land cover features



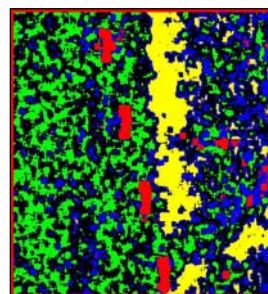
# Radiometric Resolution



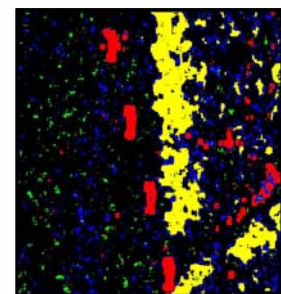
Original (-27 dB)



-18 dB



-15 dB



-11 dB

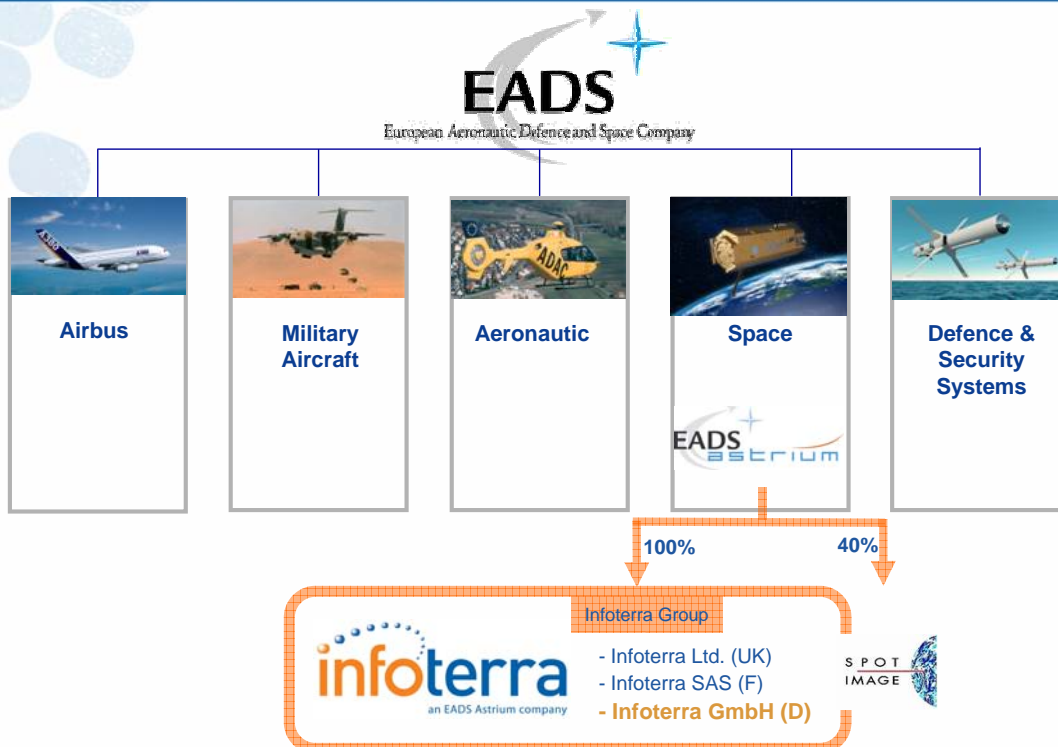


Classification of SAR image with different contrast (represented by noise equivalent  $\sigma_0$ ). 4 classes selected. Green: grass; blue: forest; yellow: shadow; red: hard target

# Flexibility in Data Acquisition

- **Elektronic radar beam steering**
  - **Quick change between targets and modes**
  - **Distance between images**
    - SpotLight: 25-45 km
    - StripMap: 7 km
    - ScanSAR: 7 km
- **Image collection performance**
  - 1 m: 80 Scenes/Orbit
  - 3 m: 60.000 km<sup>2</sup>/Orbit
  - 16 m: > 200.000 km<sup>2</sup>/Orbit
- **Image transmission in real-time**

# Infoterra within EADS





## Commercial Exploitation of TerraSAR-X

- Monitoring
- Change detection
- Mapping



## GMES and Mapping Services

- Environment (water, soil)
- Security (regions, disasters)
- Topographic maps



## Friedrichshafen, Headquarters

## Potsdam, Production Facility

## Neustrelitz, Receiving Station

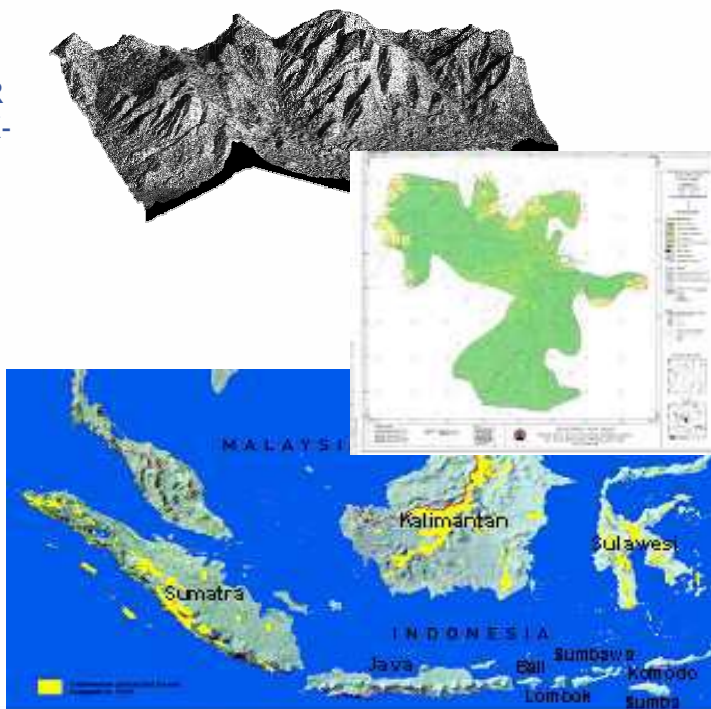
- Tasking and PA in Oberpfaffenhofen
- Online-Node for TerraSAR-X-Data near Bonn



