Synspective SAR DATA PRODUCT GUIDE

Version 20.0
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Revision History

Version	Date	Description
2.2	Nov 25, 2021	- First edition
3.1	Mar 19, 2022	- Introduced the specifications of StriX-β - Standardized some terms and units in Table 2.1 and 2.2 and added annotations - Replaced Figure 3.1 - Revised an error in the SLC product column of Table 4.1
3.2	Apr 13, 2022	- Updated the value of slant azimuth pixel spacing in Table 2.1.
3.2.1	Apr 22, 2022	- Updated Cover page and final page - Updated table of contents
3.2.2	Nov 16, 2022	- Corrected typos
4.0	Dec 19, 2022	- Introduced the specifications of StriX-1
5.0	Mar 3, 2023	- Updated GRD resampling description in “3. GROUND RANGE DETECTED (GRD)” - Added notation for ground range / azimuth pixel spacing in Table 2.1 and 2.2 - Corrected ground range resolution for StriX-β and -1 Stripmap in Table 2.1 - Corrected the number of looks for Stripmap in Table 2.1
6.0	May 15, 2023	- Corrected notation for “Slant azimuth pixel spacing [m]” in Table 2.1 and 2.2 - Ground range pixel spacing in range and azimuth direction in Table 2.1 and 2.2 no longer depend on the latitude. - Updated the resampling description in “3 PRODUCT PROCESSING LEVEL (SLC)”
7.0	June 5, 2023	- Added Stripmap Super-Resolution GRD (SR-GRD) product
8.0	Aug 1, 2023	- Added Sliding Spotlight Super-Resolution GRD (SR-GRD) product
9.0	May 15, 2024	- Added StriX-3 - Replaced the image in Figure 3.2 - Updated status of orbit status Table 1.1
10.0	Oct 2, 2024	- Added Staring Spotlight
11.0	Nov 12, 2024	- Consolidated the columns in Table 1.1 - Updated center frequency and RF peak power in Table 1.2 - Consolidated the columns in Table 2.1, 2.2 and 2.3 - Removed offnadir angle, polarizations and looks in Table 2.1, 2.2 and 2.3 - Added a note about NESZ, ASAR, RSAR in Table 2.1, 2.2 and 2.3 - Updated Table 3.1 and added Table 3.2 for specification of GRD and SR-GRD product
12.0	Dec 3, 2024	- Added Staring Spotlight 2 in Table 2.3, 3.1 and 3.2 - Updated Azimuth S/A in Table 2.1, 2.2 and 2.3

Version	Date	Description
		- Updated NESZ in Table 2.2
13.0	Mar 25, 2025	- Changed the cover pages and table coloring - Added descriptions and figures about orbit type - Added notes in product swath and length - Added description of Long Stripmap - Added description of Staring Spotlight 1 and 2 - Merged cells for the common values in Table 2.3 - Added notes about calibration factor in GRD XML file
14.0	May 23, 2025	- Added chirp bandwidth in Table 1.2 - Added Sliding Spotlight 2 in Table 2.2, 3.1 and 3.2 - Added Staring Spotlight 3 and 4 in Table 2.3, 3.1 and 3.2
15.0	June 25, 2025	- Added a note about interference signal - Updated available number scenes for Long Stripmap
16.0	Dec 9, 2025	- Updated swath width of Stripmap in Table 2.1 - Updated a description of GeoTIFF data format
17.0	Mar 11, 2026	- Add duty cycle and receiver bandwidth in Table 1.2 - Add a new product, Spotlight Enhanced
18.0	Apr 1, 2026	- Added Orthorectificed (ORT) product - Added ORT in Table 4.1
19.0	Jul 29, 2026	- Added Compensated Phase History Data (CPHD) product - Added CPHD in Table4.1 - Updated DEM version in ORT product
20.0	Oct 14, 2026	- Updated the overview of processing levels in “3 PRODUCT PROCESSING LEVEL” - Added available observation modes in “COMPENSATED PHASE HISTORY DATA (CPHD)” - Added a note on Long Stripmap in Table 4.1

1 SATELLITE ORBIT & SPECIFICATION

Synspective's small Synthetic Aperture Radar (SAR) satellite StriX boasts a larger swath, lower noise and wider area than other satellites in its class. The first StriX satellite, StriX-α was placed in orbit in 2020, with more satellites being added each year.

