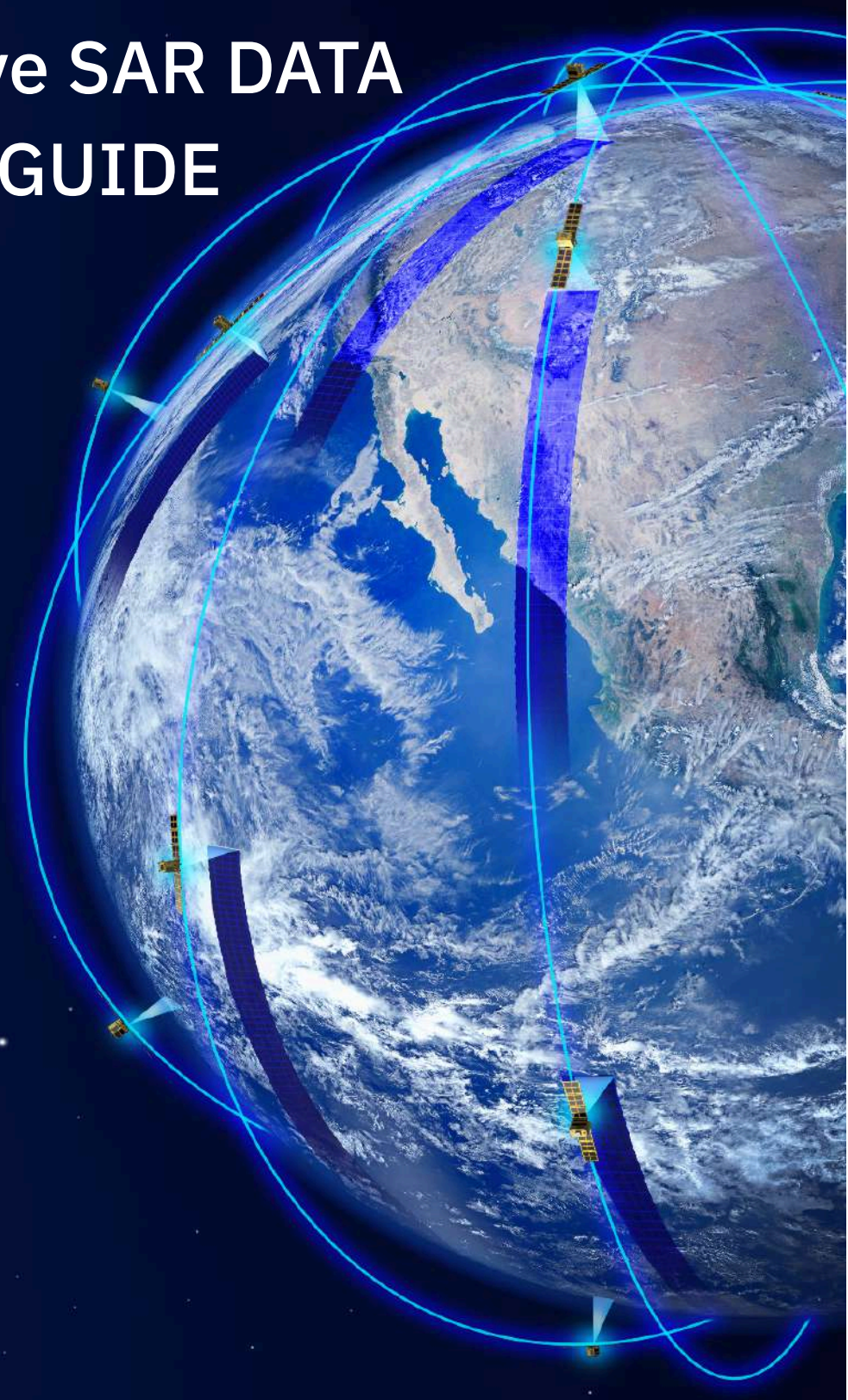
Synspective SAR DATA PRODUCT GUIDE



Version 9.0

May 15, 2024

TABLE OF CONTENTS

1 SATELLITE ORBIT & SPECIFICATION 3

2 OBSERVATION MODE 5

STRIPMAP MODE 5

SLIDING SPOTLIGHT MODE 6

3 PRODUCT PROCESSING LEVEL 9

SINGLE LOOK COMPLEX (SLC) 9

GROUND RANGE DETECTED (GRD) 10

SUPER-RESOLUTION GROUND RANGE DETECTED (SR-GRD) 10

4 DATA FORMAT 12

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

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.