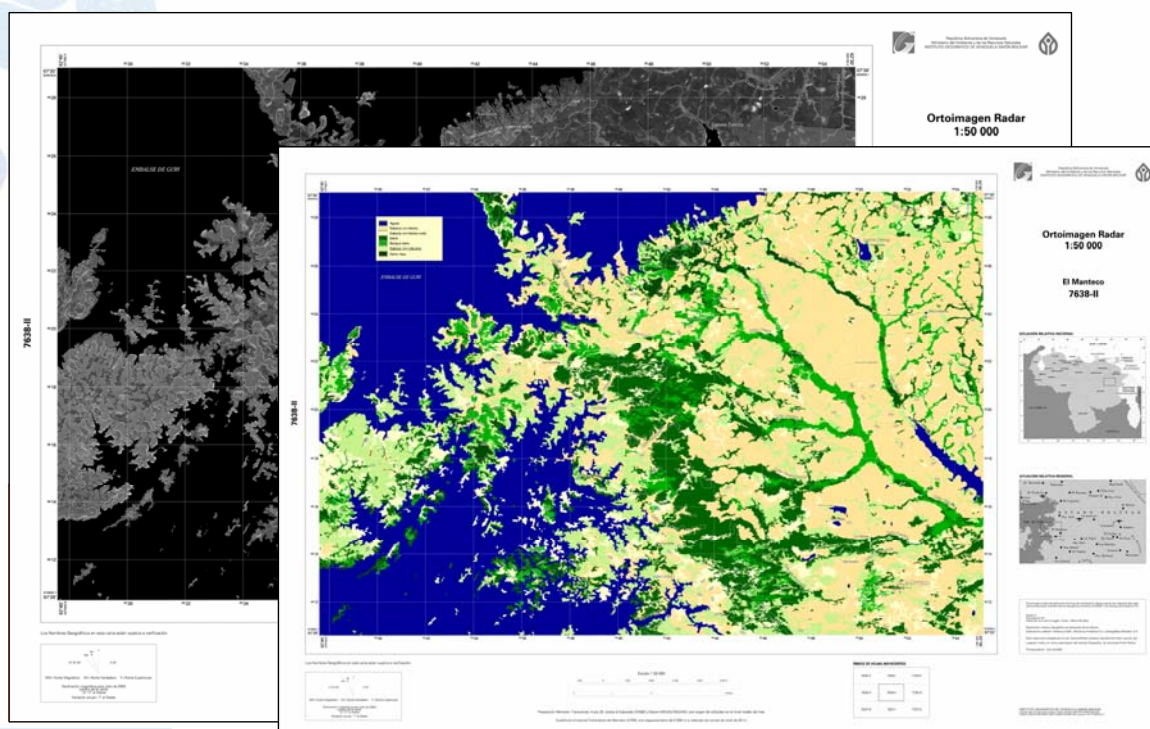
# Heritage in Airborne SAR Mapping

## Forest Indonesia

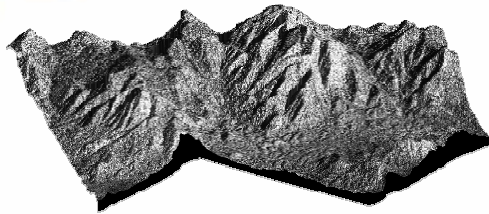
- Airborne single-pass SAR interferometry (DoSAR, X-band) in 1996
- Resolution 0.8 m
- Height resolution 0.1 m
- Data acquisition and processing of approx. 20,000 km<sup>2</sup> per week; total: 300,000 km<sup>2</sup>
- Sustained near real-time digital processing up to final map printouts
- Semi-automatic supervised texture analysis



