

# TerraSAR-X and TanDEM-X: Revolution in Spaceborne Radar

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## INTRODUCTION

While Earth Observation from space in the past was mainly focused on scientific purposes, today data and the derived information products are increasingly used for various commercial applications. Potential users are planning and consulting offices, food and natural resource industries, insurance companies or agencies. New data of enhanced quality, available quickly and reliably, independently of daylight and weather conditions, are required for an increasing and sustained commercial exploitation of Earth Observation data.

The design and performance of TerraSAR-X, high resolution satellite X-band satellite, built on a public-private-partnership agreement between the German Aerospace Centre DLR and EADS Astrium GmbH will exactly meet these requirements. Launched on the 15<sup>th</sup> June 2007 from the Russian Cosmodrome in Baikonur (Kazakhstan), the Synthetic Aperture Radar (SAR) instruments of the spacecraft supply radar images of high quality, day and night and under nearly all weather conditions; leaving thus the way open for the establishment of a worldwide commercial EO-market and the development of numerous applications, products and services.

Those services include highly sophisticated client-specific image interpretation, topographic maps up to a scale of 1:10,000, geospatial databases and terrain analysis in demand for a wide scope of applications. Other purposes comprise environmental planning, land cover and natural resource exploration, regional and urban development, insurance, risk assessment and humanitarian objectives, particularly in time-critical situations, as well as applications in border control, security and defence. Moreover the smallest movements of the Earth's surface due to tectonics, volcanism, earthquakes, and land slides are further challenging fields of application of TerraSAR-X interferometry.

## 1. TERRASAR-X BASIC IMAGE PRODUCTS

The TerraSAR-X is a Synthetic Aperture Radar instrument based on an active phased array technology. The radar carrier frequency is of 9.65GHz (X-band). The nominal range bandwidth is 150 MHz, the maximum one 300 MHz. The spacecraft was successfully launched into a sun-synchronous dusk-dawn orbit with a nominal orbit height at the equator of 514 km. It is flying at a velocity of about 7,6km/s; this results in about 15 revolutions around the Earth per day and in a revisit time of 11 days. **Fehler! Verweisequelle konnte nicht gefunden werden.** presents an overview of the TerraSAR-X main orbit parameters.

Parameter	Mission Orbit
Orbit type	Sun-synchronous repeat orbit
Repeat Period	11 days
Repeat cycle	167 orbits in the repeat
Orbits per day	15 <sup>2</sup> / <sub>11</sub>
Equatorial crossing time	18:00 ± 0.25h (local time)
Inclination	97.4438°
Altitude at equator	514.8 km

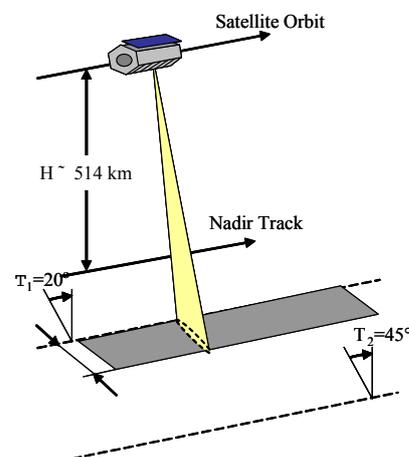
*TerraSAR-X Orbit parameters*

## 1.1 TerraSAR-X imaging Modes

TerraSAR-X sensor is designed for multiple imaging modes and can acquire in StripMap, SpotLight and ScanSAR modes with single-, dual- or full polarization. The characteristics of each imaging mode are described in the following subsections.

### 1.1.1 The StripMap mode

The ground swath is illuminated with continuous sequence of pulses while the antenna beam is fixed in elevation and azimuth (Fig. 1). This results in an image strip with a continuous image quality in the flight direction. Besides dual polarization StripMap images will even be available as quadruple polarisation data that are still under investigation.



*Fig. 1: The StripMap imaging geometry*

	Single pol SM	Dual pol SM
Polarizations	HH or VV	HH/VV, HH/HV or VV/VH
Scene dimensions	50km x 30km	50km x 15km
Full performance range	20° - 45°	20° - 45°
Azimuth resolution	3.3m	6.6m
Ground range resolution	1.70 – 3.49m (@45°...20°inc)	1.70 – 3.49m (@45°...20°inc)

### *The SpotLight (SL) and High Resolution SpotLight (HS) modes*

Two variants of the spotlight mode (Spotlight (SL) and High Resolution SpotLight (HS)) are designed with different values for azimuth resolution and scene size. As depicted in Fig. 2, SL and HS modes use electrical beam steering in azimuth direction in order to increase the illumination time, i.e. the size of the synthetic aperture. The larger aperture results in a higher azimuth resolution at the cost of azimuth scene size.

