TerraSAR-X Image Product Guide

Basic and Enhanced Radar Satellite Imagery

1 Introduction

TerraSAR-X and TanDEM-X are commercial German Synthetic Aperture Radar (SAR) Earth observation satellites, which were launched in June 2007 and June 2010 respectively. Both satellites feature a scheduled lifetime of 5 years. However, in May 2014 it was announced that both satellites display excellent health status with the radar instruments working nominally and an exceptional battery status. Lifetime expectancy of TerraSAR-X and TanDEM-X radar satellites was thus extended by a further five years, enabling the delivery of first-class SAR data well beyond 2018.

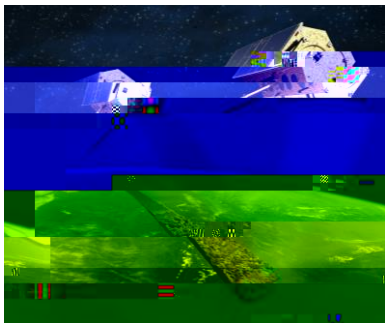
TerraSAR-X and TanDEM-X offer outstanding operational features that have not been available from spaceborne data sources before: The satellite design is based on well-founded technology and knowledge achieved during the successful Synthetic Aperture Radar SIR-C/X-SAR and SRTM missions. The satellites carry a high frequency X-band SAR sensor, which can be operated in flexible imaging modes in order to meet the requirements of versatile applications.

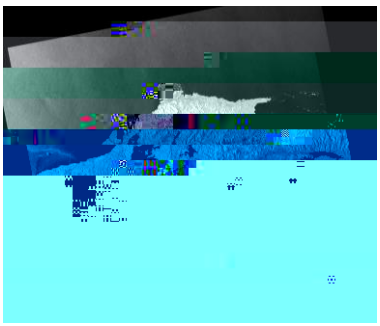
The TerraSAR-X and TanDEM-X missions are realised in the frame of a Public Private Partnership (PPP) between the German Ministry of Education and Science (BMBF) represented through the German Aerospace Centre (DLR) and Airbus Defence and Space. Airbus Defence and Space successfully developed, integrated, and tested the satellite. Commercial distribution of TerraSAR-X data, value-adding, service development, and user training are the tasks of the Intelligence programme line within Airbus Defence and Space. DLR implemented the satellite control system and the payload ground segment for reception, processing, archiving and distribution of the X-band SAR data. DLR is also responsible for instrument calibration and the operation of the two satellites. The scientific use of TerraSAR-X and TanDEM-X data is coordinated via DLR's TerraSAR-X Science Service System.

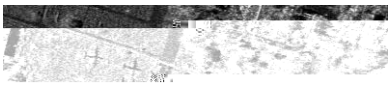
The two satellites are operated in a close formation flight with distances of down to only a

Elevation Model, featuring an unrivalled combination of coverage, accuracy and quality.

As the two satellites are virtually identically in construction and feature the same acquisition modes and imaging characteristics, in this document reference is only made to TerraSAR-X. However, all information provided is equally valid for TanDEM-X image products.







In **Wide ScanSAR (WS)** mode, a swath width of up to 270 km is achieved by scanning six adjacent ground sub-swaths. Due to the switching between the beams, only bursts of SAR echoes are received, resulting in a reduced bandwidth and hence, reduced azimuth resolution.

In **ScanSAR** mode a spatial resolution of up to 18.5 m is achieved, while for **Wide ScanSAR** a spatial resolution of 40 m is achieved. The standard scene size is 100 km x 150 km (width x length) for ScanSAR and up to 270 km x 200 km for Wide ScanSAR for easily manageable image file size. The acquisition length is extendable up to 1,650 km for ScanSAR and up to 1,500 km for Wide ScanSAR.

The **advanced TerraSAR-X imaging modes** use a dual receive antenna by splitting the antenna into two parts. The dual receive antenna is only available for ordering in case of designated mission campaigns, which are announced by the operator DLR. It enables the acquisition of the following products:

StripMap twin polarisation data recorded in HH and VV at a standard scene size of 30 km x 50 km (width x length).

StripMap quadruple polarisation data recording the full scattering matrix, allows the derivation of further polarisation states (circular or elliptic).

The table below gives an overview of the operational modes of TerraSAR-X. The six different imaging modes are distinguished by their spatial resolution and coverage:

4 TerraSAR-

5 TerraSAR-X Basic Image Products

The SAR raw data are processed by the TerraSAR-X Multi Mode SAR Processor (TMSP). For each order - future acquisition order or catalogue order - the customer can specify processing options, which determine the Basic Image Product w.r.t.

the geometric and radiometric resolution,

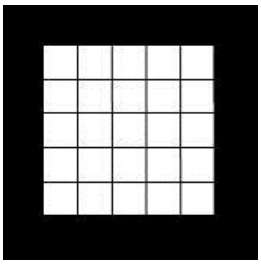
the geometric projection and

the auxiliary information and annotation.

5.2 Detected Products

In the detected products, the spatial resolution is reduced (the number of looks is increased accordingly) in order to reduce speckle and thermal noise, i.e. to improve the radiometric resolution. Three different product types of detected image products exist for all imaging modes.