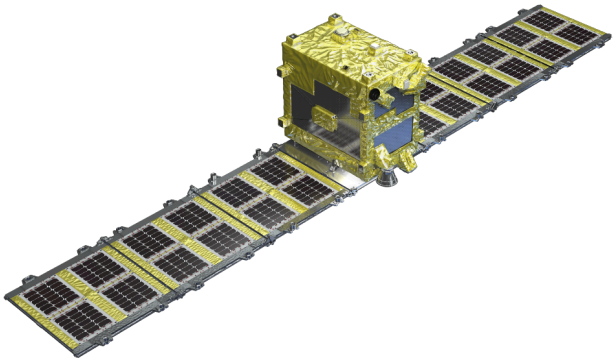


Figure 1.1 Image of StriX-α

SATELLITE ORBIT

Operating at a nominal altitude in the range from 500 km to 561 km, StriX satellites follow a sun-synchronous or inclined orbit and are capable of making frequent visits to the same location. The revisit frequency will only increase as our constellation grows in size.

The specifications of the StriX satellite orbits are described in Table 1.1.

Table 1.1 Orbit Parameters of StriX Satellites

Orbit type	sun-synchronous or inclined orbit
Nominal altitude	500 - 561 km
Orbit inclination angle	43 - 97.7 degree
Revisit period	1 - 7 days

Sun-synchronous orbits enable an observation of a ground location at the same time of the day at some certain frequency. Also, the satellites pass through the North and South poles and can image the entire Earth's surface.

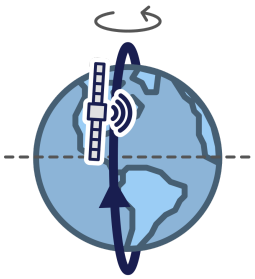


Figure 1.2 Sun-synchronous orbit

Inclined orbits enable more frequent revisits of the interested areas within a certain band of latitude than the sun-synchronous orbit

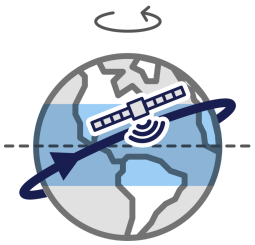


Figure 1.3 Inclined orbit

SAR SENSORS

StriX satellites emit a X-band frequency microwave signal directed at a target on Earth. The amount of signal reflected (“backscatter”) gives a realistic image of the terrain and structural properties at the target location. This is known as a “synthetic aperture” because the moving satellite uses multiple signal captures to mimic the effect of placing one massive antenna in orbit.

The specifications of on-board SAR sensors of StriX satellites are described in Table 1.2.

Table 1.2 Sensor Specification of StriX Satellites

Center frequency	9.60 or 9.65 GHz
Look direction	Right and Left
PRF	Up to 7 kHz
Chirp bandwidth	Up to 600 MHz
Duty cycle	Up to 25%
Receiver bandwidth	Not more than 1000MHz
RF peak power	Up to 1.5 kW

Polarization	VV
Offnadir angle	15 - 45 degrees

Due to the frequency bandwidth used by StriX Satellites, the received signal may include external radio frequency interference, such as from ground-based radars. Our product processing does not remove these interference signals and they may appear in the product images.

2 OBSERVATION MODE

StriX satellites have three observation modes: Stripmap, Sliding Spotlight and Staring Spotlight.

STRIPMAP MODE

In the Stripmap mode, the center of the antenna beam moves in conjunction with the satellite at an approximately fixed offnadir angle (Figure 2.1). While inside the antenna beam, the ground is illuminated with a sequence of electromagnetic waves at radiofrequency . The outcome of this imaging mode is a long swath image with a nominal slant-range resolution of 1.8 meters and a nominal slant-azimuth resolution of 2.6 meters. Long Stripmap, whose observation duration is 16 - 80 seconds (2 to 10 scenes), is also available to cover an extensive area in the azimuth direction.