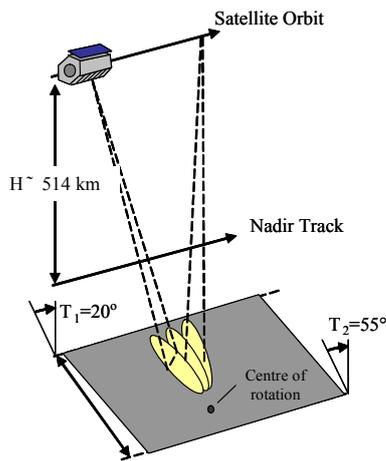


Fig. 2: The SpotLight and High resolution SpotLight imaging geometry

	Single pol SM	Dual pol SM
Polarizations	HH or VV	HH/VV
Scene dimensions	10km x 10km (SL) 10km x 5km (HS)	10km x 10km (SL) 10km x 5km (HS)
Full performance range	20° - 55°	20° - 55°
Azimuth resolution	1.7m (SL) 1.1m (HS)	3.4m (SL) 2.2m (HS)
Ground range resolution	1.48 - 3.49m (@55°...20°inc) HS with 300MHz bandwidth 0.74 - 1.77m (@55°...20°inc)	1.70 - 3.49m (@55°...20°inc)

### 1.1.3 The ScanSAR mode

The ScanSAR imaging mode combines the ability to acquire high resolution images for detailed analysis as well as wide swath images for overview applications. The electronic antenna elevation steering is used to switch after bursts of pulses between swathes with different incidence angles. In the designed TerraSAR-X ScanSAR mode, four StripMap beams are combined to achieve a 100 km wide swath (Fig. 3). Due to the switching between the beams only bursts of SAR echoes are received, resulting in a reduced azimuth resolution.

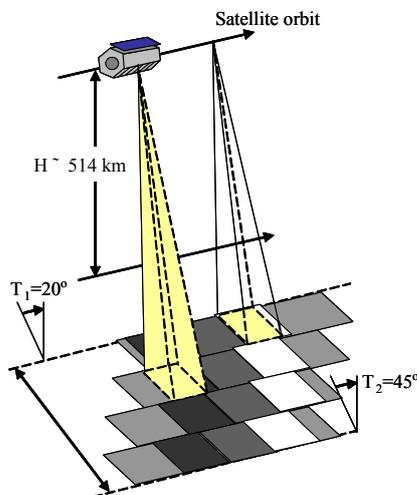


Fig. 3: The ScanSAR imaging geometry

	Single pol SM	Dual pol SM
Polarizations	HH or VV	/
Scene dimensions	150km x 100km	/
Full performance range	20° - 45°	/
Azimuth resolution	18.5m	/
Ground range resolution	1.70 - 3.49m (@45°...20°inc)	/

Additionally TerraSAR-X capabilities include an experimental Dual-Receive-Mode, which is based on the usage of the antenna in two azimuth halves and utilizes the redundant electronics set as a second receiver channel. This Dual-Receive-Mode will enable along-track interferometry, e.g. for velocity measurements and traffic control, and a full polarimetric mode, by simultaneously receiving H and V with the two sub-apertures.

## 1.2 TerraSAR-X Basic Image Products

Infoterra GmbH proposes image products that can be classified into two major product groups:

- The Basic Image Products (or L1B Products) and are the output from the TerraSAR-X Multi Mode SAR Processor (TMSP), which has been developed by the German Aerospace Centre (DLR) and correspond to the CEOS Level 1b quality. They are distributed by Infoterra GmbH for the commercial clients and by DLR for the scientific users.
- TerraSAR-X Value Added Products and processors have been defined and developed in the framework of a co-operation between Infoterra GmbH and Joanneum Research. The products are distributed by Infoterra GmbH only. They will be described in the §2.

### 1.2.1 Single Look Slant Range Complex (SSC) product

This product is the equivalent of the standard Slant Range Complex products (SLC) available from ERS-1/2, ENVISAT ASAR, RADARSAT-1 and X-SAR/SIR-C.

The SSC is the basic single look product of the focused radar signal. The product provides the full bandwidth and the phase information so that any other product can be generated at a later time. Fig. 4 represents the amplitude and the phase of the signal backscattered from the test site from Solothurn in Switzerland.

