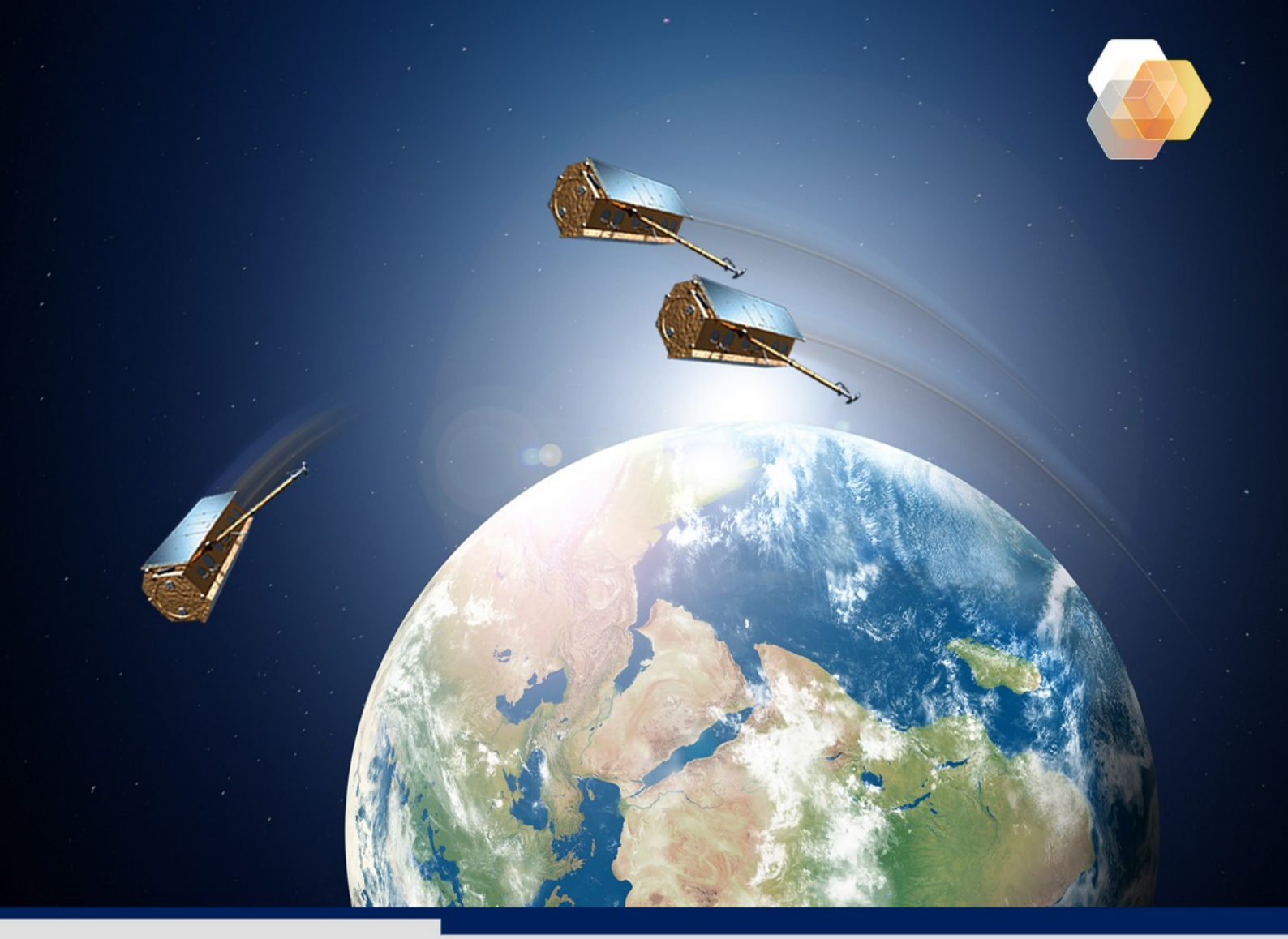


Radar Constellation (TerraSAR-X/PAZ) Image Product Guide

Basic Radar Satellite Imagery

Airbus Defence and Space - Intelligence

AIRBUS

1 Introduction

TerraSAR-X (TSX) and **TanDEM-X** (TDX) are commercial German Synthetic Aperture Radar (SAR) Earth observation satellites, launched in June 2007 and June 2010 respectively.

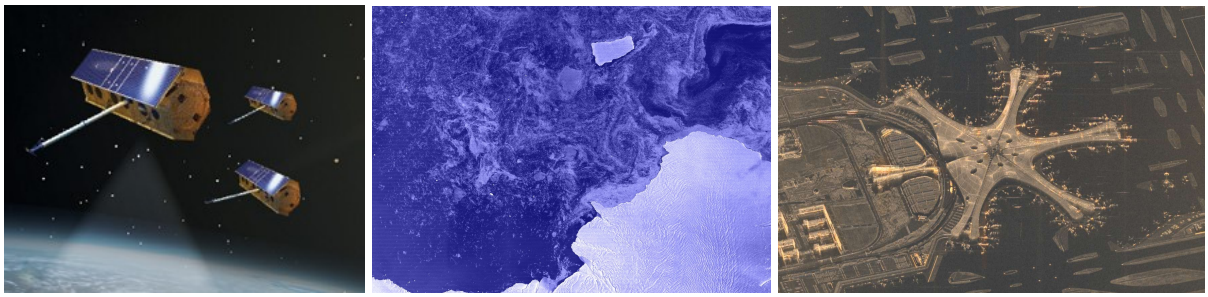
PAZ is a Spanish SAR Earth observation satellite, launched in February 2018, operating in the same orbital tube and with identical imaging modes as TerraSAR-X and TanDEM-X, allowing Airbus Defence and Space and its Partner Hisdesat Servicios Estratégicos S.A. to establish a unique commercial very high-resolution SAR constellation (**Radar Constellation**).