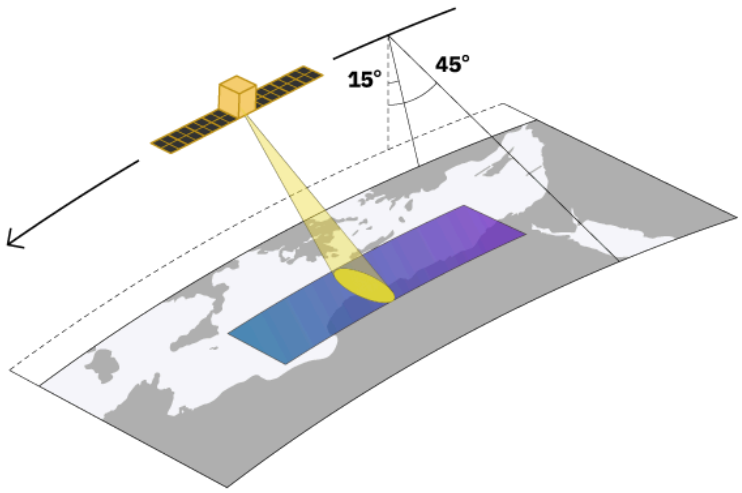


Figure 2.1 Stripmap mode

The specifications of Stripmap are provided in Table 2.1.

Table 2.1 Specifications of Stripmap mode

Observation mode	Stripmap
Nominal swath width [km][1]	20[1]
Nominal product length [km]	>50[2]
NESZ [dB]	-21.7[3,4]

Azimuth S/A (ASAR) [dB]	21.7[3,4]
Range S/A (RSAR) [dB][5]	26.0[3,4]
Slant range resolution [m]	1.8
Ground range resolution [m]	3.6[3]
Azimuth resolution [m]	2.6

1. This may vary depending on the observation conditions such as offnadir angle
2. For Long Stripmap, the length is cropped to about 50km per scene
3. This is an analysis value at an offnadir angle of 30 degree
4. The values reported in this table refer to the lowest expected performance of StriX satellites

SLIDING SPOTLIGHT MODE

The azimuth resolution of a SAR image is proportional to the scene's illumination duration or Doppler bandwidth. In the Sliding Spotlight mode, the antenna beam is steered mechanically throughout the data acquisition, which allows a long observation of a selected area (Figure 2.2). In the Sliding Spotlight mode, the antenna beam moves at a slower rate than in Stripmap mode along the Earth. Two Sliding Spotlight modes are available; one has 0.9m ground range and 0.9m azimuth resolution (Sliding Spotlight 1) whereas the other has 0.46m ground range resolution and 0.5 m azimuth resolution (Sliding Spotlight 2). Sliding Spotlight 2 uses a broader chirp bandwidth and longer observations to achieve finer resolution.

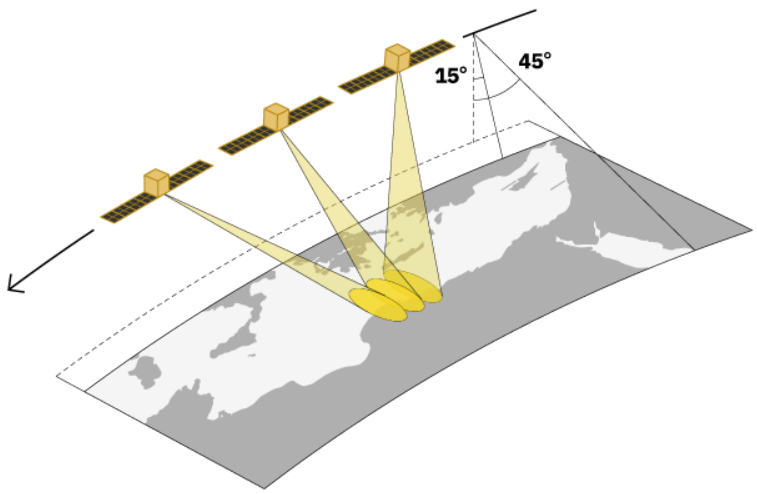


Figure 2.2 Sliding Spotlight mode

The specifications of Sliding Spotlight are provided in Table 2.2.