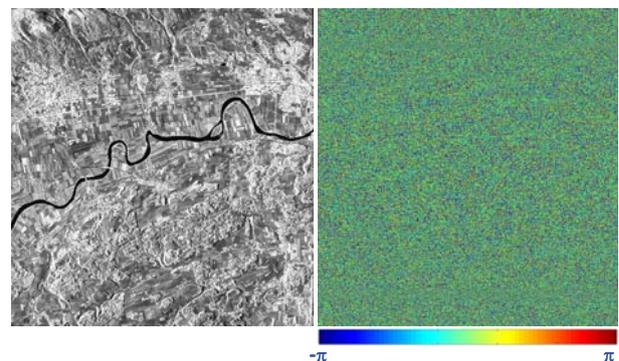


Fig. 4: Solothurn (Switzerland) - SL - amplitude and phase components of the SSC product

### 1.2.2 The Multi-Look Ground Range Detected (MGD) product

The MGD corresponds to the ERS-1/2 PRI or ENVISAT ASAR product called ASA\_IMP\_1P.

The MGD is a multi-look product with reduced speckle and approximately square ground resolution cells. The image

coordinates are oriented along flight direction and along ground range. A simple polynomial projection is performed in range to an ellipsoid in order to achieve approximately quadratic pixels. The advantage of this product is the fact that no image rotation to a map coordinate system has been performed and interpolation artefacts are thus avoided (Fig. 5).



Fig. 5: Solothurn (Switzerland) - SL – MGD product

### 1.2.3 The Geocoded Ellipsoid Corrected (GEC) product

The product corresponds to the ERS-1/2 GEC or the ENVISAT SAR product called ASA\_IMG\_1P.

The GEC is a multi-look detected product. It is projected and resampled to either UTM or UPS with WGS84 as reference and assuming one average terrain height. The pixel spacing is equidistant in northing and easting.

As the ellipsoid correction does not consider a DEM, the pixel location accuracy varies due to the terrain.

The GEC is the recommended product for marine and coastal applications where topography doesn't affect the location accuracy (Fig 6).



Fig. 6: Solothurn (Switzerland) - SL – GEC product

### 1.2.4 Enhanced Ellipsoid Corrected (EEC) product

The product corresponds to the ERS-1/2 GTC or the ENVISAT ASAR DLR-Value-added products.

Like the GEC, the EEC is a multi-look detected product provided in UTM or UPS projection. WGS84 will be used as

the geodetic datum. Terrain induced distortions are corrected considering a DEM of a moderately coarser resolution than the TerraSAR-X products. The pixel location accuracy in these products is highly precise. The geometric quality depends on the height accuracy and resolution of the DEM in combination with the type of terrain and the incidence angle. DEMs from SRTM (C-band and X-SAR), ERS-derived elevation models and GLOBE provide a global basis for a terrain correction service (Roth et al., 2004). The orbit precision will be the main factor for the achieved location accuracy. Depending on the time delay between acquisition and processing, predicted ( $\pm 700$  m), rapid ( $\pm 2$  m) or science orbits ( $\pm 20$  cm) will be used for the geocoding (Roth et al., 2004).



Fig. 7: Solothurn (Switzerland) - SL – EEC product

In contrast to ERS-1/2 and ENVISAT/ASAR products, two resolution variants will be offered for each of the detected products MGD, GEC and EEC. One is optimised with respect to the spatial, the other with respect to radiometric resolution. The spatially enhanced (SE) product is designed for the highest possible ground resolution while the radiometrically enhanced (RE) variant improves the radiometry by multi-look.

## 2. TERRASAR-X VALUE-ADDED PRODUCTS

The Value Added Products are based on TerraSAR-X Basic Image Products and can be generated from new acquisitions, catalogue orders, or a combination of both. They represent a higher level of image processing (also called Enhanced Image (EI) Products).

### 2.1 Value-Added Product Description

#### 2.1.1 Radiometrically corrected image - $RaN^{SAR}$

Calibration of the backscatter values is necessary for inter comparison of radar images acquired with different sensors, or even of images obtained by the same sensor if acquired in different modes or processed with different processors.

The Basic Image Products GEC and EEC are delivered as radar brightness ( $\beta_0$ ). Further radiometric corrections, compensating for effects of local pixel scattering area and local incidence angle on the local backscatter, can be carried out. Two different kinds of radiometric corrections; radiometric calibration and normalization will lead to an absolute measurement of the sigma naught ( $\sigma^0$ ) or gamma naught ( $\gamma^0$ ) coefficients respectively, depending on the customer's selection.

- Radiometric calibration: resulting in sigma naught ( $\sigma_0$ ).

- Radiometric normalisation: resulting in gamma naught ( $\gamma_0$ ).