All three satellites offer outstanding operational features: 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. They 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 and TanDEM 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 satellites. Commercial distribution of TerraSAR-X/TanDEM-X data, value-adding, service development, and user training are the tasks of the Integrated Space Solutions 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 space crafts are operated in a close formation flight with distances of down to only a few hundred meters. Together they acquired the data basis for Airbus' global WorldDEM™ and WorldDEM Neo Digital Elevation Models, featuring an unrivalled combination of coverage, accuracy and quality.

The Spanish Radar Mission (PAZ) is a dual-use (civil/defence) and flagship mission of the Spanish Space Strategic Plan, funded and owned by the Spanish MoD and managed by the private company Hisdesat Servicios Estratégicos S.A.



Wide ScanSAR Mode (Antarctica, Brunt Ice Shelf / Bafa-No. 1142438) Staring SpotLight Mode (Beijing Daxing Int'l Airport / Bafa-No. 1131622)

The information in this **Radar Constellation (TerraSAR-X/PAZ) Image Product Guide** is primarily based on the 'TerraSAR-X Basic Product Specification Document' and 'TerraSAR-X L1B Product Format Specification'. For data from the PAZ satellite origin, this information might deviate. For more details, please see 'PAZ Image Product Guide' and 'PAZ SAR Level 1b Product Format Specification for PAZ SAR Processor' (each in its latest issue), which prevail.

2 Radar Constellation Facts

TerraSAR-X/TanDEM-X, PAZ Technical Facts	
Nominal Operational life	5 years for TerraSAR-X and TanDEM-X, an extended lifetime beyond 2028 is foreseen (Status: January 2024). 7 years for PAZ, an extended lifetime beyond 2028 is expected (Status: January 2024).
Orbit	Sun-synchronous repeat orbit.
Repeat period	11 days per individual satellite. 4 and 7 days in constellation (TSX/PAZ).
Equatorial crossing time (GMT)	18:00 hrs ascending pass (± 0.25h) 06:00 hrs descending pass (± 0.25h)
Inclination	97.44°
Altitude at the equator	514 km (319.8 miles)
Antenna type	Active Phased Array Antenna, electronically separable
Antenna size	4.8 m x 0.7 m (15.7 feet x 2.3 feet)
Centre Frequency	9.65 GHz (X band)
Chirp bandwidth	100 MHz / 150 MHz / 300 MHz
Nominal acquisition direction	Right looking
Polarisation	Single, dual - depending on imaging mode.

GMT Greenwich Mean Time

Radar Constellation Key Features:

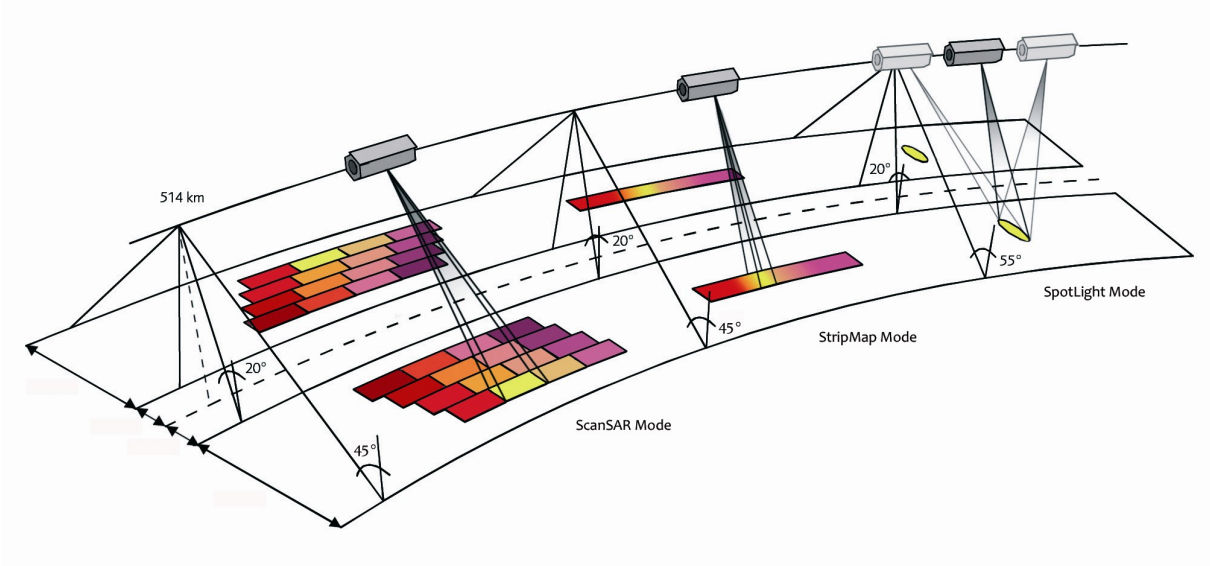
The **flexible Imaging Modes and characteristics** benefit data collections from very-high-resolution to wide-area-coverage. Due to the nature of SAR, the satellites operate **independently of daylight and weather conditions** resulting in an unrivalled reliability in terms of data collections.