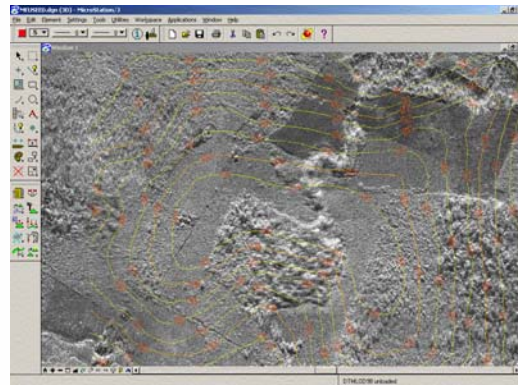
# Heritage in Airborne SAR Mapping



# Outlook: TanDEM-X Products

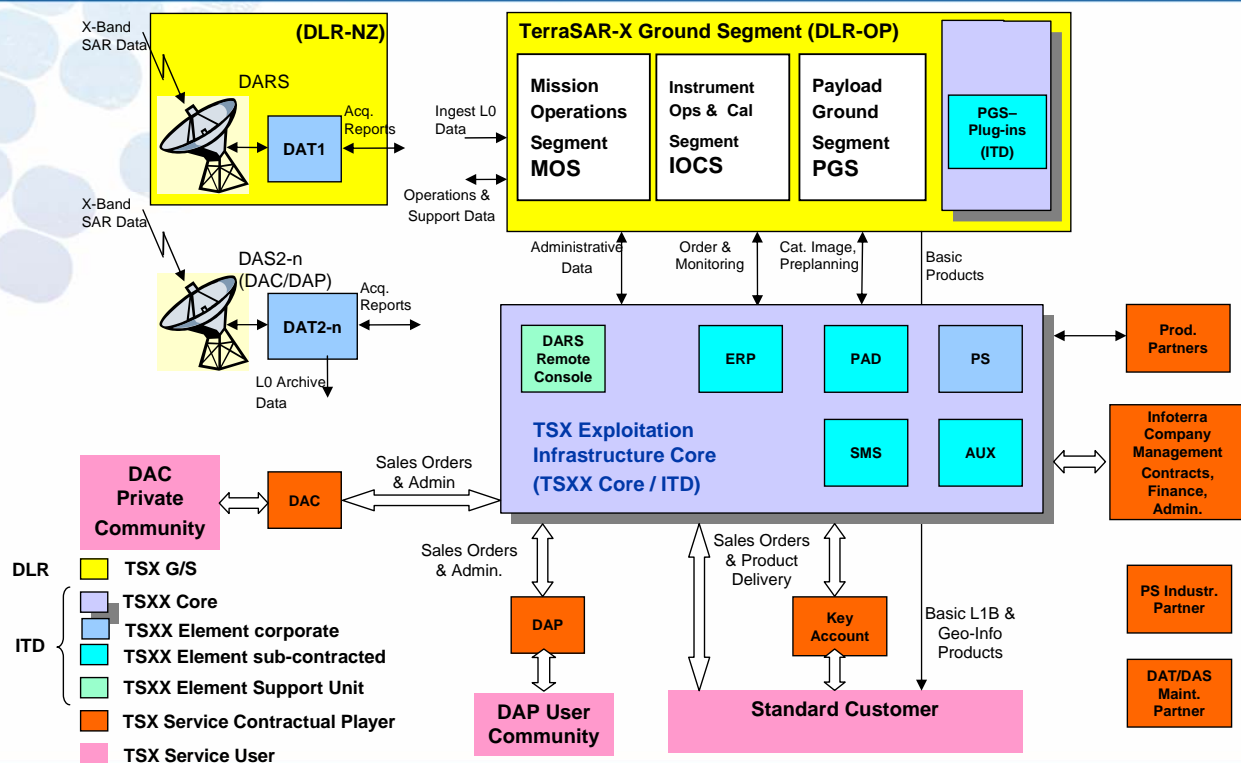


**DEM Product**  
 (High Resolution Terrain Information; 12 m posting, < 2 m height accuracy)



**Topo Base Product**  
 (Image Map with Contour Lines; basis for topographic maps in the scales 1:25,000 or 1:50,000)

# TerraSAR-X Service Segment



# TerraSAR-X Reference Station in Neustrelitz

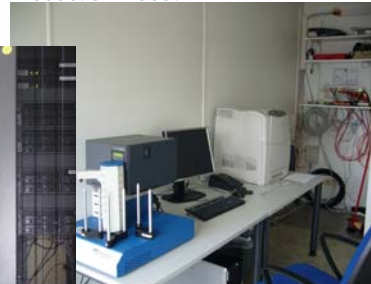
DLR Data Reception



Infoterra Facilities



Production Robot



Processing Operators Area



Processing Server

Two first international  
TerraSAR-X Stations  
in Japan  
ready by May 2007

# Direct Access Service

- Most direct means to receive TerraSAR-X data
- Certified processor/equipment in terminal ensures best performance
- Terminal operator training
- Multimission station upgrade, or Station setup support
- Service and terminal maintenance
- Upgrade and enhancement packages



First installation: Japan

# Demand for TerraSAR-X Services

## Demand from

- Private and government customers world wide
- Value adding firms (vertical)
- Data distributors (horizontal)

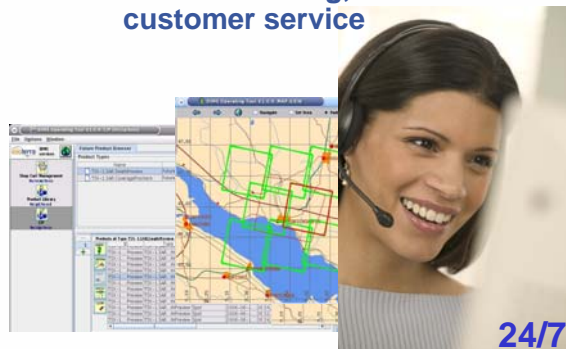


- Regional surveillance
- Object analyses
- Assessments of natural disasters
- Maritime surveillance
- Coastal monitoring
- Topographic mapping
- Change mapping
- Exploration
- Pipeline Monitoring
- Forest inventories

# TerraSAR-X Products and Services

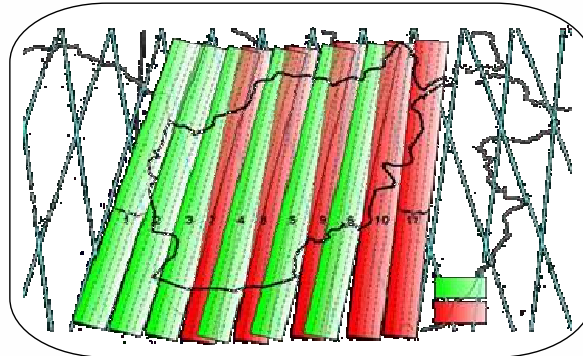
- **Products**
  - Basic Products (Imagery)
  - Ortho Images
  - Subsidence Maps
- **Services**
  - Direct Access Service
  - Monitoring
  - Training for analysts and value adders
  - Consultancy
- **Applications**
  - Object Analyses
    - (air-)ports, facilities
    - Ship identification
  - Topographic maps
  - Change maps

- **Resolutions: 1 – 16 m**
- **Image widths: 10 – 100 km**
- **Order lead times:**
  - Standard: 72h
  - Priority: 24h
  - Exclusiv: 6h
  - Reserved: 1h
- **Online ordering, customer service**