The output of the radiometric correction (called  $RaN^{SAR}$ ) and normalization will be scaled to a pixel depth corresponding to the product specification.

The standard map projections are UTM or UPS with WGS84 ellipsoid.

Radiometric correction may be preferred if the images are to be used for classifications which do not take angular dependencies of the SAR data into account. Further, it is also important in order to minimize the differences in the radiometry of the various images if several images of the same area or neighbouring areas are to be composed.

Fig 8 and Fig 9 illustrate the corrections added by the computation of the sigma naught coefficient.

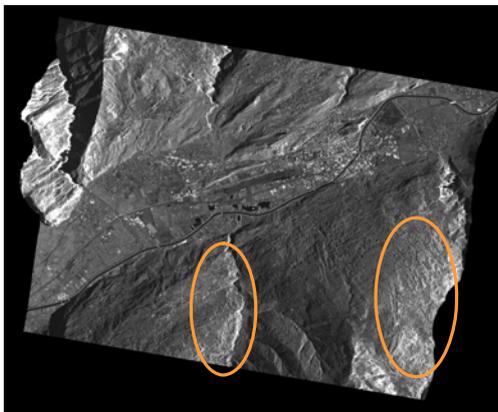


Fig. 8: Sion (Switzerland) - SL – EEC product

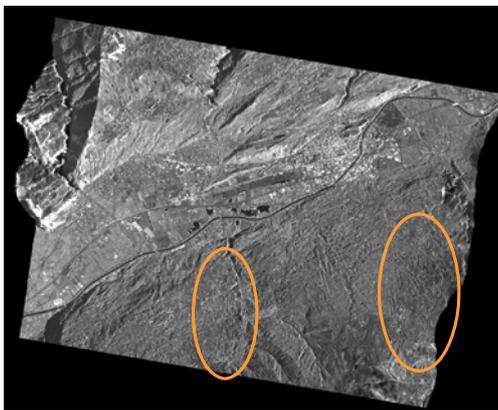


Fig. 9: Sion (Switzerland) - SL –  $RAN^{SAR}$  product

### 2.1.1.2 Orthorectified Image - $ORI^{SAR}$

The ORI processor generates a high precision terrain corrected geocoded image product, and can generally be used for all TS-X image modes. For the generation of such an advanced ORI product digital elevation models (DEM) provided by or purchased for a customer are used. It is assumed that the DEM which is used for advanced ORI production provides a higher vertical accuracy and a better spatial accuracy in comparison to DEMs available from the DEM database, which will be provided by DLR.

The  $ORI^{SAR}$  product is represented in map geometry. The standard map projections are UTM or UPS with WGS84 ellipsoid.

The  $ORI^{SAR}$  is available with the radiometric representation in radar brightness  $\beta_0$  like the Basic Image Products by default; or as  $RaN^{SAR}$  product.

This product is expected to provide a higher level of geometric correction in comparison to Basic Image Products due to higher quality DEMs being used and sensor model optimization procedures being applied. It can be interpreted very quickly and is ideal for combination with other sources of information.

### 2.1.3 Mosaic - $MC^{SAR}$

To cover a geographical area larger than a standard scene, neighbouring geocoded or orthorectified images are seamlessly combined into one image. Possible input products are  $ORI^{SAR}$ , EEC or GEC, depending on the customer's localization accuracy requirements.

The  $MC^{SAR}$  is represented in map geometry. The standard map projections are UTM or UPS with WGS84 ellipsoid. The product provides seamless image information over a large area. It is quickly interpretable and combinable with other sources of information. Thus, it can be used for map sheet generation.

### 2.1.4 Ascending/Descending Merge - $ADM^{SAR}$

Typical characteristics of SAR images acquired over rugged terrain are the radar layover, foreshortening and shadow effects, which are not useful in an ortho-rectified product. A reduction of these effects can be achieved by a combination of ortho-rectified SAR images which have been acquired from ascending and descending right looking orbits. Respective merging options are included in the VA processing suite, resulting in a so-called  $ADM^{SAR}$  product.

During ascending/descending merge, an ascending and a descending ortho image are combined in order to replace no-information areas – like layover and shadow areas – by information available in the respective other image. Furthermore, also for the information areas an “optimized” output pixel can be generated, based on decision and merge criteria, which consider e.g. the local incidence angle or pixel resolution relationship.

EEC,  $ORI^{SAR}$  or  $MC^{SAR}$  can be used as input to the  $ADM^{SAR}$  generation. The Source Image Mask (SOU) will present the origin of each pixel in the product. The  $ADM^{SAR}$  is represented in map geometry. The standard map projections are UTM or UPS with WGS84 ellipsoid.