Table 2.2 Specifications of Sliding Spotlight mode

Modes	Sliding Spotlight 1	Sliding Spotlight 2
Nominal swath width [km]	10[1]	
Nominal product length [km]	10	
NESZ [dB]	-15.7[2,3]	-15.4[2,3]
Azimuth S/A (ASAR) [dB]	21.7[2,3]	28.9[2,3]
Range S/A (RSAR) [dB]	23.5[2,3]	16.5[2,3]
Slant range resolution [m]	0.5	0.23
Ground range resolution [m]	0.9[2]	0.46[2]
Azimuth resolution [m]	0.9	0.5

1. This may vary depending on the observation conditions such as offnadir angle
2. Analysis value at an offnadir angle of 30 degree
3. The values reported in this table refer to the lowest expected performance of StriX satellites

STARING SPOTLIGHT MODE

Similar to Sliding Spotlight mode, in Staring Spotlight mode, the antenna beam is steered mechanically throughout the data acquisition. The difference is that Sliding Spotlight mode's rotation center is located below the Earth surface, on the other hand in Staring Spotlight mode, the rotation center is on the Earth surface. This allows the scene's area to be concentrated on the smaller area and its illumination duration to be longer. As a result, Staring Spotlight mode provides a finer azimuth resolution and a shorter product length than Sliding Spotlight mode. Five different Staring Spotlight modes are available, consisting of combinations of two observation parameters; the chirp bandwidth for range resolution, observation duration for azimuth resolution. Staring Spotlight 4 has the finest range and azimuth resolution. While Staring Spotlight 1,2,3,4 is processed for a single look, Spotlight Enhanced is multilooked with 3 looks in azimuth direction to reduce speckle noise and its resolution is made equivalent to Staring Spotlight 3.

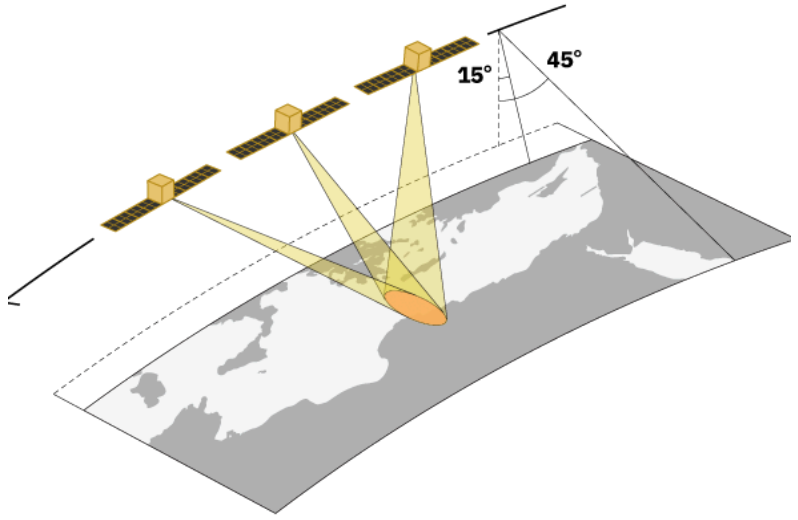


Figure 2.3 Staring Spotlight

The specifications of Staring Spotlight are provided in Table 2.3.

Table 2.3 Specifications of Staring Spotlight mode

Modes	Staring Spotlight 1	Staring Spotlight 2	Staring Spotlight 3	Staring Spotlight 4	Spotlight Enhanced
Nominal swath width [km]	10[1]				
Nominal product length [km]	3				
NESZ [dB]	-17.4[2,3]		-17.1[2,3]		
Azimuth S/A (ASAR) [dB]	20.2[2,3]		30.4[2,3]		
Range S/A (RSAR) [dB]	23.5[2,3]		16.5[2,3]		
Slant range resolution [m]	0.5		0.23		NA[4]
Ground range resolution [m]	0.9[2]		0.46[2]		
Azimuth resolution [m]	0.5	0.25	0.5	0.25	0.5[5]