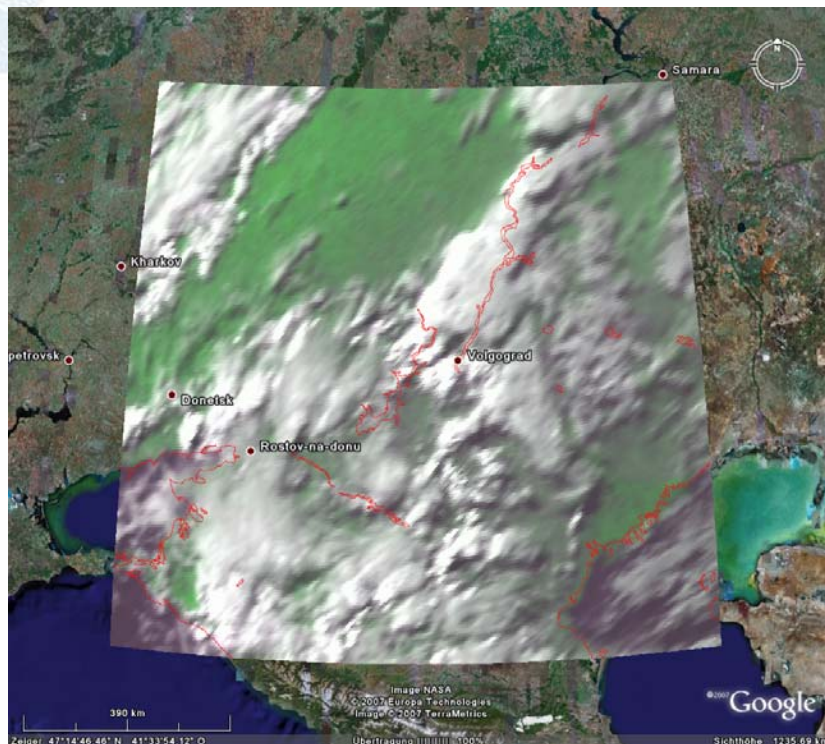


# Topographic Base Mapping

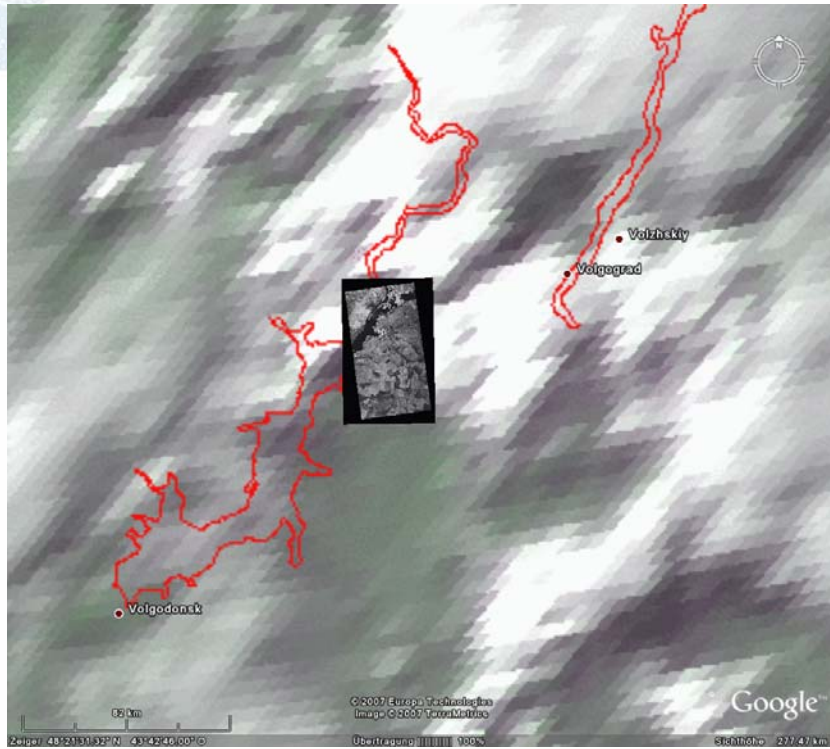
- **Base Mapping, e.g. Afghanistan (650,000 km<sup>2</sup>)**
  - 1:200,000 in 1.5 months
  - 1:50,000 in 2.5 months
- **Continuous production flow: delivery after 4 months**
- **Cost-efficient compared to aerial surveys**



# Up-to-date despite heavy Weather



# First TerraSAR-X Image



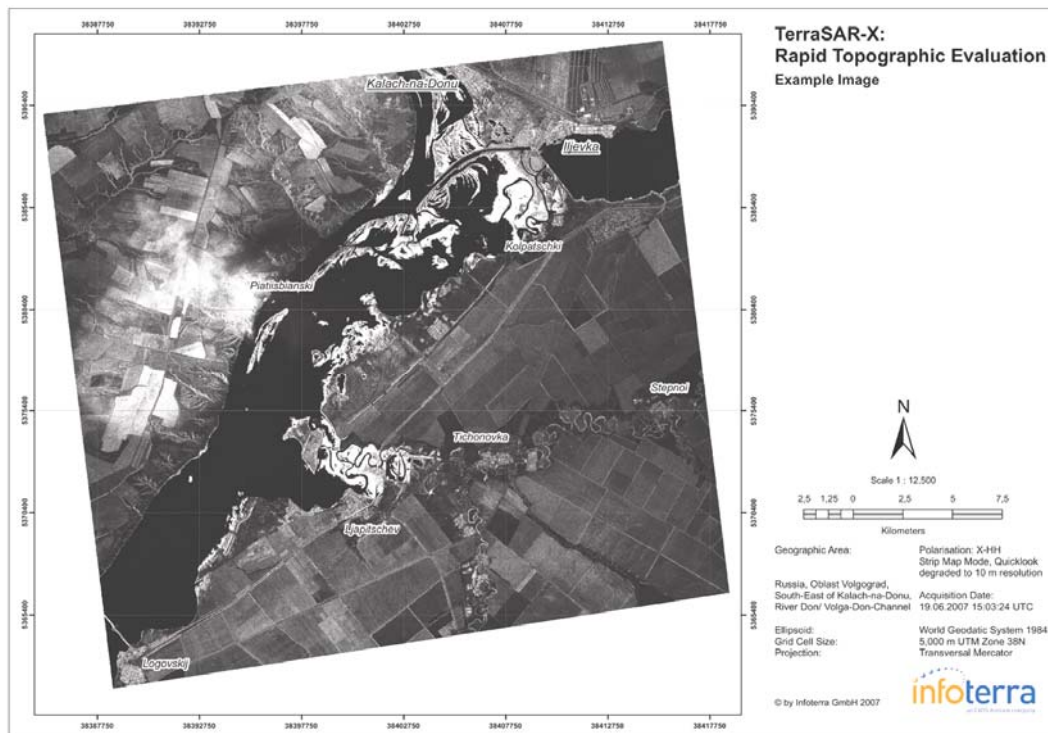
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# Image Map