The  $ADM^{SAR}$  is of particular interest for areas with steep mountain terrain, where shadow and layover can significantly disturb the analysis.

### 2.1.5 Oriented Image - $OI^{SAR}$

The Oriented Image is a subset of an orthorectified or geocoded image scene, mosaic or ascending / descending merge. The subset region is defined by the customer through an area of interest polygon or corner coordinates of the desired region. The product can either be characterized by the user defined area of interest or by a map sheet orientation according to relevant mapping standards or customer defined extensions. The product is represented in map geometry, with the standard map projections UTM or UPS with WGS84 ellipsoid.

The  $OI^{SAR}$  can be combined with other sources of information, so it can directly be used e.g. for map sheet generation. The customer receives an image that covers the specified area of interest rather than satellite-typical image strips that may only cover the area in fractions.

## 2.2 Processing options for Value Added Products

All TS-X Value Added Products are accompanied by auxiliary raster products, which can contain conversion, positional

information and other ancillary information. Depending on the Value Added Product type, different auxiliary raster products are available.

**Geocoded Incidence Angle Mask (GIM):** The GIM contains information on the local incidence angle and on the location of radar shadowing and layover. This mask has the same coding and file structure as the GIM available for the EEC products [1]. The mask can be used for further processing, e.g. radiometric calibration using the incidence angle information. The GIM is available for ORI<sup>SAR</sup>, RAN<sup>SAR</sup>, and all other VA products derived from these products or EEC.

**Incidence Angle Mask (IAM):** The IAM is an alternative representation of the local incidence angle information. The values are not coded, thus the mask can be directly used for further processing such as radiometric calibration using the incidence angle information. The IAM is available for ORI<sup>SAR</sup>, RAN<sup>SAR</sup>, and all other VA products derived from them.

**Layover and Shadow Mask (LSM):** The LSM is the second part of the alternative representation of the GIM. It contains information on radar shadow and layover regions in the image. Like the IAM it can directly be combined with the image data. The LSM is available for ORI<sup>SAR</sup>, RAN<sup>SAR</sup>, and all other VA products derived from them.

**Local Resolution Mask (RES):** The RES identifies the actual ground resolution of the SAR system for each pixel resulting from the local topography and incidence angle. The RES is available for the ORI<sup>SAR</sup> and products derived from it.

**Source mask (SOU):** The source mask gives a numeric value that allows the identification of the source input image for each output pixel. The Source Mask is optionally available for the MC<sup>SAR</sup>, ADM<sup>SAR</sup> and the OI<sup>SAR</sup>.

**Enumeration files:** Enumeration files consists of the **Along Track** Enumeration file (**ALT**) and **Across Track** Enumeration file (**ACT**). Both files provide the original location in SAR (range-azimuth) geometry for each output pixel. These files are useful for conversions from slant range to geocoded geometries (and vice-versa), e.g. for geocoding additional products co-registered with the input image. The enumeration files are only available for ORI<sup>SAR</sup> if it is produced with a DEM provided by the customer.

The following table gives an overview on the availability of Auxiliary Raster Products for TS-X Value Added Products.

Product	Auxiliary files						
	GIM	IAM	LSM	SOU	RES	ALT	ACT
ORI <sup>SAR</sup>	✓	✓	✓		✓	✓*	✓*
RAN <sup>SAR</sup>	✓	✓	✓				
MC <sup>SAR</sup>	✓*	✓*	✓*	✓	✓*		
OI <sup>SAR</sup>	✓*	✓*	✓*	✓*	✓*		
ADM <sup>SAR</sup>	✓*	✓*	✓*	✓	✓*		

\* optional, depending on input products type (see description)

### 3. TERRASAR-X APPLICATIONS

#### 3.1 Mapping activities

##### 3.1.1 Land Use/Land Cover Mapping

TerraSAR-X high geometric and radiometric resolution, high repeat cycle and polarisation availability can support, in combination with ancillary data, the generation of update land

use/land cover information map. Land use or land cover mapping products are needed by many authorities on rather different spatial levels and with different thematic contents (land use mapping, transport agency, environmental entities ...) for the use in GIS systems.

