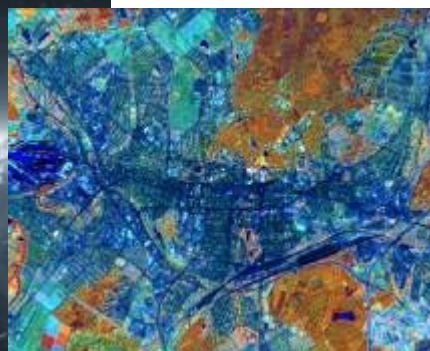
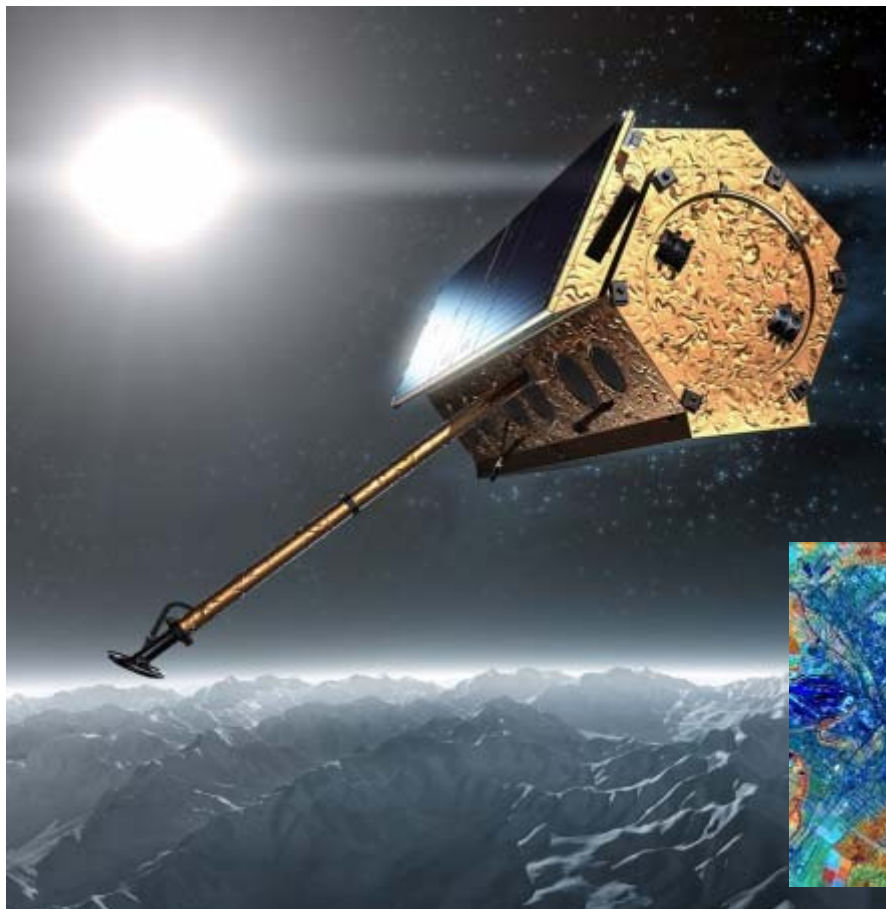


TerraSAR-X in support of Crop Monitoring

MARS – PAC Conference 2007



TerraSAR-X – How it came about

Mission

- The mission has a scheduled lifetime of five years
- Is realized through a public-private partnership (PPP) between the German Ministry of Education and Science (BMBF), the German Aerospace Center (DLR) and EADS Astrium GmbH.

Sustainability

- Infoterra GmbH's commitment to reinvest profits from the commercial sale of TerraSAR-X data into the next generation satellite- TerraSAR-X-2.
- A second TerraSAR-X satellite called TanDEM-X will be launched in 2009

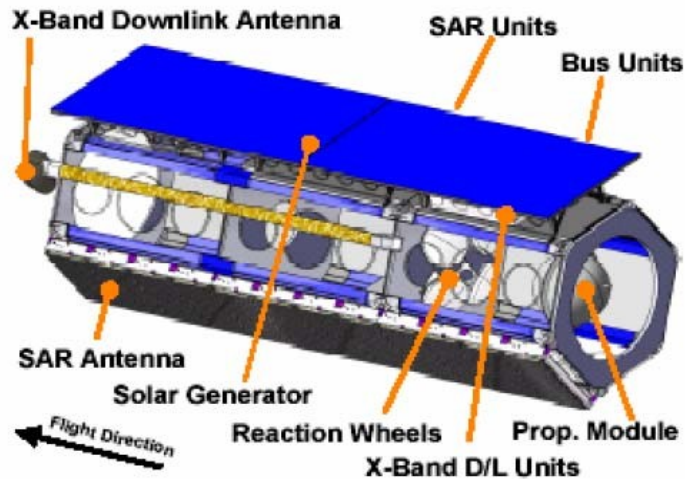


©Astrium GmbH



Credit: Artists view of TerraSAR-X in space – © Astrium GmbH

TerrSAR-X Technical Specification

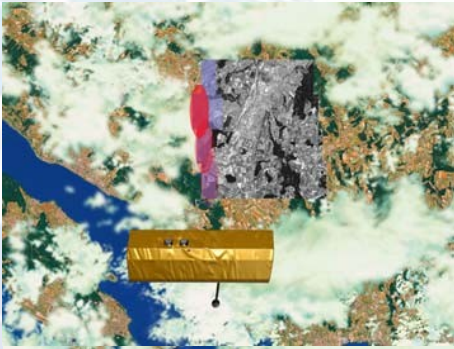


repeat cycle	11 days = 167 orbits
orbits per day	$15^{2/11}$
local time at ascending node equator crossing	18:00 ± 15 minutes
altitude at equator	514.8 km
inclination angle	97.44°
semi-major axis	6883.513 km
eccentricity	0.001
argument of perigee	90°
true anomaly	0°
right ascension of ascending node	88.617°
ground track repeatability	± 500 m per cycle for mapping