1. This may vary depending on the observation condition such as offnadir
2. This is an analysis value at an offnadir angle of 30 degree
3. The values reported in this table refer to the lowest expected performance of StriX satellites
4. For Spotlight Enhanced, only Ground Range Detected (GRD) products are available. Thus, the slant range resolution is noted as Not Applicable (NA).
5. This resolution is after multilooked by 3 looks

3 PRODUCT PROCESSING LEVEL

Synspective SAR data products consist of digital image data and corresponding image annotation metadata. The products are defined by each observation mode and processing level. There are five processing levels: Compensated Phase History Data (CPHD), Single Look Complex (SLC), Ground Range Detected (GRD), Super-Resolution Ground Range Detected (SR-GRD) and Orthorectified (ORT).

COMPENSATED PHASE HISTORY DATA (CPHD)

Compensated Phase History Data (CPHD) is the earliest processing level offered prior to image formation. It contains the motion-compensated phase history signal together with a Per-Vector Parameter (PVP) record describing the transmit/receive geometry and timing for each pulse, following the sensor-independent CPHD product definition published by the National Geospatial-Intelligence Agency (NGA)[1]. CPHD products are intended for users who wish to perform their own image formation, phase history analysis, or SAR processing algorithm development.

Synspective's CPHD products are generated from a single monostatic collection channel with vertical (V) transmit and receive polarization only; the multi-channel, multi-polarization, and bistatic configurations described in the general CPHD standard are not produced. As CPHD precedes image formation, no super-resolution (SR) counterpart is available for this processing level. CPHD products are available for Stripmap, Sliding Spotlight and Staring Spotlight 1, 2, 3, 4 observations, and are not available for Long Stripmap or Spotlight Enhanced observations.

SINGLE LOOK COMPLEX (SLC)

Single Look Complex (SLC) are single look products for imaged SAR signals. The coordinates of the image are the flight direction (azimuth direction) and slant range direction acquired by the satellite. Pixels are approximately equidistant in the azimuth and slant range directions. They are represented by complex numbers; thus, they contain both amplitude and phase information. The alignment of the pixels in the slant range direction coincides with the 0-Doppler direction. SLC products are suitable for applications that rely on phase information or need to take advantage of scenes with better resolution. SLC products are especially useful for those who want to perform interferometry and those who want to detect ground surface changes by coherent change detection (CCD).

See Figure 3.1 for the definitions of slant range and ground range related to the definition of coordinates for each processing level.

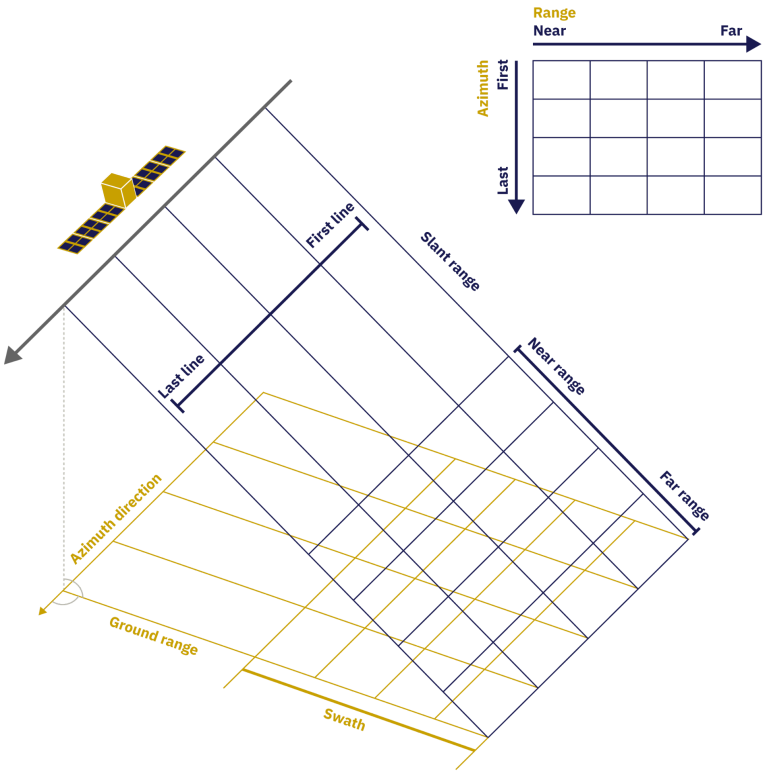


Figure 3.1 Definition of slant range and ground range

GROUND RANGE DETECTED (GRD)

Ground Range Detected (GRD) products are imaged SAR data that are projected onto the ground using an earth ellipsoid model.