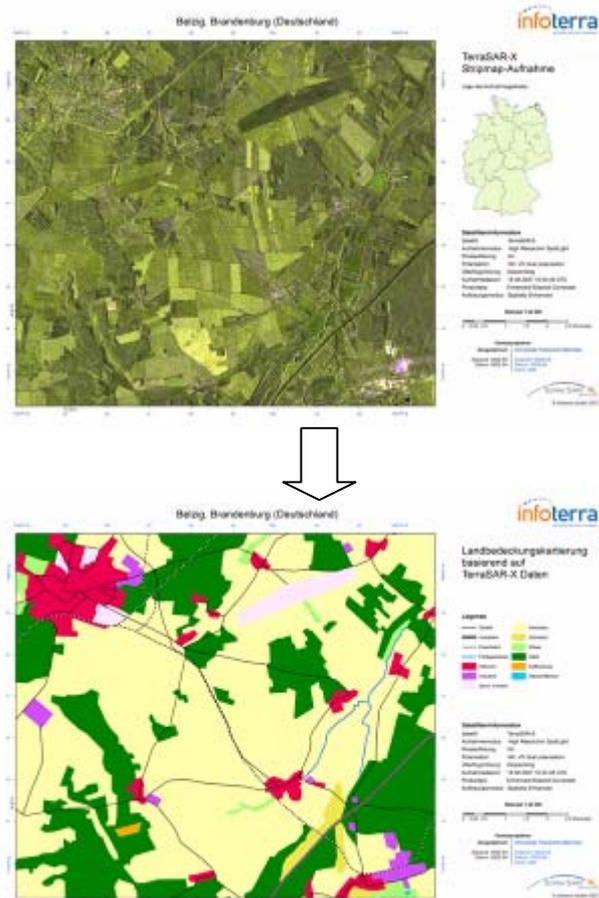


Fig. 10: Demonstration using LMCS / sub-set of CORINE Land Cover class types – Belzig, Brandenburg (Germany)

Fig. 10 shows the land cover classification according to the CORINE nomenclature of the test site of Belzig in Germany.

The following image (Fig 11) shows a high resolution SpotLight data over the coastal zone of Irian Jaya, Indonesia. It can be easily seen on the TerraSAR-X image that different types of vegetation cover the considered area. The coast line is in fact covered of mangrove, whereas palm oil plantation is dominated on the drier land. Studies are currently on-going in order to determine how much TerraSAR-X can support forestry activities.

Our preliminary studies thus showed that the very high resolution, the multi-polarization and multi-incidence angle capability of TerraSAR-X open very interesting perspectives for the mapping and monitoring of urban areas.

##### 3.1.2 Topographic Mapping

Topographic base maps contain surface forms, surface features (vegetation cover, man-made surfaces and buildings, traffic lines, water lines and bodies etc). They are essential instruments for any planning activity (e.g. strategic, spatial, agricultural, forestial, and environmental) and are a prerequisite for the retrieval of further value added geo-information products.

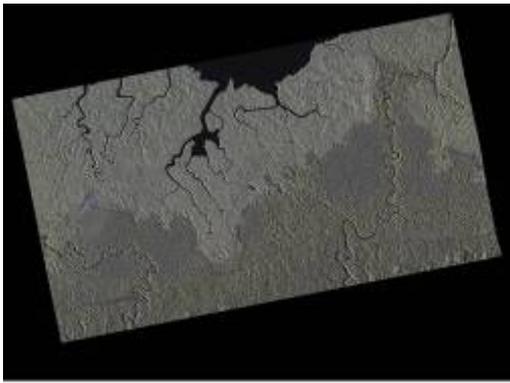


Fig. 11: Irian Jaya, Indonesia – HS – HH/VV

Map scales created through TerraSAR-X data exploitation can range from large area overviews (1:250.000) up to higher resolution maps (1:10.000) depending on the area and application.

### 3.2 SAR Interferometry

TerraSAR-X repeat pass interferometry can be applied in arid areas. The first results achieved by the German Aerospace Centre show that TerraSAR-X SpotLight modes allows the realisation of Digital Elevation Model with 5m horizontal and vertical accuracy (Adam, 2007). Moreover TerraSAR-X also allows urban ground motion with significantly higher resolution and shorter temporal baselines than current SAR satellites.

Many studies are currently on-going and further results will be presented during the workshop.

### 3.3 DinSAR and PS-InSAR

Several applications regarding subsidence mapping on base of TerraSAR-X data are currently under evaluation. These comprise subsidence/uplift due to oil-/gas production and related stimulation activities as well as those related to the storage of gas in abandoned gas production sites. In addition, examples from construction activities (e.g. tunnelling/subway construction) are under investigation.

First results using Differential Interferometry (DInSAR) are promising: Precise orbit information provided by using scientific orbits for TerraSAR-X data are reducing efforts for baseline estimation and potentially existing baseline error related residues in DInSAR results. Furthermore, the existence of an acquisition tube for TerraSAR-X leads to a majority of baselines below 300 m and thus a suitability of most of interferograms due to restricted loss of geometric decorrelation.