Height	5.0 m
Wet mass	1.230 kg
incl. payload mass	394 kg
SAR Antenna	4.8 m x 0.7 m x 0.15 m
Resolution	1 m @ 5 x 10 km Scene
Power consumption	800 W average
Data storage	256 Gbit
Data transmission	300 Mbit/s X-Band Downlink
Orbit	514 km
	98° Inclination
	sun-synchronous
Repetition rate (orbit repeat cycle)	11 days
Life time	5 years

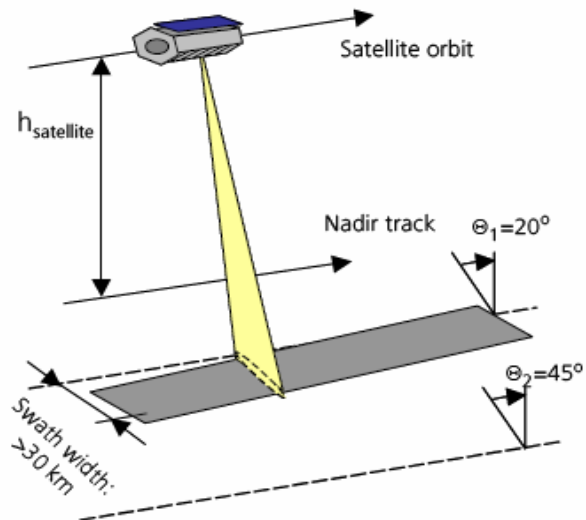
http://www.dlr.de/tsx/main/mission_en.htm

TerraSAR – X Image Modes

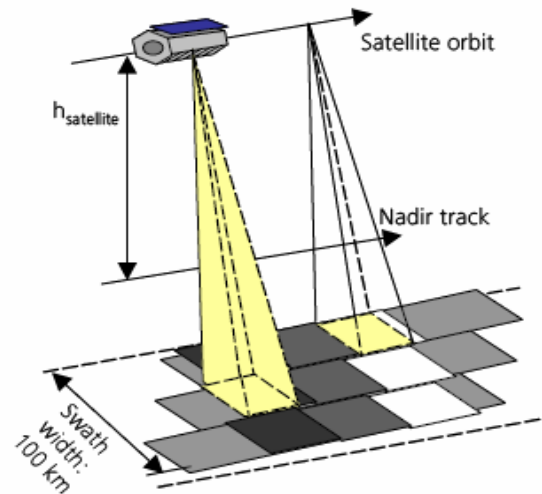


Mode	Spatial Resolution (max)	Spatial Coverage (max)
Spotlight	1m	10 x 10km
Strip Map	3m	30 x 1500km
Scan SAR	16m	100 x 1500km