Pixels (pixel spacing) are equidistant in the azimuth and range directions on the ground. The ground range coordinates are projected slant range coordinates onto the ellipsoid of the Earth. The slant range to ground range projection uses the WGS84 ellipsoid, the average scene elevation, or the target elevation.

The GRD products are resampled to orient the map coordinate system (North-up).

Unlike SLC products, the pixel value represents the magnitude of the detected signal; thus, they do not contain phase information.

GRD products of Stripmap and Spotlight Enhanced are multi-look processed, therefore speckle is reduced. Sliding Spotlight and Staring Spotlight 1, 2, 3, 4 products are single-look processed.

Table 3.1 Specifications of GRD product

Parameters	Looks	Pixel spacing [m]
Stripmap	2	5
Sliding Spotlight 1	1	1
Sliding Spotlight 2	1	0.5
Staring Spotlight 1	1	0.5
Staring Spotlight 2	1	0.25
Staring Spotlight 3	1	0.5
Staring Spotlight 4	1	0.25
Spotlight Enhanced	3	0.5

SUPER-RESOLUTION GROUND RANGE DETECTED (SR-GRD)

Very bright targets illuminate a large, cross-like region surrounding the pixel they belong to. This issue complicates the interpretation of SAR images and makes them less sharp. These cross-shaped artifacts are automatically detected and removed by the Spatially Varying Apodization (SVA) technique. SVA is applied directly on the Single Look Complex (SLC) images; then, the SVA-processed SLCs are projected on the ground to produce Super-Resolution Ground Range Detected Images (SR-GRD).

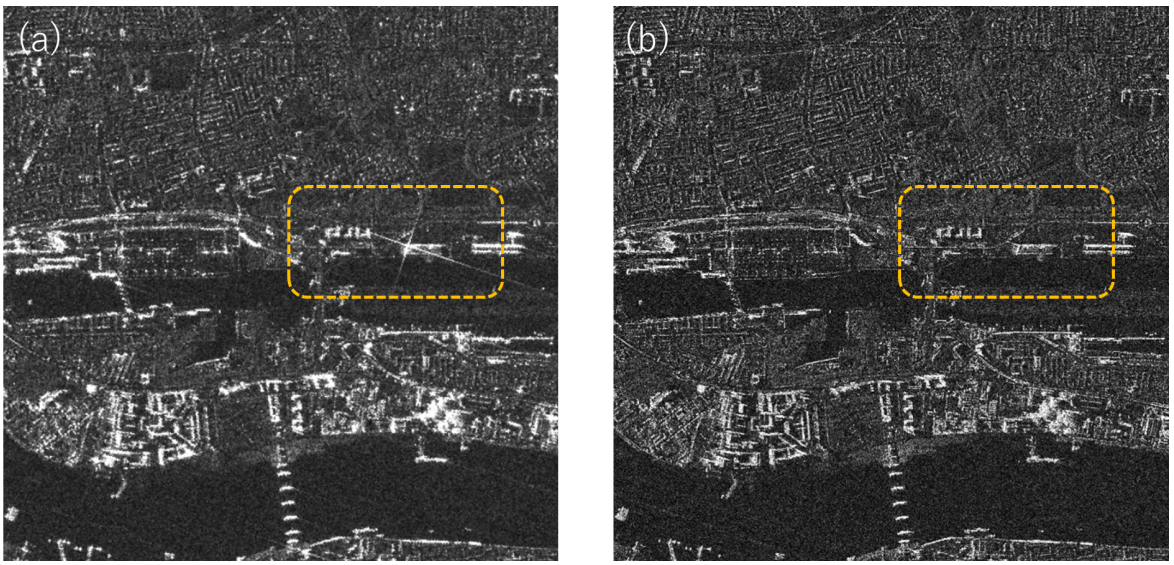


Figure 3.2 (a) 5m x 5m GRD image; (b) 1m x 1m SR-GRD image(Stripmap).
The suppression of sidelobes is clearly noticeable for the bright target in the dashed rectangle.