For the application of persistent scatterer techniques, the acquisition of data stacks is currently ongoing for different areas of interest with known surface displacements. Specific persistent scatterer analyses are foreseen as soon as suitable data stacks are available.

### 3.4 Risk Management and Disaster assessment

TerraSAR-X high repeat cycle and resolution are important contributors for risk diagnostics, which are related to natural hazards. In the following subsection are proposed four examples of TerraSAR-X capability for disaster assessment and monitoring.

- Flood extend mapping
- Oil Spills

- Burned area mapping

#### 3.4.1 Flooding Mapping

Floods are among the most frequent types of natural disasters in Europe: More than one hundred major floods were recorded in the past decade alone, each causing severe social, ecological and economic damages. The overall objective of an effective flood risk management is to reduce the likelihood as well as the impact of floods. Thus, geo-information services and related Earth observation data are a fundamental source of information for all phases of risk management. They reliably support the responsible authorities and relief units in their decision-making.

The following example (Fig 12) illustrates the assessment of a flood extent over the area of Trinidad, capital of Beni. The flood extent was realised by UNOSAT with a single polarisation TerraSAR-X images; RADARSAT-1 images from the 08/02/2008 and 05/04/2001 were additionally used.

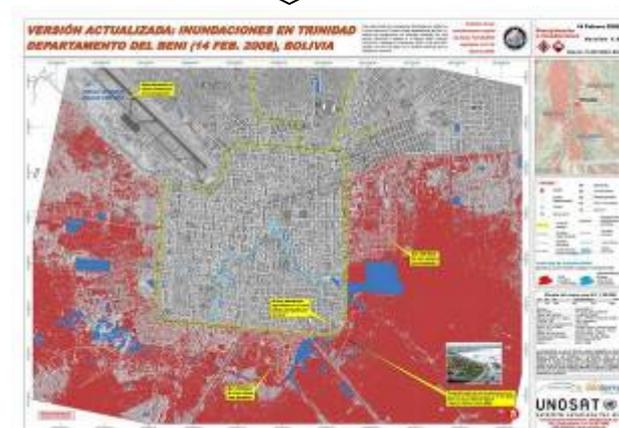
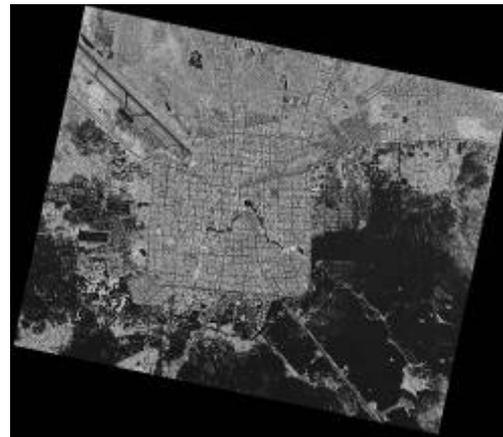


Fig. 12: Flooding in the urban area of Trinidad, TerraSAR(SL) /Radarsat radar images Source: TerraSAR-X; Radarsat , 1 m SpotLight (X-Band) resolution.- @UNOSAT2008

#### 3.4.2 Oil Spills Monitoring

TerraSAR-X acquires oil slicks in the Black Sea - Nov 16 2007: The StripMap image acquired 5 days after an oil tanker broke into two pieces shows massive oil slicks drifting on the surface.

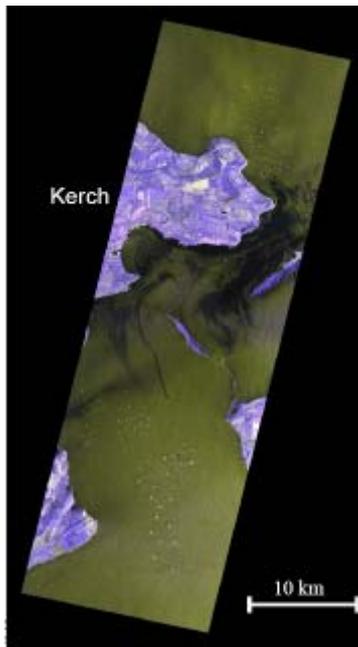


Fig. 13: TerraSAR-X StripMap mode dual polarisation for oil spills monitoring

### 3.4.3 Burned area mapping

In this example, the analysis of TerraSAR-X images was realised by Apogee Imaging International (Fig. 14).