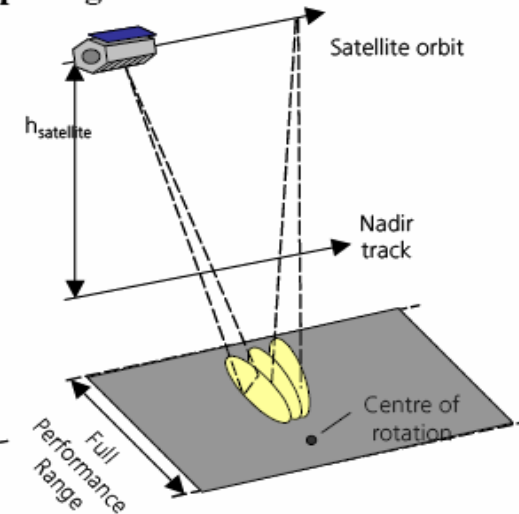
StripMap



ScanSAR



SpotLight



©Astrium GmbH

TerraSAR-X Image Examples: Spotlight

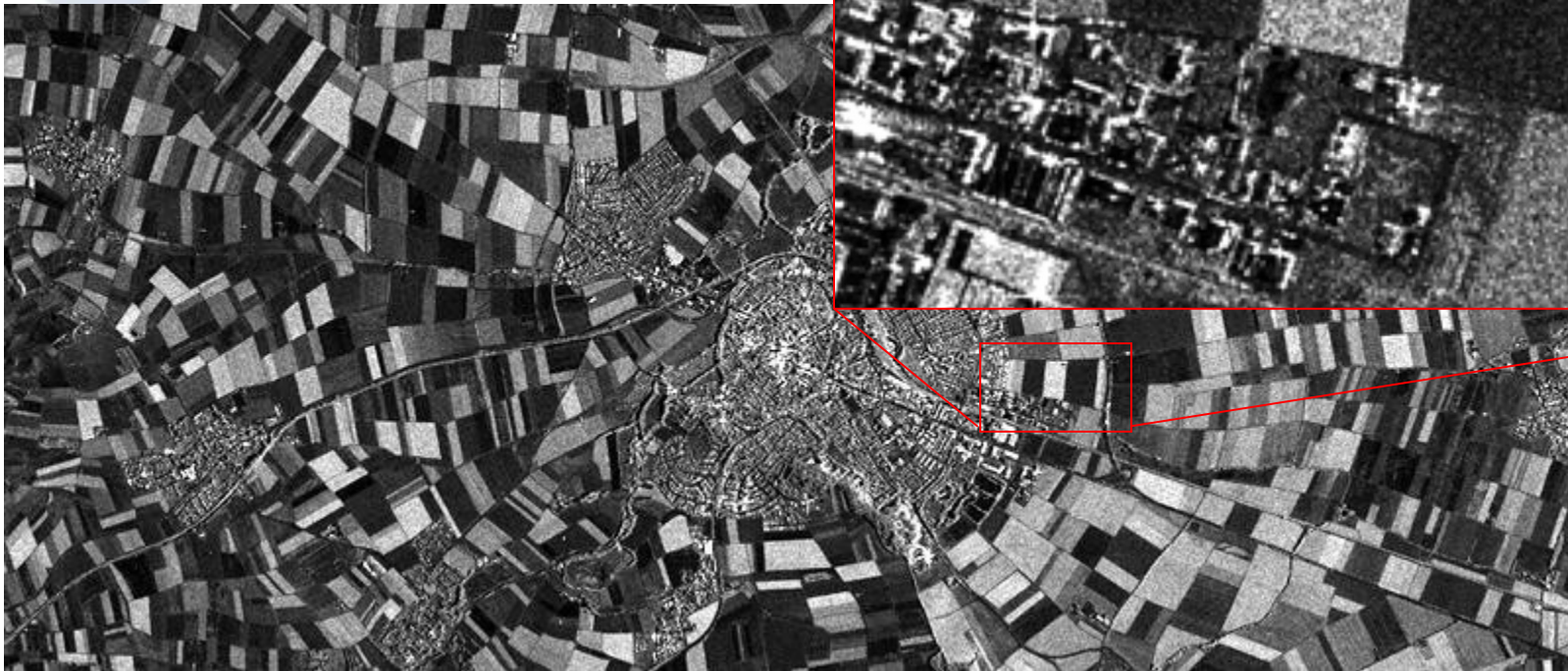
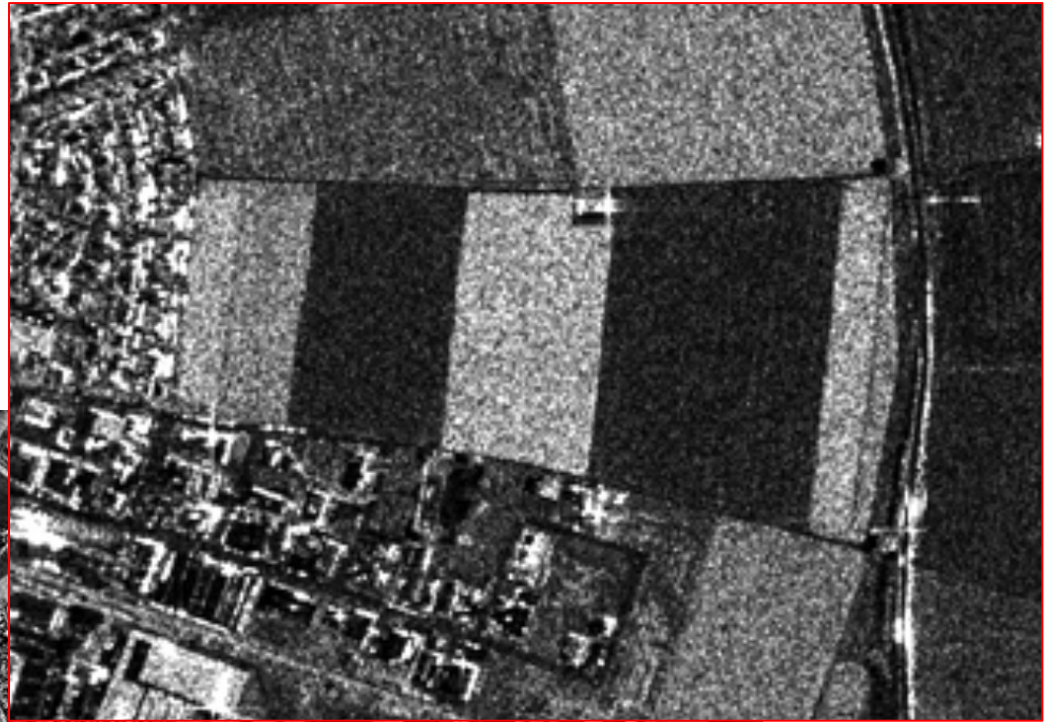


Giza Pyramids - TerraSAR-X High Resolution Spotlight acquisition
(1m resolution, reduced); Jul. 2, 2007; polarisation: HH