The projection on the Earth ellipsoid of SVA-processed images is carried out similarly to standard GRD images; the proper handling of sharpened images requires some adjustments though. Multi-looking (spatial average) is not applied in order not to deteriorate the image resolution. Very high resolution demands smaller sampling steps thus resulting in larger image size

compared to the standard GRD images. Please note that SR-GRD products are not available for Spotlight Enhanced observations.

Table 3.2 Specifications of SR-GRD product

Parameters	Looks	Pixel spacing [m]
Stripmap	1	1
Sliding Spotlight 1	1	0.5
Sliding Spotlight 2	1	0.25
Staring Spotlight 1	1	0.25
Staring Spotlight 2	1	0.125
Staring Spotlight 3	1	0.25
Staring Spotlight 4	1	0.125

ORTHORECTIFIED PRODUCT (ORT)

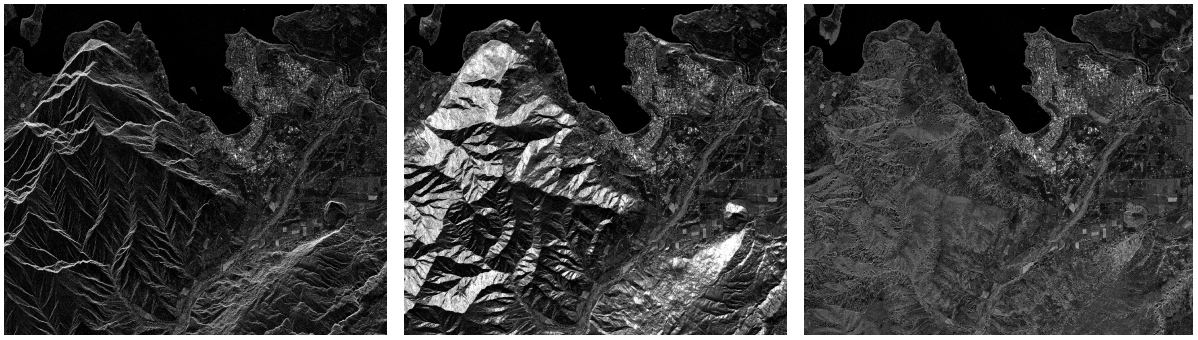
Orthorectified Products (ORT) are terrain-corrected SAR products generated from Single Look Complex (SLC) data using a Digital Elevation Model (DEM). Unlike GRD and SR-GRD products, which project data onto a smooth reference ellipsoid, ORT corrects terrain-induced geometric distortions such as foreshortening and layover, resulting in improved geolocation accuracy in areas with significant topography. Radar shadow regions, where the terrain blocks the radar signal entirely, are identified in an accompanying layover/shadow mask.

Each ORT delivery includes two radiometric variants:

- ORT sigma-naught - backscatter calibrated using the ellipsoid incidence angle $\sigma_0=\beta_0 \cdot \sin\theta_E$, the same backscatter definition as GRD. Terrain slope effects remain in the radiometry.

- ORT gamma-naught - backscatter normalised by the local illuminated area computed from the DEM, satellite orbit, and antenna pointing geometry (terrain-flattened gamma-naught via Radiometric Terrain Correction: RTC). This removes the effect of terrain slope on radar backscatter brightness, following the pixel area integration method of Small (2011) [2]. The Synspective ORT gamma-naught product is CEOS-ARD NRB-compliant [3] as of 4 May 2026. Recommended for quantitative backscatter analysis and time-series monitoring in areas with topographic variation.