- Six different Imaging Modes – from up to 25cm to 40m resolution.
- Large area coverage of up to 270 km Swath width using Wide ScanSAR Mode.
- Approx. daily global mean revisit capacity.
- Interferometric (InSAR) Repeat Cycle of 4 / 7 days.
- Weather/cloud and daylight independent.
- Geolocation accuracy of <1m. No external ground control points needed.
- Capability to detect changes and measure surface motion and surface heights

In constellation the TSX/TDX formation and PAZ are phased 98° apart leading to an **Interferometric (InSAR) Repeat Cycle** of 4 and 7 days.

3 Imaging Modes

The **satellites standard operational mode** is the single receive antenna mode from which the following imaging modes can be retrieved: SpotLight, StripMap, and ScanSAR. The single receive antenna mode uses a chirp bandwidth of up to 300 MHz.



Credit: DLR (CC BY-NC-ND 3.0)

The **SpotLight** imaging modes use phased array beam steering in azimuth direction to increase the illumination time, i.e. the size of the synthetic aperture. This leads to a restriction in the image / scene size. Thus, the scene size is technically restricted to a defined size: 10 km x 10 km (width x length) for the **SpotLight (SL)** mode and 5 to 10 km x 5 km (width x length) in the **High Resolution SpotLight (HS)** mode. The **Staring SpotLight (ST)** mode is an extreme case, in which the antenna footprint rests on the scene and the scene length corresponds to the length of the antenna footprint. Thus, the scene size is highly dependent on the incidence angle: at small incidence angle wide footprints at short length are received and with increasing incidence angle nearly equal proportions are obtained, i.e. 7.5 km x 2.5 km @ 20° incidence angle and 4 km x 3.7 km @ 60° incidence angle (width x length). This sophisticated imaging mode makes it possible to acquire data with up to 0.25 m resolution in Staring SpotLight mode, 1 m resolution in High Resolution SpotLight mode (acquired with a bandwidth of 300 MHz) and 2 m in SpotLight mode.

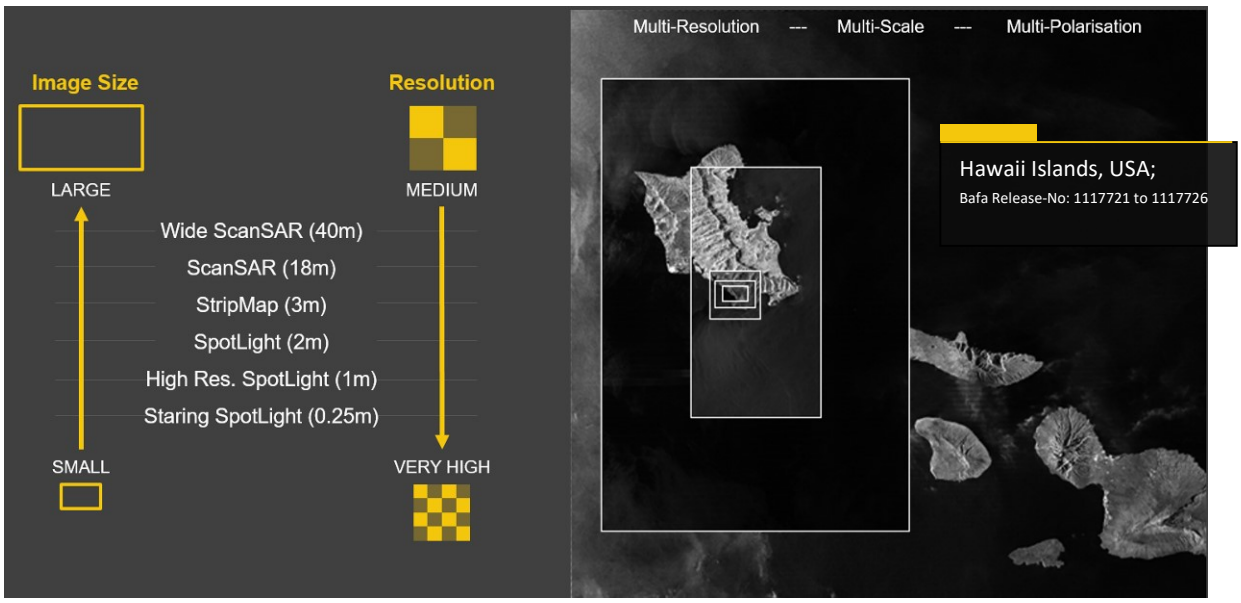
StripMap (SM) is the basic SAR imaging mode as known e.g. from ERS-1 and other radar satellites. The ground swath is illuminated with continuous sequence of pulses while the antenna beam is fixed in elevation and azimuth. This results in an image strip with a continuous image quality (in flight direction). StripMap dual polarisation data have a slightly lower spatial resolution and smaller swath than the single polarisation data.

In StripMap mode, a spatial resolution of up to 3 m can be achieved. The standard scene size is 30 km x 50 km (width x length) in order to obtain manageable image files; however, acquisition length is extendable on request.