©Infoterra GmbH / DLR

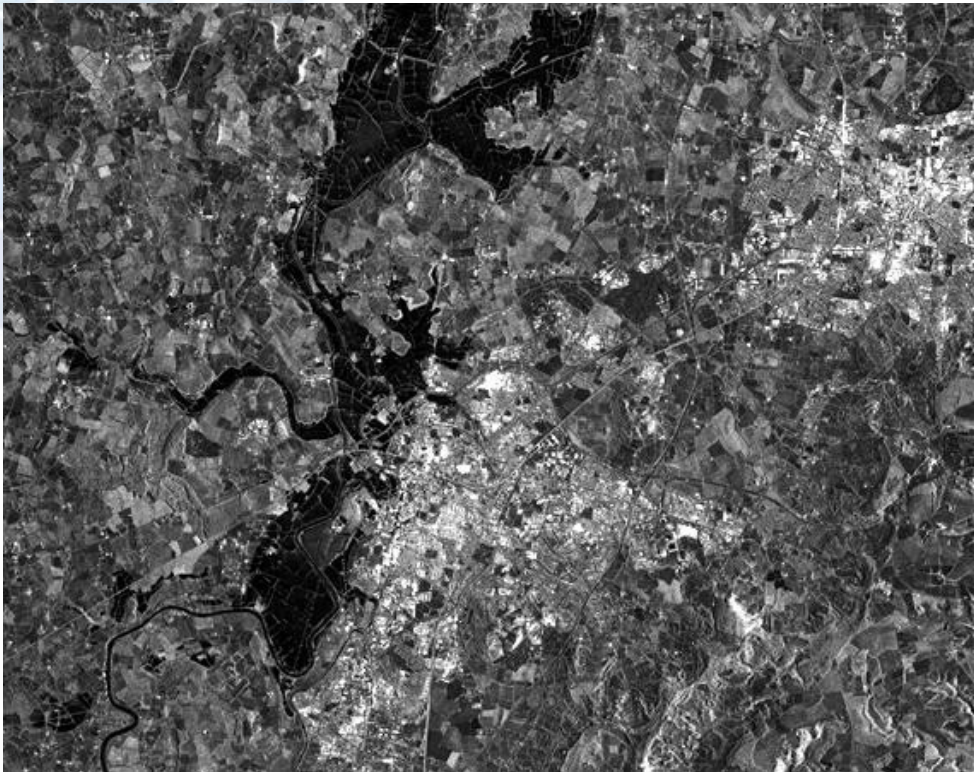
TerraSAR-X Image Examples: Spotlight

Germany, Noerdlinger Ries - Spotlight
Acquisition (1m resolution, reduced), Jul.
01, 2007; polarisation: HH



©Infoterra GmbH / DLR

TerraSAR-X Image Examples: Stripmap



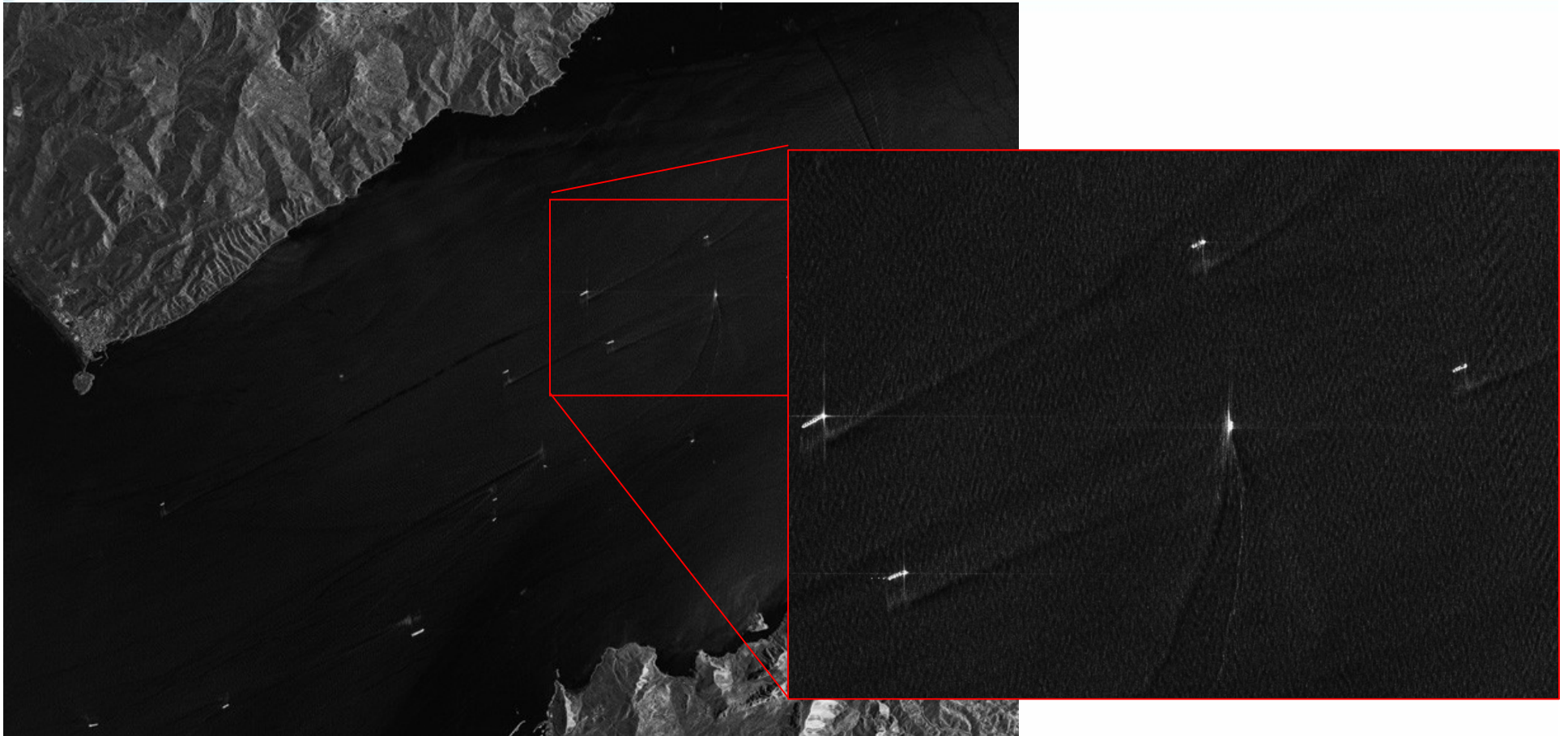
OS Licence No: 200016034

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England - TerraSAR-X shows floods - StripMap Acquisition
(3m resolution, reduced), Jul. 25, 2007; polarisation: HH