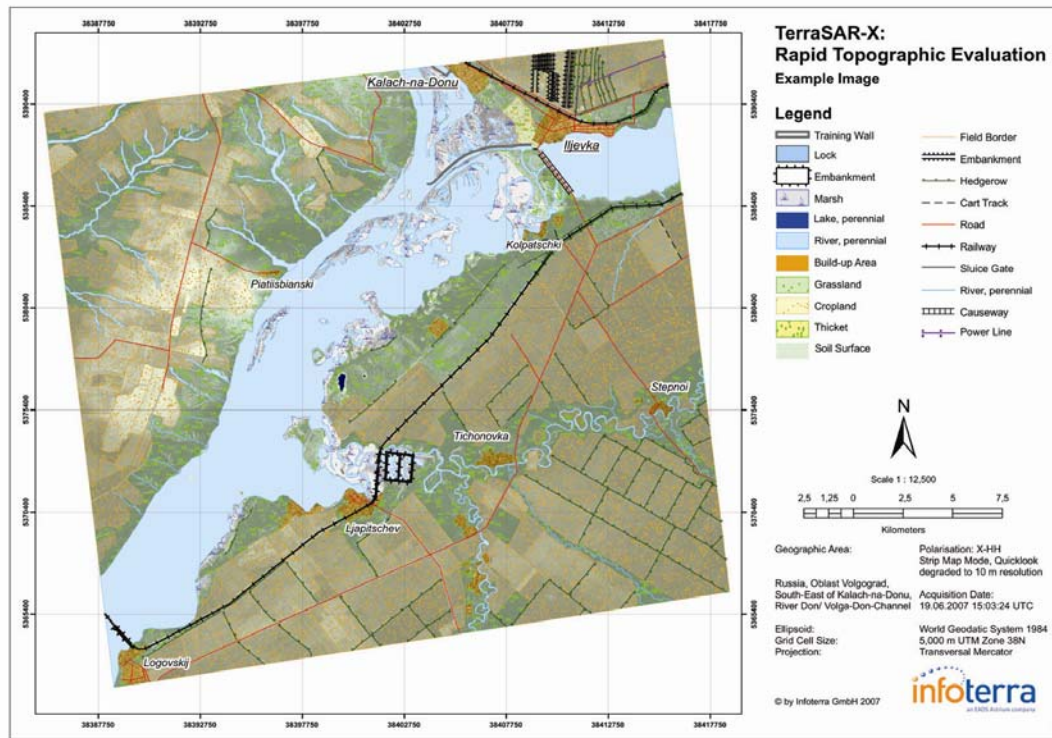
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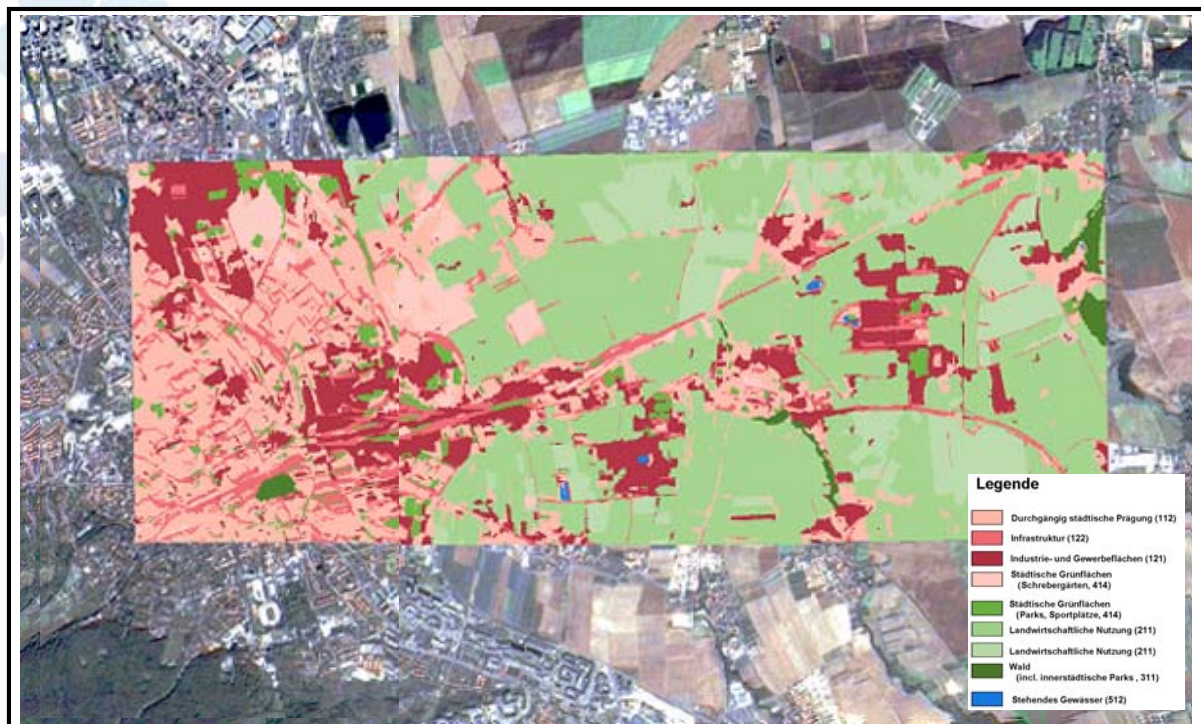
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# Derived Topo Map



# Urban and Regional Planning





## Airport Sao Paulo, Brasilia



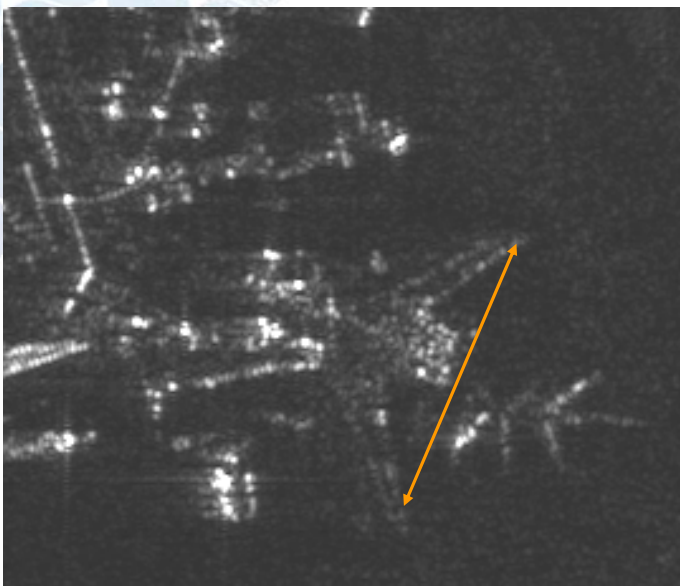
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## Sao Paulo Airport – Airliner



Measured wing span: 63.5 meters

→ Wing span of a Boeing 747 is approx. 64 meters

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# Airport Sao Paulo, Brasilia



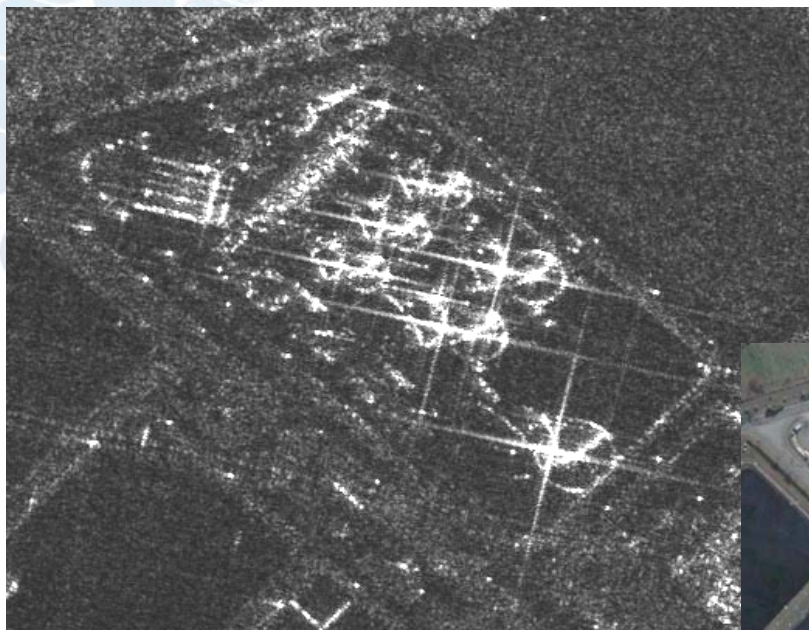
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# Sao Paulo Airport – Storage Tanks