In the **ScanSAR** imaging modes, electronic antenna elevation steering is used to acquire adjacent, slightly overlapping coverages with different incidence angles that are processed into one scene. In **ScanSAR (SC)** mode, a swath width of 100 km (and even more) is achieved by scanning four adjacent ground sub-swaths with quasi-simultaneous beams, each with different incidence angle.

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 for ScanSAR and Wide ScanSAR is extendable on request.



Radar Constellation (TerraSAR-X/TanDEM-X & PAZ) Acquisition Modes: Resolution vs. Standard Scene size

In addition to the operational modes the following *advanced TerraSAR-X imaging modes (non-commercial)* use a dual receive antenna by splitting the antenna into two parts. The dual receive antenna is only available in case of designated scientific 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 (quad) polarisation* data recording the full scattering matrix, allows the derivation of further polarisation states (circular or elliptic).

In addition to the graphic above, the following table provides a detailed overview of the **operational modes**. The six different imaging modes are distinguished by their spatial resolution and area coverage:

Imaging Mode	Standard Scene Size[a] [km]	Maximum Acquisition Length [km]	Slant Range Resolution[b] [m]	Azimuth Resolution[b] [m][c]	Polarisation[f]	Full Per-formance Range [°]
Staring SpotLight (ST)	4 x 3.7[d]	3.7	0.6	0.24	Single (VV or HH)	20° to 45°
HighRes SpotLight 300 MHz (HS300)	10 x 5[d]	5	0.6	1.1	Single (VV or HH)	20° to 55°
HighRes SpotLight (HS)	10 x 5	5	1.2 1.2	1.1 2.2	Single (VV or HH) Dual (HH & VV)	20° to 55°
SpotLight (SL)	10 x 10	10	1.2 1.2	1.7 3.4	Single (VV or HH) Dual (HH & VV)	20° to 55°
StripMap (SM)	30 x 50 single pol 15 x 50 dual pol	1,650[e]	1.2 1.2	3.3 6.6	Single (VV or HH) Dual (HH & VV, HH & HV, or VV & VH)	20° to 45°
ScanSAR (SC)	100 x 150	1,650[e]	1.2 (at 150 MHz)	18.5	Single (VV or HH)	20° to 45°
Wide ScanSAR (WS)	270 x 200[d]	1,500[e]	Depending on range bandwidth 1.7 - 3.3	40	Single (VV, HH, HV or VH)	15.6° to 49°

[a] Approximate width x length (range x azimuth)
[b] Figures correspond to the Single Look Slant range Complex (SSC) image products
[c] Figures correspond to the Single Look Slant range Complex (SSC) image products
[d] Depending on incidence angle
[e] Theoretical Maximum Acquisition length, commercially not applicable. Extended Acquisition Length on request.
[f] Available for Radar Constellation offer

4 Basic Image Products

Basic Image Products (or L1B Products) are *satellite path oriented* data sets. They correspond to the CEOS Level 1b quality and can be ordered as future acquisitions or from the data catalogue. In case of a future acquisition order, the customer can determine the following acquisition options:

Acquisition Options	
Area of Interest (or scene centre coordinate)	
Imaging Mode	Staring SpotLight (ST) – up to 0.25m resolution High Resolution SpotLight (HS), 300MHz – up to 1m resolution High Resolution SpotLight (HS), 150 MHz – up to ~1.4m resolution SpotLight (SL) – up to 2m resolution StripMap (SM) – up to 3m resolution ScanSAR (SC) – up to 18m resolution Wide ScanSAR (WS) – up to 40m resolution
Polarisation Mode	Single (S) for all modes Dual (D) for High Resolution SpotLight (HS), SpotLight (SL) and StripMap (SM)
Incidence Angle Range	15° - 60° [e]
Pass Direction	Ascending (A) or Descending (D)
Acquisition Start and Stop Time	
Polarisation Channels	Single polarisation: HH or VV, for Wide ScanSAR additionally: HV or VH, Dual polarisation: HH/VV, for StripMap only: HH/HV or VV/VH

Naturally, for Basic Image Products ordered from the catalogue, these parameters are fixed.

Processing options for Basic Image Products, however, can be determined for both future acquisition orders and catalogue orders.

The TSX/TDX SAR raw data are processed by the TerraSAR-X Multi Mode SAR Processor (TMSP). The PAZ SAR raw data are processed by the PAZ SAR Processor (PSP).

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.

Airbus' Radar Constellation (TerraSAR-X/PAZ) Basic Image Products are processed and delivered in radar brightness β0, making them comparable to the detected ground range

[e] Data outside performance range (see table in chapter 3) might not fulfill the product specification.

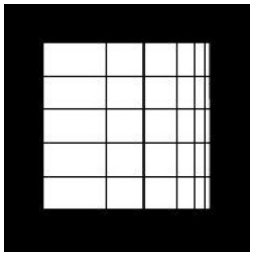
products from e.g. ERS-1 and 2, ENVISAT/ASAR and RADARSAT. The complex slant range products are also delivered in radar brightness.

With respect to the geometric projection and representation of the data, Basic Image Products are differentiated into four individual **Product Types**, also called **Processing Levels**, which are described in the following.

4.1 Slant Range Product

The slant range product is a single look product of the focused radar signal. For this product, no additional processing options are available.