TerraSAR-X Image Examples: Strip map



©Infoterra GmbH / DLR

Strait of Gibraltar - StripMap
Acquisition (3m resolution,
reduced), Jul. 5, 2007;
polarisation: HH

TerraSAR-X Image Examples: ScanSar

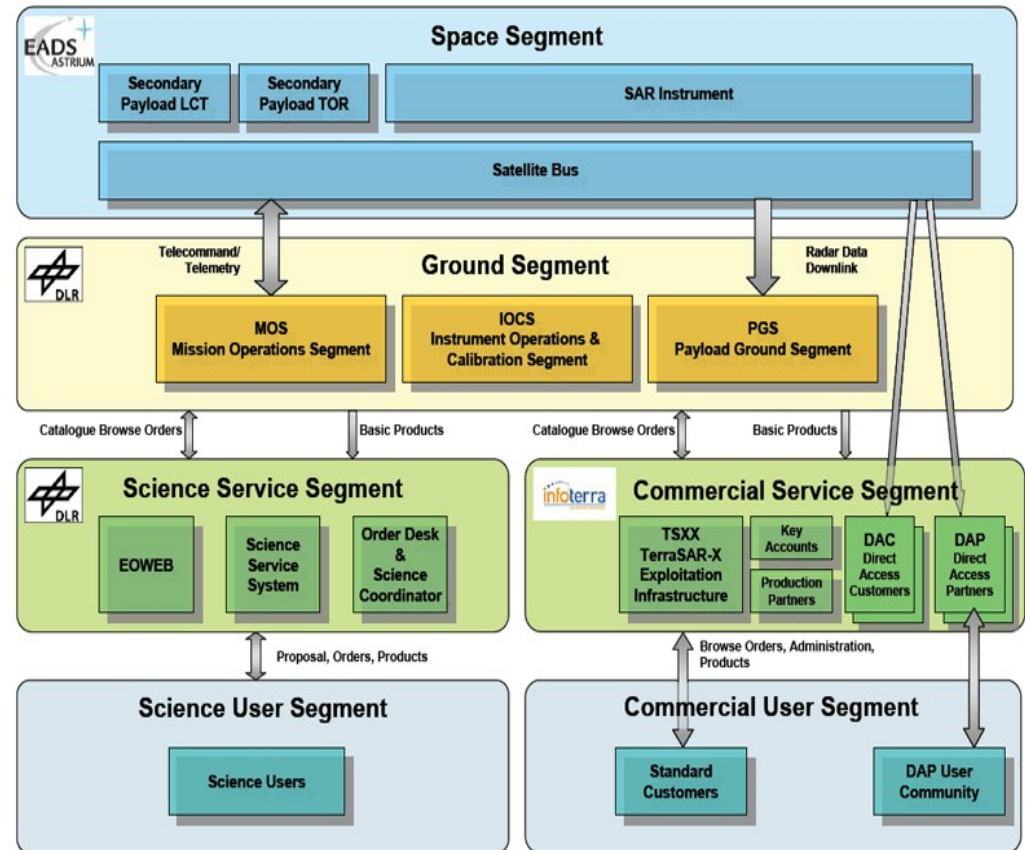


Brasília, Mato Grosso, Rain forest -
ScanSAR Acquisition (16m resolution,
reduced), Jul. 08, 2007; polarisation: HH

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Commercial Rights and Data Sales

- Infoterra GmbH, an Astrium subsidiary, holds the exclusive rights for commercial exploitation of the data,
- DLR is responsible for the coordination of the scientific data use.
- An equal share of mission resources, particularly data acquisition capacity, has been agreed for commercial and scientific use.



Benefits of TerraSAR for Crop Monitoring – Initial Expectations

Crop monitoring falls within mapping of Renewable Resources and Land Use / Land Cover Mapping products

TerraSAR X benefits:

- timely coverage / guaranteed availability for reference / reporting year @ 3-15 m resolution (weather independent)
- rapid coverage & mapping, if needed for rapid situation assessment
- yearly up-dates feasible (e.g. to monitor urban growth)
- ARD: re-forestation success monitoring (early growth phase)

Hypothesis

- The use of radar data should improve the data availability (main crop, intercropping)
- The information content of radar should be comparable or better than optical data

Current Perceived Limitations:

- relief (hilly – alpine terrain): ascending / descending merge necessary – limited interpretability
- positional accuracy, if no local DEM available:

Trial results: much better object identification than expected (on-going work)

- UrbanAtlas at 0.25 ha
- Land Use / Land cover maps at 1 – 5 ha
- Forestry: ARD, fast growing fiber wood, oil palms,
- Agriculture: cereals vs. corn vs. root crops vs. oil seeds