Figure 3.3 illustrates the difference between the three products (GRD, ORT sigma naught and ORT gamma naught). The image is a mountainous area illuminated from the north (top to bottom), so north-facing slopes appear brighter in the radar image. In GRD (a), these slopes are also geometrically compressed (foreshortening). ORT sigma-naught (b) corrects the geometry using the DEM, placing features in their true position, but the terrain-induced brightness variation remains. ORT gamma-naught with RTC (c) additionally removes the terrain slope effect, revealing surface properties independent of terrain orientation.



a) GRD sigma-naught b) ORT sigma-naught c) ORT gamma-naught

Figure 3.3 Comparison of GRD, ORT sigma-naught, and ORT gamma-naught with RTC for a mountainous image. The observation direction is from north (top to bottom).

ORT product is projected to a fixed UTM (Universal Transverse Mercator) grid where pixel positions are aligned to exact multiples of the pixel spacing. This ensures that repeat acquisitions share identical pixel positions, enabling direct time-series analysis without resampling.
The pixel spacing is 5.0 m × 5.0 m for Stripmap (same as GRD) and 1.25 m × 1.25 m for Sliding Spotlight and Staring Spotlight (coarser than GRD, with reduced speckle and data volume). The spacings of Stripmap and Sliding/ Staring Spotlight nest exactly (4 × 4 Sliding/ Staring Spotlight pixels = 1 Stripmap pixel).

The DEM used for orthorectification is the Copernicus DEM GLO-30 version 2024_1 (~30 m resolution, global). This is a Digital Surface Model (DSM) derived from TanDEM-X mission data, meaning it represents the radar scattering surface including vegetation canopy rather than bare ground. In forested or densely built-up areas, the DSM may overestimate ground elevation due to canopy or structures above the surface, which reduces the accuracy of the terrain correction in these areas.
Absolute location error (ALE) estimates are provided per satellite and mode in the product metadata. For details on product composition, file naming, metadata, and GeoTIFF specifications, refer to the Synspective SAR Data Product Format Manual.

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4 DATA FORMAT

The product data formats for each observation mode and processing level can be seen in Table 4.1.

Table 4.1 Synspective SAR data's product formats

Observation mode	Processing Level			
	CPHD	SLC	GRD, SR-GRD	ORT
Stripmap	CPHD (not available for Long Stripmap)	CEOS or SICD	GeoTIFF + XML	GeoTIFF + XML
Sliding Spotlight	CPHD	CEOS or SICD	GeoTIFF + XML	GeoTIFF + XML
Staring Spotlight	CPHD	CEOS or SICD	GeoTIFF + XML	GeoTIFF + XML
Spotlight Enhanced	Not available	Not available	GeoTIFF + XML (GRD only)	Not available

Image data is provided in CPHD format for CPHD, CEOS or SICD format for SLC and GeoTIFF format for GRD, SR-GRD and ORT.

The CEOS format is suitable for storing complex-valued images and their processing parameters. SICD is the standard format for SLC defined by the National Geospatial-Intelligence Agency (NGA).

GeoTIFF can be easily viewed with common SAR analytic software and GIS software. GeoTIFF product is provided together with XML, which makes it easy to understand the product without the use of special software.

The GRD XML contains the calibration factor to convert the digital number to sigma naught. Two GRD GeoTIFF files are available, one of which is calibrated for analytical use and the other is tone corrected and downsized, for a better visual experience. ORT products are delivered as calibrated float32 values in linear power scale — no additional calibration factor is needed. All files are Cloud Optimized GeoTIFF (COG).

For details on data format, refer to the Synspective SAR Data Product Format Manual.

5 REFERENCE

[1] National Geospatial-Intelligence Agency, Compensated Phase History Data (CPHD) Design & Implementation Description Document, Version 1.1.0. https://nsgreg.nga.mil/doc/view?i=5388(accessed Jul 21, 2026)

[2] D. Small (2011), "Flattening Gamma: Radiometric Terrain Correction for SAR Imagery," IEEE Transactions on Geoscience and Remote Sensing, 49(8), 3081–3093. DOI: 10.1109/TGRS.2011.2120616

[3] CEOS Analysis Ready Data for Synthetic Aperture Radar, Product Family Specification v1.2. https://ceos.org/ard/files/PFS/SAR/v1.2/CEOS-ARD_PFS_Synthetic_Aperture_Radar_v1.2.pdf (accessed March 31, 2026)

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