SSC - Single Look Slant Range Complex



The SSC product is a **single look product** of the focused radar signal and the closest to the recorded raw data. The pixels are spaced equidistant in azimuth (according to the pulse repetition interval PRI=1/PRF) and in slant range (according to the range sampling frequency). The data are represented as complex numbers containing amplitude and phase information. Each image pixel is processed to zero Doppler coordinates in range direction, i.e. perpendicular to the flight track. Due to the nature of azimuth/slant-range coordinates, no geocoding is available. The SSC is delivered in the DLR-defined binary 32 bit CoSAR format (see TerraSAR-X Level1B Product Format Specification) requiring professional image processing software.

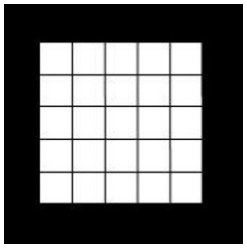
The product is compatible with the standard slant range products (SLC) available from ERS-1/2, ENVISAT ASAR, RADARSAT-1 and X-SAR/SIR-C.

The SSC product is intended for applications that require the full bandwidth and phase information, e.g. for SAR Interferometry (InSAR processing, DEM generation) and Polarimetry. Depending on the required application, this product may be preferred over geocoded data, since it does not include any radiometric artefacts, which may be introduced during spatial resampling and geocoding.

4.2 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.

MGD - Multi Look Ground Range Detected

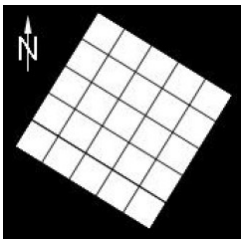


In the MGD product, the SSC product has now been projected to the ground (ground range geometry) with no geocoding being established yet. The MGD product is a **detected multi look** product with reduced speckle and approximately square resolution cells. The image coordinates are oriented along flight 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 is delivered as 16 bit Geotiff.

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 with a DEM is to be applied by the customer. It is close to the original radiometry and thus often used by reconnaissance interpreters or in case geocoding is not required.

GEC - Geocoded Ellipsoid Corrected



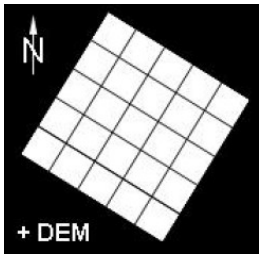
The GEC product is a **multi-look detected product**, which is resampled and projected to the WGS84 reference ellipsoid assuming one average height. The image is represented in map geometry with ellipsoidal corrections only, thus no terrain correction is performed. Available grid formats are UTM (Universal 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 GEC is delivered as 16 bit Geotiff.

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 or overview mapping where no DEM is available or necessary. 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.

EEC - Enhanced Ellipsoid Corrected



The EEC product is a **multi-look detected product** as well, projected and resampled to the WGS84 reference ellipsoid, and the highest level of processing. However, image distortions caused by varying terrain height are corrected using an external Digital Elevation Model (DEM). The image is represented in map geometry with terrain correction. The available map projections are UTM or UPS.

The pixel localization of this product is of a higher accuracy, however, it depends on the type of terrain, the quality and resolution of the DEM used for the ortho-rectification as well as the incidence angle of the acquisition (see Annex for details on pixel location accuracy). An additional geocoded file is included which shows those pixels that are affected by layover and shadowing. The EEC is delivered as 16 bit Geotiff.

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

The EEC product features the highest level of geometric correction available for Basic Image Products. It can be used in GIS software and is thus quickly interpretable and combinable with other sources of information. It is used for all kinds of mapping purposes that require a precise geocoding.

4.3 Basic Image Products Processing Options

For the Detected Products, the customer can specify additional processing options. These influence the spatial / radiometric resolution and the auxiliary information and annotation.

4.3.1 Resolution Mode

In contrast to ERS-1 and ENVISAT/ASAR, the range resolution of TerraSAR-X, TanDEM-X and PAZ is close to or even better than the azimuth resolution and looks cannot be derived by degrading the azimuth resolution. Therefore, two variants of detected products have been designed: one is optimised for resolution (spatially enhanced) and one is optimised for radiometry (radiometrically enhanced). In either variant, a square ground resolution cell is implemented.

For each Detected Product, the customer can choose either one of the two resolution modes: spatially enhanced (SE) or radiometrically enhanced (RE) products.

The **Spatially Enhanced Product (SE)** is designed for the highest possible square ground resolution. Depending on imaging mode, polarisation and incidence angle, the larger resolution value of azimuth or ground range determines the square pixel size. The smaller resolution value is adjusted to this size and the corresponding reduction of the bandwidth is used for speckle reduction.

For the two ScanSAR modes no Spatially Enhanced Products are available.

The **Radiometrically Enhanced Product (RE)** is optimised with respect to radiometry. The range and azimuth resolution are intentionally reduced. This significantly reduces speckle by averaging 5 to 7 looks to obtain a radiometric resolution of about 1.5 dB.

4.3.2 Orbit Measurement Precisions

Positional accuracies depend (among other things) on the precision of the orbit measurement (see Annex for details on pixel location accuracy).

Three orbit precisions are available for Basic Product generation. Customers can choose between them, considering their individual time of availability.