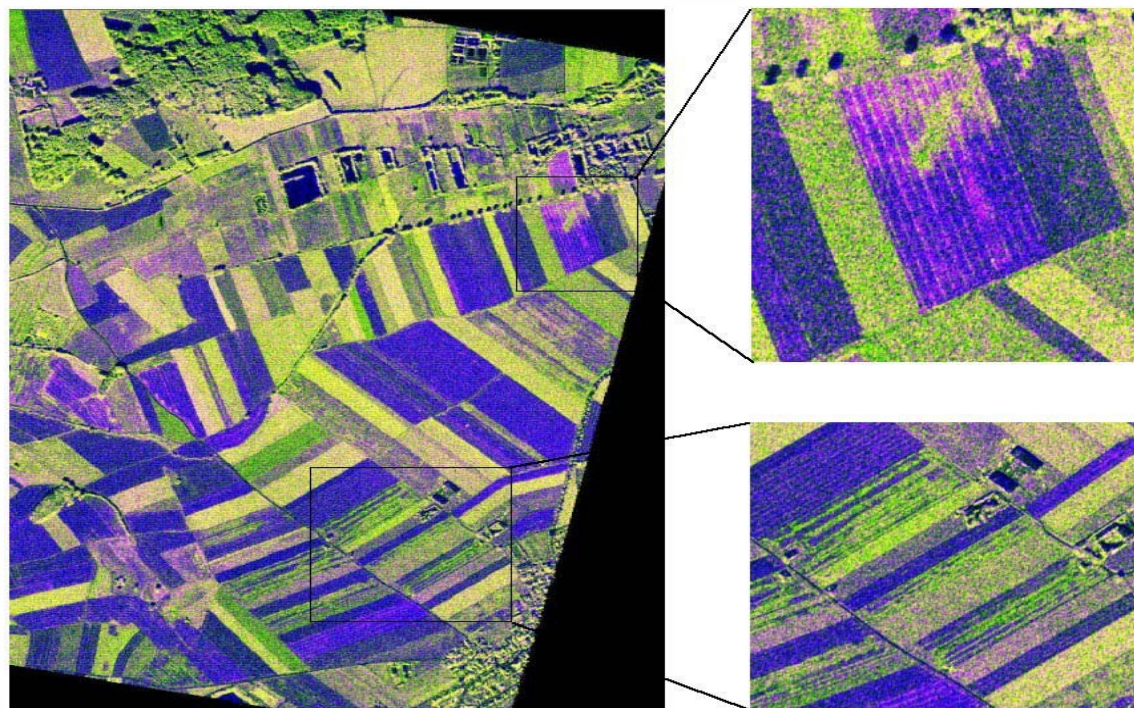
Crop Monitoring – what TerraSAR-X should support

Agriculture

- Mapping of acreage / detection of small fields
- Mapping of field heterogeneities
- Crop type recognition
- Growth stage assessment
- Crop parameter assessment

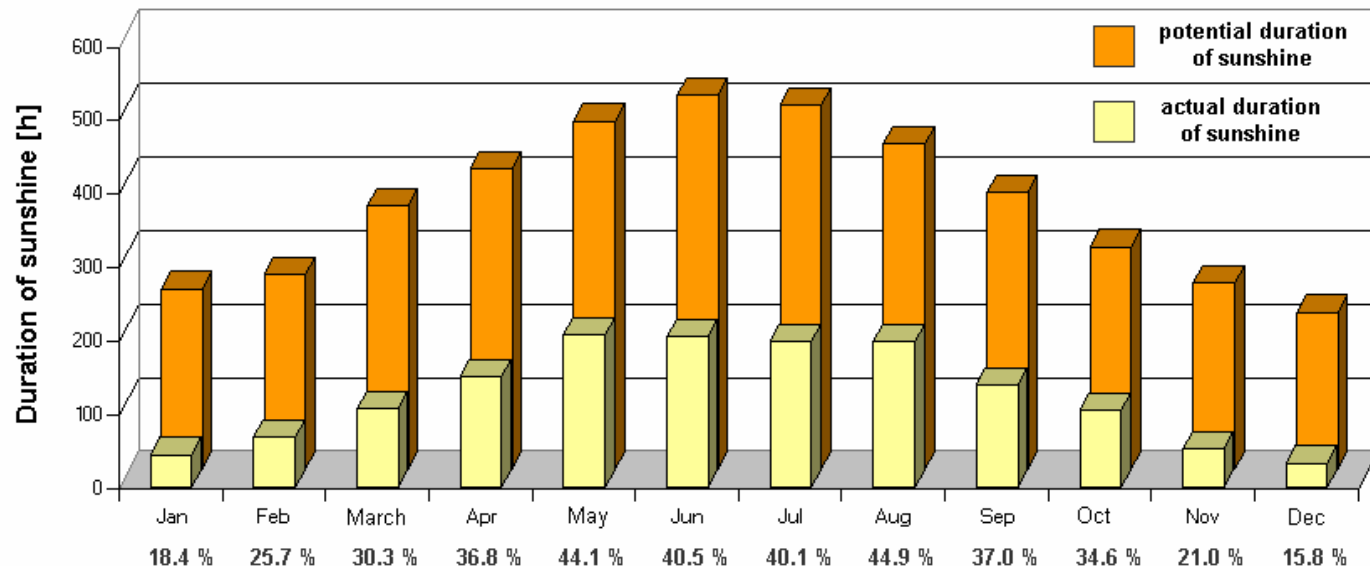
Forestry

- Tree type identification
- Mapping of disturbances caused by fire, insect attacks, deforestation
- Forest Parameter Assessment