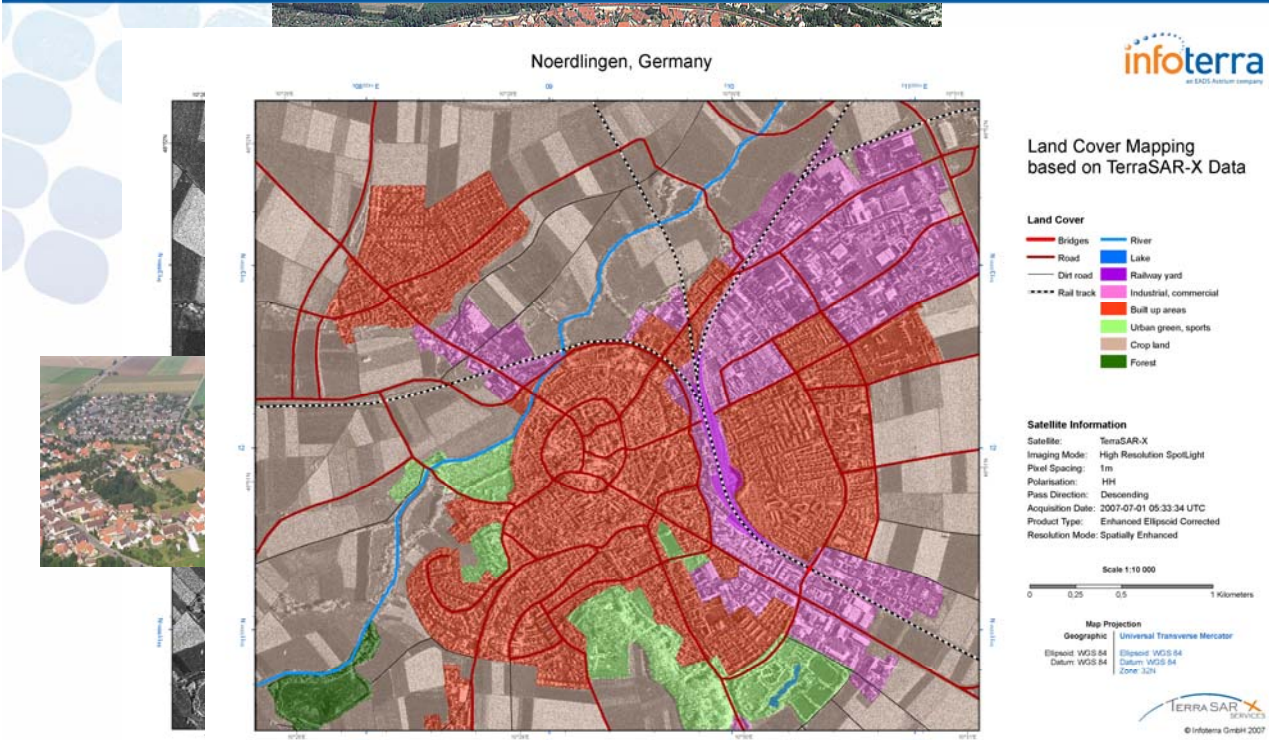
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# Land Monitoring



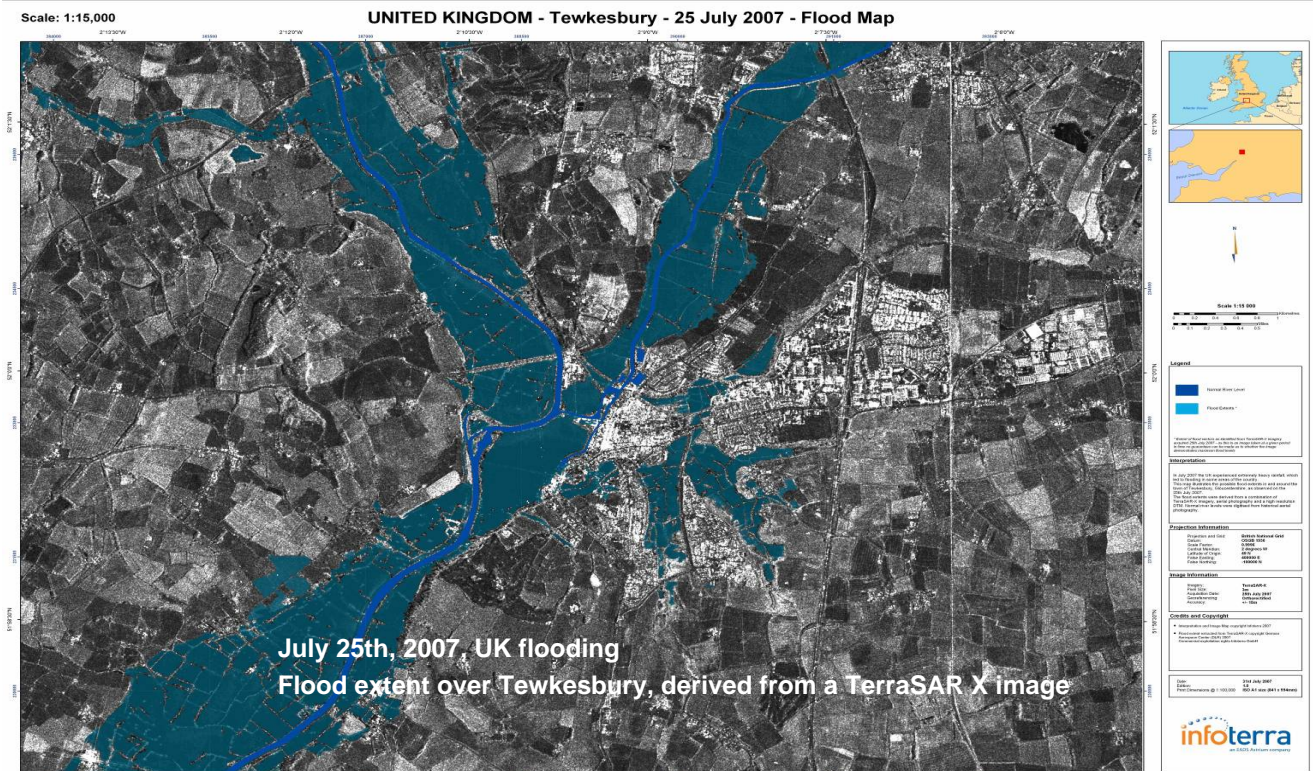
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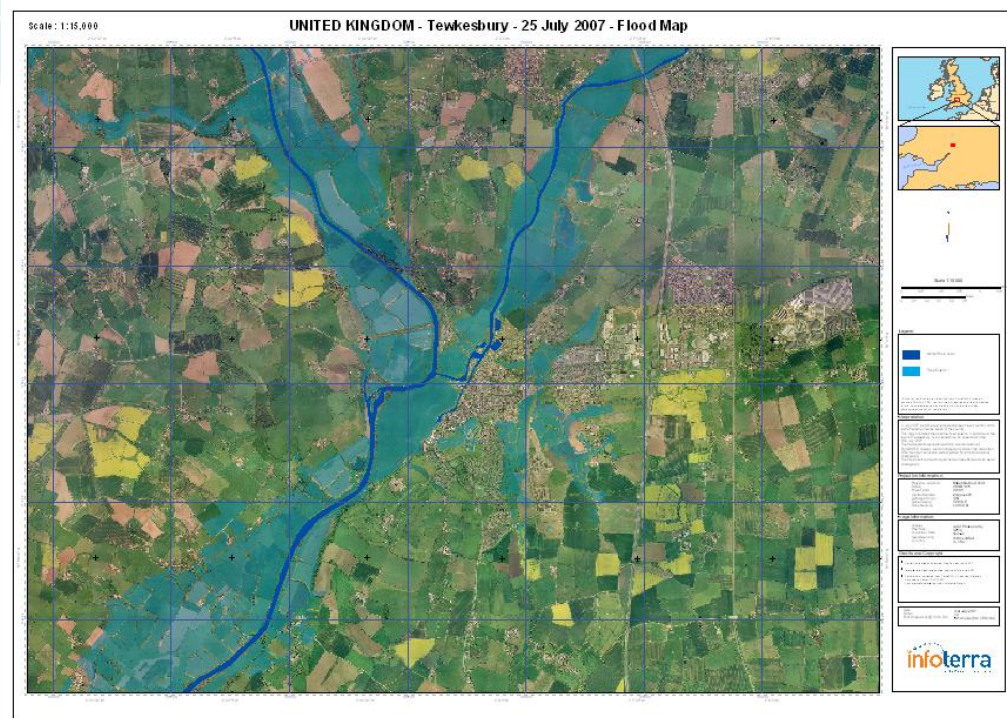
# Flood Map Derived from TerraSAR X