Type of Orbit	Accuracy	Processing Purpose
Predicted Orbit	700 m along track	Used for processing of Near Real Time products; available within 7 h after acquisition.
Rapid Orbit	2 m (3-d, 1 sigma)	**Standard processing** for basic image products; available within 1 to 3 days after acquisition.
Science Orbit	20 cm (3-d, 1 sigma) aiming at 10 cm	The science orbit provides the highest location accuracy and is recommended for data stacks (e.g. time series, interferometry). Basic image products generated with this orbit are typically available within 5 to 7 days after acquisition.

4.3.3 Auxiliary Raster Products

A **Geocoded Incidence Angle Mask (GIM)** is available for the Enhanced Ellipsoid Corrected (EEC) product. The GIM contains information on the local incidence angle and on the location of radar shadowing and layover in a coded mask. The mask can be used for further processing such as radiometric calibration.

The EEC product is always accompanied by a **DEM Coverage Map (DEM Map)**. The DEM Map is a matrix containing an index that identifies the name(s) of the DEM(s) used for the orthorectification (EEC generation) process. A lookup table, which describes the index, is part of the delivered product.

The DEM used for EEC product generation itself is typically not a TerraSAR-X/TanDEM-X or PAZ product and is not delivered with the product.

4.3.4 File Format

The Basic Image Product SSC is delivered in the DLR-defined COSAR binary format. The detected products are delivered in GeoTiff format. The annotation information of all Basic Image Products is provided in xml format.

Standard COTS software packages (e.g. Leica Geosystems Erdas Imagine, PCI Geomatics, ENVI, etc.) support the formats.

4.3.5 Processor Gain Attenuation

Basic Image Products are available in 16 bit integer values. As sometimes the backscatter values of the SAR 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, it can be used to increase or reduce the radiometric contrast between very high returns (from land) versus very low return (water).

Selectable values: 0 dB (default), 10 dB and 20 dB

Examples:

For military applications, where shadows or low values are of interest, the default value 0 dB is usually used. For images of very dense urban area acquired in the Staring Spotlight mode, which are characterised by a lot of very high returns, the recommended value for the processor gain attenuation is 10 dB.

5 Ordering & Delivery

5.1 Ordering Process

5.1.1 Standard Ordering Procedures

The easiest way to order Radar Constellation data is to **contact** Airbus Defence and Space's Customer Service at tel.: +49 7545 8 4344 or e-Mail terrasar-x@airbus.com or access the Airbus webpage (http://www.intelligence-airbusds.com/contact/). Alternatively customers can contact the regional Service Partner.

In order to best select the data product optimised for a specific purpose, it is recommended to refer to the **Applications and Parameters guide** (available on https://intelligence.airbus.com/imagery/how-to-order-imagery-and-data/faq/radar-constellation-technical-documents/). In addition, Airbus Defence and Space's Customer Service Team is happy to support the selection of the most suitable ordering parameters.

Together with the customer, Airbus Defence and Space's Customer Service Team carefully reviews the data requirements and discusses any remaining questions. The customers will then receive an **acquisition plan**, with technical details about the requested acquisition for the Area of Interest, and a **financial quotation**, which must be counter-signed by the customer and returned by e-Mail.

Upon receipt of the signed financial quotation, the acquisition request is entered into the **ordering system** and the **order is confirmed** to the customer, who will be kept informed about the status of the acquisition. An automated email will be sent as soon as the product has been **delivered to the customer's account**. Invoicing will follow delivery of the data.

Alternatively, after qualification and registration of interested customer's by Airbus, Radar Constellation data can also be ordered online via our **OneAtlas Radar** Tasking and Archive service (a.k.a. Radar Portal) available via our OneAtlas platform, where customers can search, plan and set up orders directly (https://connect4.intelligence-airbusds.com/adfs/ls/).

5.1.2 Tasking Concept

The acquisition of Radar Constellation imagery is subject to a Rapid Tasking concept. There are three Levels available:

Standard ordering for all orders placed with Airbus up to 3 days before submission deadline are at no surcharge.

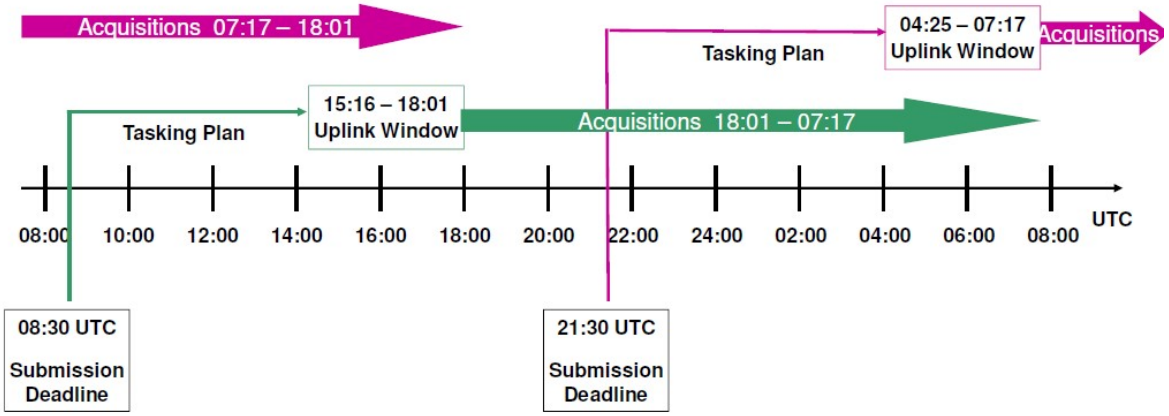
The next Rapid Tasking level, named **Fast**, applies for signed orders sent between 3 and 1 day before submission deadline. A surcharge of €400/image will be charged.