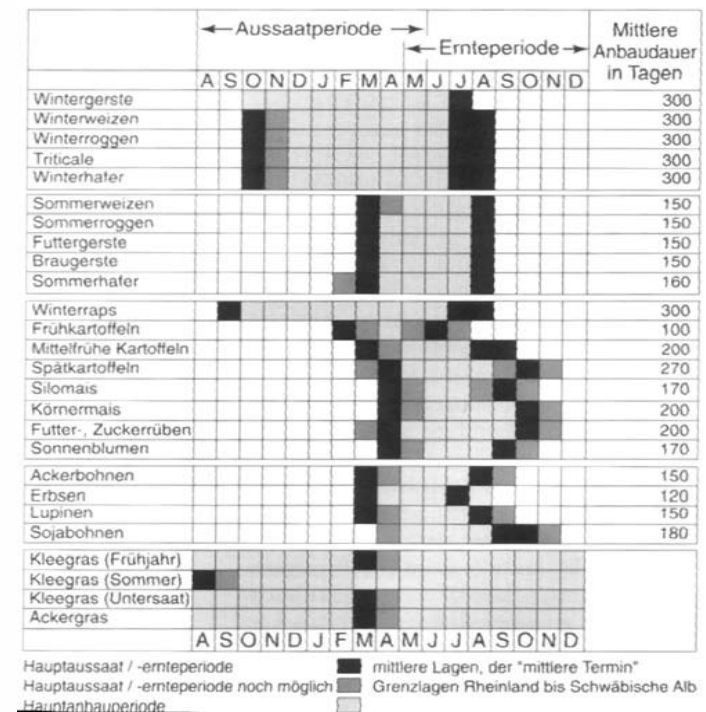
Why TerraSAR for Crop Monitoring? – Data Availability

- Data availability is the most critical point in using remote sensing in agriculture
- The spectral response of agricultural crops and the suitable time windows which are applicable for crop monitoring varies from year to year and between different cultivars.
- In terms of using remote sensing as an information source for real-time modeling (fertilizer inputs, pesticide application and yield estimation) data availability is a key issue.



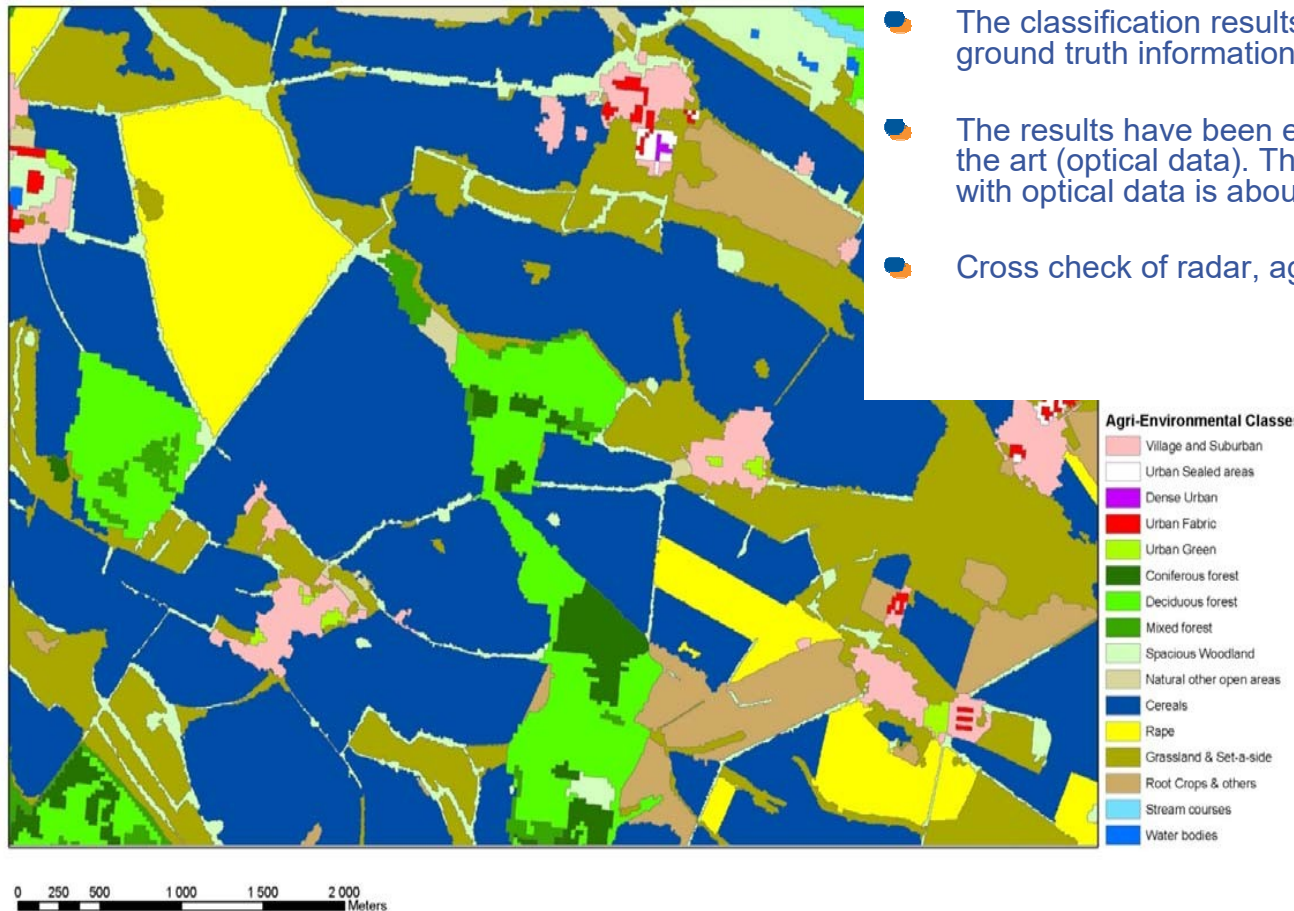
Why TerraSAR for Crop Monitoring? - Crop Phenology

- Clouds and phenology are the major problems in the operational retrieval of crop and crop rotation information for all kinds of nutritional modeling.
- Data availability is the big problem of optical data
- Remote sensing allows identifying different crop types, but depending on the phenological stage, the reflectance information of optical systems changes rapidly