MGD - Multi Look Ground Range Detected

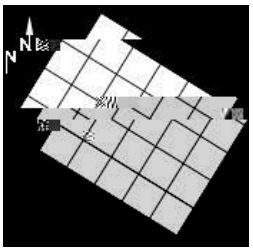


The MGD product is a detected multi look product with reduced speckle and approximately square resolution cells. The image coordinates are oriented along flight direction and along ground range. The pixel spacing is equidistant in azimuth and in ground range. For the slant to ground range projection the WGS84 ellipsoid and an average, constant terrain height value are used.

The MGD corresponds to the ERS-1/2 PRI or ENVISAT ASAR product called ASA_IMP_1P.

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. This product is useful, if geocoding or orthorectification is to be applied by the customer, or in case geocoding is not required.

GEC - Geocoded Ellipsoid Corrected



The GEC product is a multi-look detected product, which is resampled and projected to the WGS84 reference ellipsoid assuming one average height. The image is represented in map geometry with ellipsoidal corrections only, thus no terrain correction is performed. Available grid formats are UTM (Universal Transversal Mercator) and UPS (Universal Polar Stereographic).

Since the ellipsoid correction does not use height information from a Digital Elevation Model (DEM) for geometric correction, the pixel location accuracy varies depending on the local terrain. For other types of relief, the terrain induced SAR specific distortions are not corrected and significant location shifts can appear, particularly for a strong relief and/or steep incidence angles (see Annex for details on pixel location accuracy).

The product corresponds to the ERS-1/2 GEC or the ENVISAT SAR product called ASA_IMG_1P.

The GEC allows a fast orientation for the interpreter. Further, the data can be combined directly with other sources of information. For flat terrain, a good pixel location accuracy of the multi-temporal and reference data sets is achieved.

5.3.5 Processor Gain Attenuation

TerraSAR-X Basic Image Products are available in 16 bit integer values. As sometimes the backscatter values of the TerraSAR-X images exceed this data range, a scaling of the values is required. It might happen that the backscatter values of very bright targets (e.g. corner reflectors) are clipped due to this scaling.

The processing parameter **processor gain attenuation** parameter influences the scaling, i.e. the clipping of values of very bright targets is prevented at the cost of not optimally quantised radiometry for low backscatter areas. Thus

Layover and Shadow Mask (LSM): The LSM is the second part of the alternative representation of the GIM. It contains the information on radar shadow and layover regions in the image. Like the IAM, it can be directly composed with the image data.

The LSM is available for ORI^{SAR}, RAN^{SAR}, and any other Enhanced Image Product derived from them.

Local Resolution Mask (RES): The RES identifies the actual ground resolution of the SAR system for each pixel as this depends on the local topography and incidence angle for every pixel.

The RES is available for the ORI^{SAR} and products derived from it.

Source Mask (SOU): The SOU provides a numeric value that allows the identification of the source input image for each output pixel.

The SOU is available for the MC^{SAR}, ADM^{SAR} as well as any oriented image (OI^{SAR}) generated from one of these products.

Enumeration files: Enumeration files consist of the Along Track Enumeration file (ALT) and Across Track Enumeration file (ACT). Both files provide the original location in SAR geometry (range-azimuth) for each output pixel. These files are useful for conversions between slant range and geocoded geometries, e.g. for geocoding additional products that are co-registered with the input image.

The Enumeration files are available for the ORI^{SAR} only if it is produced with a DEM owned by the customer.

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6.3 Customisation Services

Customisation Services are available for TerraSAR-X Basic and Enhanced Image Products. In the following the different customisation services are detailed.

6.3.1 Oriented Image (OI^{SAR})

OI^{SAR} - Oriented Image

The Oriented Image is a subset of an orthorectified or geocoded image scene, a mosaic or an ascending / descending merge. The subset region is defined by the customer via an Area of Interest polygon or corner coordinates of the desired region. The product can either be characterised 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 being UTM or UPS with WGS84 ellipsoid.

The OI^{SAR}

7 Ordering & Delivery

7.1 Ordering Process

7.1.1 Standard Ordering Procedures

The easiest way to order TerraSAR-X data is to **contact** the regional TerraSAR-X Services Partner (http://www.intelligence-airbusds.com/en/34-commercial-

corresponds to an acquisition window in the evening of the same day, the later submission deadline corresponds to the acquisition window early in the next day.

The submission deadlines are indicated in the acquisition plan. The financial quotation must

8.2 Radiometric Resolution

TerraSAR-X radiometric accuracies were determined during the commissioning phase of TerraSAR-X for StripMap products:

Type of Accuracy	Definition	Design Specification [dB]
Absolute Radiometric Accuracy	Root mean square (RMS) error between the measured and the true radar cross section at different locations within one scene and also over time	0.6

9 Contact

For feedback or further inquiry please contact the Airbus Defence and Space Customer Service via telephone at +49 7545 8 4344 / eMail: terrasar-x@airbus.com or visit http://www.intelligence-airbusds.com/terrasar-x/