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# Flood Map Derived from TerraSAR X overlain on GeoPerspectives



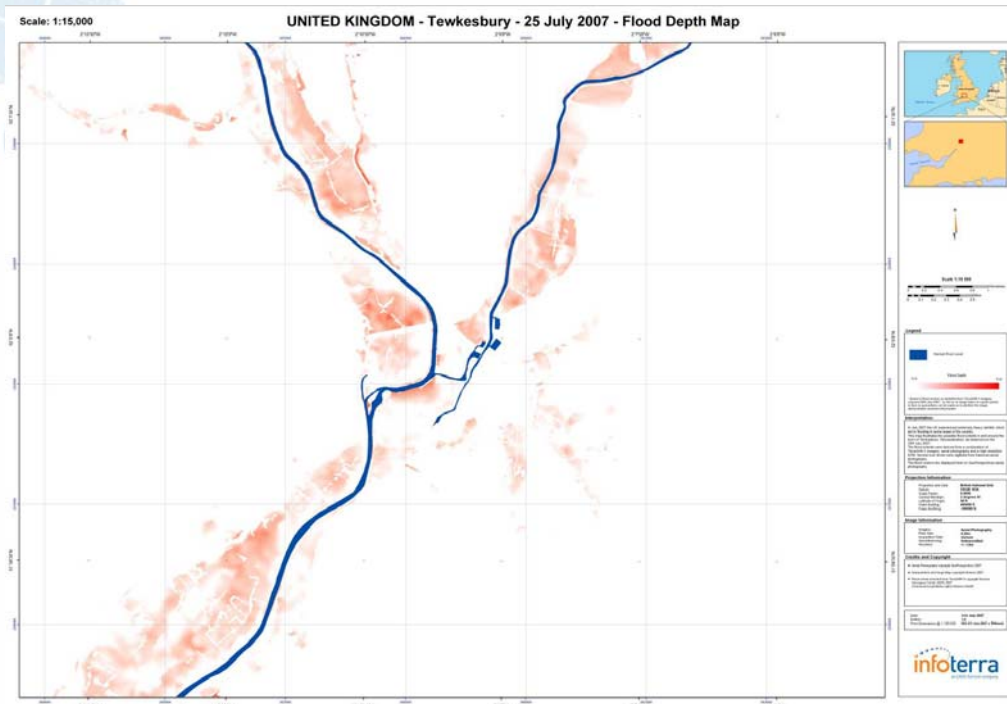
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# Approximate flood water depth map



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## Buildings Impacted by Flooding

- Example highlighting buildings impacted by flood waters
- Flood extents mapped on 25<sup>th</sup> July, from TerraSAR X, superimposed on GeoPerspectives photography



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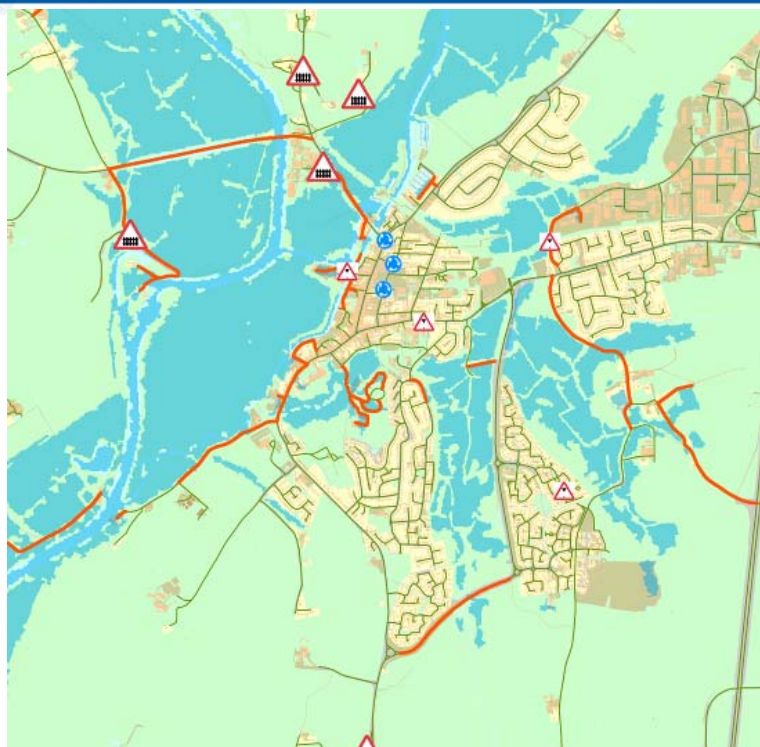
57