TerraSAR-X for Crop Monitoring - Results

Agri-Environmental Mapping Service Test site Netzow 2002



- Comparison with available reference data from optical EO classification
- The classification results have been checked against ground truth information from the farm manager.
- The results have been evaluated against the state of the art (optical data). The overall accuracy reachable with optical data is about 80 to 90%
- Cross check of radar, against optical classification

TerraSAR-X for Crop Monitoring - Results

- The radar classification performed better in the detecting cereals compared to optical remote sensing. This is due to the fact that the spectral reflectance of cereals (wheat, rye, barley) is very similar at these phenological stage.
- Radar, which is more sensitive to structural differences in plant morphology is able to differentiate the crops by there plant size. It was also possible to detect sugar beet and peas by radar at that early development stage.
- Optical data performed slightly better at oilseed rape detection because at the beginning of flowering the spectral reflectance is very dominant compared to other crops.
- Fields classified as “set a side” are a specific problem, they can be grassland, sunflowers or oilseed rape

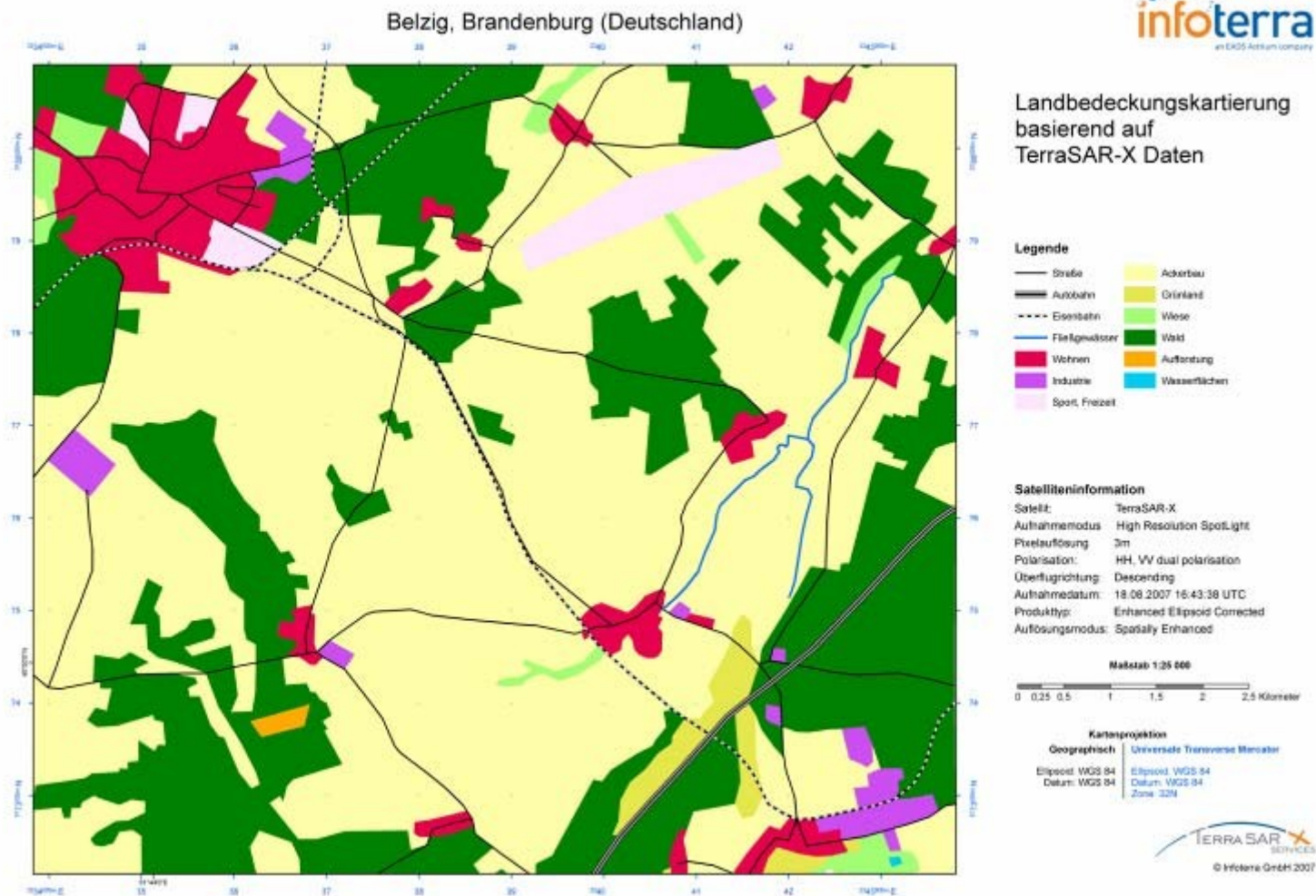
Multi-Temporal (3m) Strip Map



©Infoterra GmbH / DLR

Germany, Northwestern of Munich,
multitemporal - Stripmap Acquisition
(3m resolution, reduced), Jun. 26 and
Jul. 07, 2007; polarisation: VV and HH

Land Use / Land Cover (3 m)



TerraSAR-X summary

- Operation “cloudfree” and 24/7
 - timely coverage
 - rapid coverage / access
 - Align to phenological development of crop types
- Image acquisition
 - availability guaranteed with max. 10 days lead-in time (single scenes)
 - global aspect: rapid mapping, yearly repetition for up-dates / monitoring
 - tropical aspect: area coverage for inventories (“un-mapped” or “under-mapped” areas)
 - sustainable: first of a series of X-Band satellites
- Capability of large area multi-temporal monitoring of crop types with a yearly update cycle
- Crop type mapping feasible using X-band



Thank you