The highest Rapid Tasking level, named **Urgent**, applies for signed orders sent less than 1 day before submission deadline. A surcharge of €900/image will be charged.

There are two **Submission Deadlines** each day: 8:30 hrs and 21:30 hrs (UTC). They correspond to uplink windows for satellite tasking. The early submission deadline

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 be signed and sent back to Airbus Defence and Space prior to this point in time in order for the desired acquisition to be tasked at the specified programming level and the corresponding price.



5.1.3 Archive Orders

Acquired images are archived and can be ordered by customers. Archive requests can be placed with our Customer Service. In such cases customers are asked to provide details regarding the Area of Interest and/or details regarding the desired scene, i.e. acquisition date, time and location (as .kml or .shp).

For registered customers, the TSX/TDX and PAZ archives are also available through Airbus' online **OneAtlas Radar** Tasking and Archive service (a.k.a. Radar Portal). A 'Guest access' to explore the archive with only an initial quick registration is available since 2023.

Depending on acquisition parameters and acquisition date, discounts are applicable for archive data.

5.1.4 Considerations before Ordering

In order to identify the best possible data parameters for a specific application, the following considerations should be made before ordering:

- What application will the data be used for?
- Are several acquisitions required (time? repeat passes?)?
- Resolution and extend of the area of interest are key factors for selecting the acquisition mode (ST, HS, SL, SM, SC or WS).
- Will single or dual polarisation imagery provide the required information better (reduced resolution in dual polarisation acquisitions)?

Airbus Defence and Space's Customer Service is happy to assist with any doubts regarding these choices. If need be, a team of SAR experts is available to discuss such problems so the customer is guaranteed a sound advice.

5.2 Registration and Legal Aspects

In order for Airbus Defence and Space to meet the requirements of the German Satellite Data Security Law (SatDSiG), all customers must be formally checked and registered with the ordering system.

For this registration, companies must provide:

- Full name and legal address of the company
- Name and nationality of at least one key contact person
- A valid phone, e-Mail address and fax number

Further, a copy of your business licence (or another appropriate document for institutions such as universities or governmental authorities) is required for an identity verification of the company. In some cases, a certified document may be requested by the German Satellite Data Security Law (SatDSiG).

5.2.1 German Satellite Data Security Law

Airbus Defence and Space has to comply with the German Satellite Data Security Act (SatDSiG). All TerraSAR-X/TanDEM-X Data distribution is subject to SatDSiG, which has as objective to safeguard the Security Interests of the Federal Republic of Germany from Endangerment by the Distribution of High-Grade Earth Remote Sensing Data.

This means that for TSX/TDX images with a certain resolution and / or covering specific areas, German governmental authorities reserve the right to either release or to prohibit the delivery of the data. This is decided on a case by case basis. A delivery delay of 5 days is possible for certain resolutions.

Customers must be aware that Airbus Defence and Space is required by law to disclose the customer data to the governmental authorities responsible for the Satellite Data Security Law (SatDSiG). The authorities are obliged to keep these data confidential.

5.2.2 Spanish Governmental Regulations

All PAZ Data is property of Hisdesat Servicios Estratégicos S.A., Spain. All PAZ Data requests and distribution is governed by Spanish Governmental Regulations and licensors instructions and therefore subject to be limited or rejected by Hisdesat Servicios Estratégicos S.A. accordingly.

5.2.3 End User Licence Agreement

The End User License Agreement (either the Radar Constellation End User License Agreement or respective TSX/TDX and PAZ End User Licence Agreements) apply to all radar data and any derived products purchased by an end user. An end user is either a person acting in their own name, or an organisation, which is supplied with TSX/TDX and/or PAZ data and/or any derived products. The end user must accept the TSX/TDX and/or PAZ End User Licence Agreement in advance of any usage.

In case an end user plans to use TSX/TDX and/or PAZ data and/or derived products as a single user the Single User Licence Agreement shall be applicable.

In case an end user wishes to use TSX/TDX and/or PAZ data and/or derived products as multi user (e. g. within a project together with other project partners) the Multi User Licence Agreement is applicable. Such agreement will be provided upon request and includes the registration of all affiliated end users.

5.3 Delivery

5.3.1 Delivery Media

Basic Image Products will regularly be delivered via FTPS ('pull' from Airbus delivery server).

On customer request, the products can be made available by delivery into customer cloud buckets.

5.3.2 File Sizes

Basic Image Product file dimensions depend on image mode, product type, near or far range position of the image, resolution, and polarisation mode. The following table provides an overview of the approx. file dimensions of TSX/TDX Basic Image Products. Note: File dimensions of PAZ Basic Image Products can be different.