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## Roads affected by Flooding

- Example highlighting roads impacted by flood waters
- Flood extents mapped on 25<sup>th</sup> July, from TerraSAR X, superimposed on GeoPerspectives photography



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## Change Detection



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## Europe's environment under pressure ...



**Water – 20% of all surface water sources seriously threatened by pollution**



**Soil Erosion – 17% of total European land area affected, economic loss around 85 € per ha**



**Biodiversity – 335 species highly endangered in Europe**



**Agriculture – intensification leads to water stress, soil erosion and biodiversity decline**



**Urban Settlements and transport networks growing - leads to soil sealing and fragmentation of landscape**

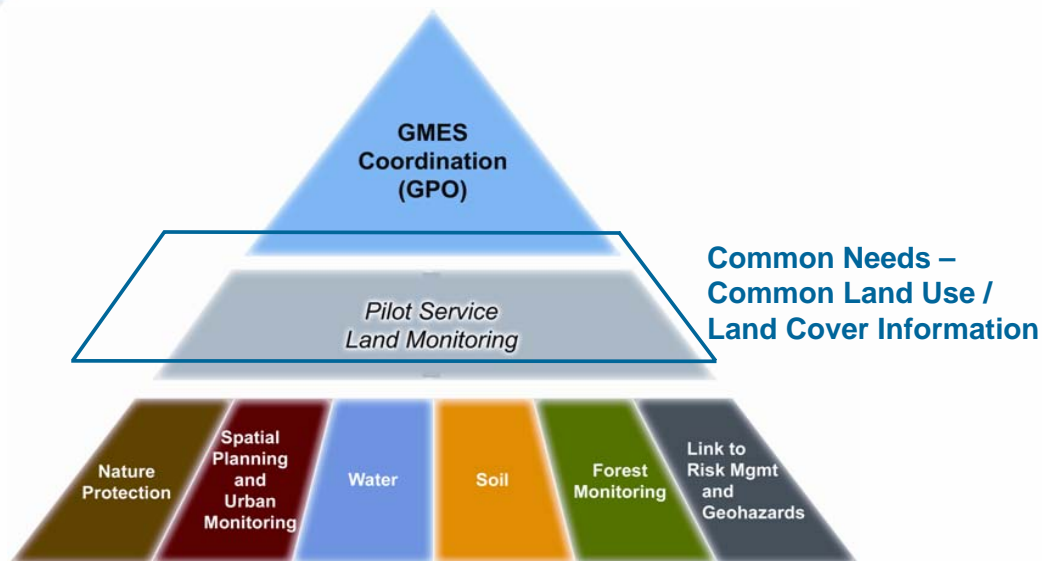
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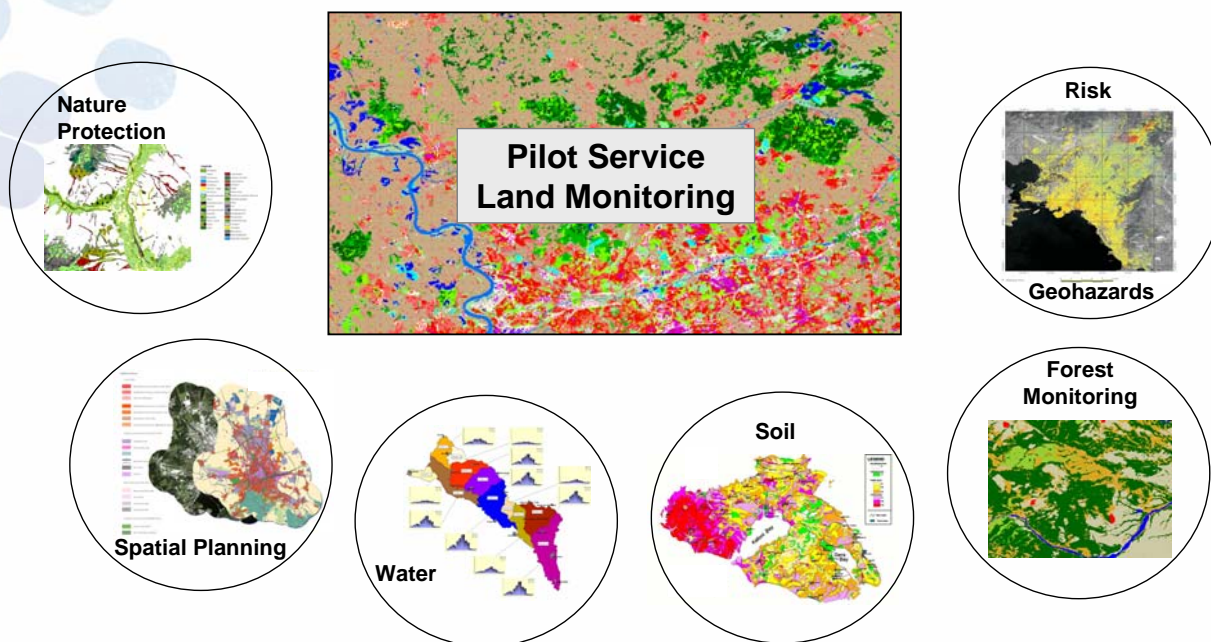
# The Stakeholder Process - Horizontal User Integration



**A European Pilot Service “Land Monitoring”  
can fuel down-stream applications & interoperable service**

# GMES – Interoperable Services

**A core service land cover is key to “fuel”  
interoperable down stream service**



# Conclusion



- Weather independence, complementary timing
- 1 meter resolution
- Multi modes
- Acquisition flexibility
- Quick global access
- High productivity
- Sustainability
- Secrecy

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