Two StripMap images (7:30am and pm) have been acquired by TerraSAR-X over bushfires in Kangaroo Island (Australia). The images show the progression of the firefront in Vivonne Bay. The yellow circles highlight the two active firefronts. The darkness of the area is caused by the defoliation and the reduction in moisture due to the fire.

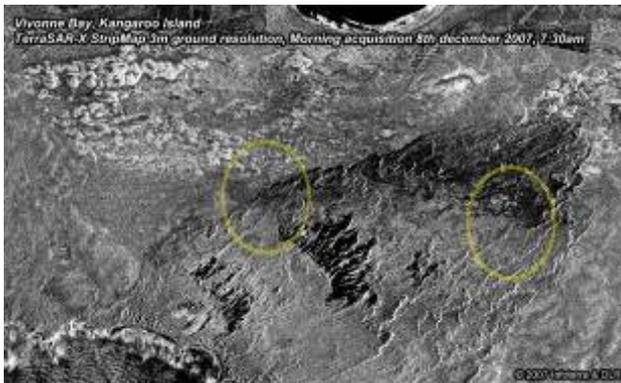


Fig. 14: TerraSAR-X StripMap mode for fire monitoring in the Kangaroo Island - @Apogee2007

## 4. TANDEM-X

The TanDEM-X mission aims at generating a global Digital Elevation Model (DEM) with an extremely high accuracy corresponding to HRTI-3 specifications defined by the U.S. National Geospatial-Intelligence Agency (NGA). This goal will be achieved by means of a second SAR satellite TanDEM-X flying in a combined orbit with TerraSAR-X. Thus SAR image and DEM data will synchronously be available for the same site.

Commercial exploitation of TanDEM-X will benefit mainly from the global high quality DEM product, the associated update services, and the generation of topographic base data (image and contour line maps). Further applications with commercial potential will be implemented, based on the applications research results (e.g. moving target detection, super resolution, differential InSAR based monitoring).

The DEM quality domain that the TanDEM-X mission can provide is today dominated by offers based on airborne campaigns. There is currently no system or process available to provide a global service for HRTI-3 (z-accuracy better than 2 m) and in specific cases HRTI-4 (z-accuracy better than 1 m) DEMs with short response time. Those requirements of the important geospatial markets can only be fulfilled by globally operating a space-borne SAR system. Optical systems require cloud free weather conditions and therefore often fail to fulfil the global response time demand. Airborne systems lack in global mapping capability.

## 5. CONCLUSION

This paper demonstrates the benefit brought by TerraSAR-X on the development of a worldwide commercial EO-market. The satellite parameters, scientific and commercial products are highly described in order to show the variety of potential applications.

As illustrated, the very high resolution, the multi-polarization and multi-incidence angle capability of TerraSAR-X open very interesting perspectives for the mapping and monitoring of urban areas. It also provides new capabilities for thematic and topographic mapping, InSAR techniques and DEM generation. The high repeat cycle and TerraSAR-X timeliness are also an asset for disaster assessment and monitoring.

TerraSAR-X, and at a later stage together with TanDEM-X, offers, with its complementary near-real time data acquisition capabilities, a whole new approach to the use of space-borne datasets for a wide variety of products and services.

## REFERENCES

- A. Roth et al., "Geocoding of TerraSAR-X data", Proc. 20th ISPRS Congress, Istanbul, Comm. 7, pp. 840-844, 2004.
- N. Adam, et al., "First TerraSAR-X interferometry evaluation", FRINGE 2007, Frascati, Italy

## APPENDIX – The Company Profile

Launched in January 2001, Infoterra GmbH is a 100% owned subsidiary of EADS Astrium, Europe's leading space company. Infoterra was founded to prepare and conduct the commercial exploitation of TerraSAR-X and TanDEM-X data services as well as system capacities.

Infoterra was formed by spinning-off the 'Earth Observation Services' division of the former EADS Astrium GmbH, Germany, re-branding of the UK-based National Remote Sensing Centre Ltd., and the French ISTAR S.A. Infoterra GmbH has a about 120-strong team of highly skilled staff, including experts in cartography, photogrammetry, forestry, agriculture, geological exploration, environmental management, and telecommunications planning. In addition, Infoterra's staff is skilled in the development of systems software specific to the management of geographic data. Such a strong market-oriented

positioning facilitates a prompt and flexible response to all enquiries within the geo-information community. Infoterra is serving and supporting both public and private customers with geo-information on cartography, land use/ land cover, and forestry as well as with a focus on TerraSAR-X, GMES (Global

Monitoring for Environment and Security), and thematic mapping services. Infoterra is ISO9001:2000 and ISO 14001 certified and guarantees that all activities are performed according to internationally accepted quality and environmental standards.