Imaging Mode	Polarisation Mode	Minimum and Maximum Number of Pixels of an MGD Product [f]	Product Size [Mb] EEC [g]	Product Size [Mb] SSC
Staring SpotLight	Single	9.375 x 3.125 to 20.000 x 18.500	117 to 1.480	592 to 750
HS 300 MHz	Single	5.600 x 4.000 to 14.000 x 10.000	90 to 560	350 to 625
High Resolution SpotLight	Single	5.000 x 2.500 to 20.000 x 10.000	50 to 800	275
	Dual	3.333 x 1.667 to 10.000 x 5.000	33 to 300	333
SpotLight	Single	3.333 x 3.333 to 13.333 x 13.333	44 to 711	338
	Dual	2.500 x 2.500 to 10.000 x 10.000	38 to 600	342
StripMap	Single	7.500 x 12.500 to 24.000 x 40.000	375 to 3840	3300
	Dual	2.727 x 9.091 to 5.000 x 16.667	149 to 500	2667
ScanSAR	Single	12.121 x 18.182	802	5940
Wide ScanSAR	Single	12.933 to 17.733 x 13.333	690 to 946	~7500

[f] Width x length (range x azimuth)
[g] EEC is the largest of the detected products; approximated size including GIM.

6 Annex

6.1 Pixel Location Accuracy

Positional accuracies depend on the precision of the orbit measurement, on incidence angle under which a scene has been acquired and on the type of DEM which has been used for the orthorectification. The available orbit measurement precisions are described in the section on Basic Image Product processing options (chapter 4.3.2).

6.1.1 Incidence Angle

The following table demonstrates the pixel displacement in range that is caused by DEM elevation errors. An elevation range from 2 m to 100 m is listed vs. the incidence angle range of TerraSAR-X. The pixel displacement in range caused by DEM elevation errors for PAZ Products can be different.*

Incidence Angle	20°	23°	26°	29°	32°	35°	38°	41°	44°	47°	48°	50°
Displace-ment Factor	2.75	2.36	2.05	1.80	1.60	1.43	1.28	1.15	1.03	0.93	0.90	0.83
DEM Eleva-tion Error	**Resulting Location Error [m]**											
2	5.5	4.7	4.1	3.6	3.2	2.9	2.6	2.3	2.1	1.9	1.8	1.7
6	16.5	14.2	12.3	10.8	9.6	8.6	7.7	6.9	6.2	5.6	5.4	4.9
8	22	19	16	14	13	12	11	9	9	8	7	7
16	44	38	33	29	25	23	21	18	17	15	14	13
30	82	71	61	54	48	43	38	34	31	28	27	25
100	275	236	205	180	160	143	128	115	103	93	90	83

Source: TerraSAR-X Basic Product Specification Document
* The Digital Elevation Model included in the TerraSAR-X Multi-Mode SAR Processor (TMSP) may be different to the one included in the PAZ SAR Processor (PSP).

6.1.2 Type of DEM

In the following table the Digital Elevation Models (DEM) used for processing of TerraSAR-X EEC Products are listed. The vertical accuracy, the spatial resolution and the geographical coverage of the DEMs is depicted.

	Vertical Accuracy [m]		**Grid Size**	**Limitations**
DEM Product	Relative	Absolute	[Arc Seconds]	
SRTM/X-SAR	6 m	16 m	1”	+/- 60º with gaps
SRTM	8 m	16 m	3”	+/- 60º
ERS-tandem	20 m	30 m	1”	Limited availability
DTED-1	20 m	30 m	3”	Limited availability
GLOBE	Varying 10 to 100s meters		30”	No restrictions

Source: TerraSAR-X Basic Product Specification Document

The Digital Elevation Models (DEM) used for processing of PAZ EEC Products are listed in the following table.

	Vertical Accuracy [m]		Grid Size	Coverage
DEM Product	Relative	Absolute	[Arc Seconds]	
w42_SRTM_USGS3 Based on SRTM/C-Band	8 m	16 m	3”	Partial: +/- 60º
w42_REF_10 Based on GLOBE	Varying 10 m to 100s of meters		10”	Global

Source: Hisdesat Servicios Estratégicos S.A

6.2 Radiometric Resolution

Radiometric accuracies were determined during the commissioning phase of TerraSAR-X for StripMap products as shown in the following table. Note: Radiometric accuracies for PAZ products can be different as they were characterized during PAZ’ commissioning phase for all PAZ modes, resulting in different values depending on the acquisition mode.

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
Relative Radiometric Accuracy	Standard deviation of the radiometric error of known targets within one data take, i.e. over range and within 220 seconds	0.3 (for StripMap, incl. long term stability)

6.3 Support Data

All image products are shipped with annotation files, which include the meta-information in xml format. The annotation files contain product and product component file description and order parameters. Each image file has the standard header information of the GeoTiff format.

Further components of the delivery are preview images, quality reports and auxiliary raster files if available.

6.4 Technical Documentation

Further details on technical specifications can be found in the TerraSAR-X Basic Product Specification Guide and/or the PAZ Image Product Guide. These guides are available on our website (https://intelligence.airbus.com/imagery/how-to-order-imagery-and-data/faq/radar-constellation-technical-documents/) or on request.

In case of deviations with respect to the information provided in this Radar Constellation Image Product Guide, the information contained in the documents mentioned below (in its latest issue) shall prevail.

TerraSAR-X Basic Products:

- TerraSAR-X Basic Product Specification Document
- TerraSAR-X L1B Product Format Specification

PAZ Basic Products:

- PAZ Image Product Guide
- PAZ SAR Level 1b Product Format Specification for PAZ SAR Processor

7 Contact

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