Operating at a nominal altitude in the range from 500 km to 561 km, StriX follows a sun-synchronous orbit typical of other Earth observation satellites and is capable of making daily visits to the same location. This visit frequency will only increase as our constellation grows in size.

StriX satellites emit a 9.65GHz (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 the orbits and on-board SAR sensors of StriX satellites are described in Table 1.1 and Table 1.2 respectively.

Table 1.1 Orbit Parameters of StriX Satellites

Parameters	StriX-α**	StriX-β	StriX-1	StriX-3
TLE	STRIX-ALPHA	STRIX-BETA	STRIX-1	STRIX-3
Orbit type	sun-synchronous orbit	sun-synchronous orbit	sun-synchronous orbit	sun-synchronous orbit
Nominal altitude	500 km*	561 km*	561 km*	561 km
Orbit inclination angle	97.3 degree*	97.7 degree*	97.7 degree*	97.7 degree
Revisit period	Approx. 5 days*	1 day*	1 day*	1 day
Local Time at Ascending Node (LTAN)	10:30	21:00	21:00	15:00

* It changes because StriX-α, StriX-β and StriX-1 do not maintain orbit.

** StriX-α ended its mission in October 2023.

Table 1.2 Sensor Specification of StriX Satellites

Parameters	StriX-α, StriX-β, StriX-1, StriX-3
Center frequency	9.65 GHz (X-band)
Look direction	Right and Left
PRF	Up to 7 kHz
Chirp bandwidth	Up to 300 MHz

RF peak power	1 kW
Polarization	VV
Off-nadir angle	15 - 45 degrees

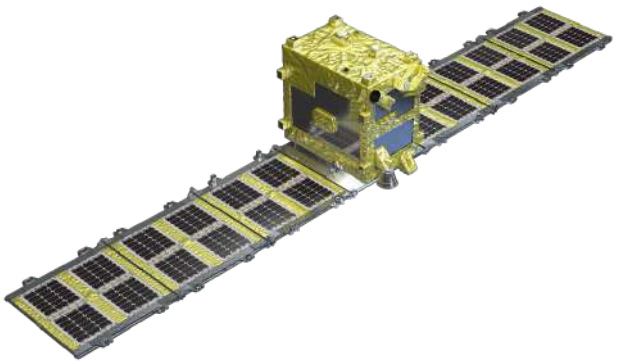


Figure 1.1 Image of StriX-α

2 OBSERVATION MODE

StriX satellites have two observation modes: Stripmap and Sliding Spotlight.

STRIPMAP MODE

In the Stripmap mode, the center of the antenna beam moves in conjunction with the satellite at an approximately fixed off-nadir angle (Figure 2.1). While inside the antenna beam, the ground is illuminated with a sequence of electromagnetic pulses. 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.

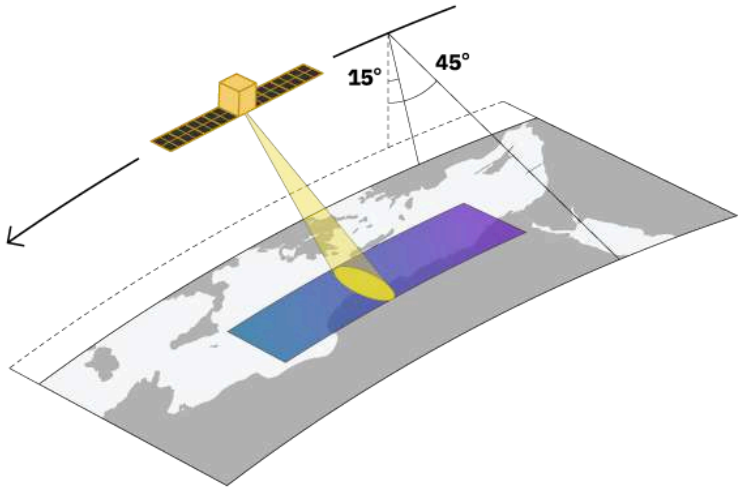


Figure 2.1 Stripmap mode

The specifications of Stripmap are provided in Table 2.1.

Table 2.1 Specifications of Stripmap mode

Parameters	StriX-α	StriX-β, StriX-1, StriX-3
Nominal swath width [km]	10-30（Nominal 20）	10-30（Nominal 20）
Nominal product length [km]	50-70	50-70
Off-nadir angle [deg]	15-45	15-45
NESZ [dB]	-22.7*	-21.7*

Azimuth S/A (ASAR) [dB]	13.2*	13.2*
Range S/A (RSAR) [dB]	26.0*	26.0*
Slant range resolution [m]	1.8	1.8
Slant azimuth resolution [m]	2.6	2.6
Slant range pixel spacing [m]	1.5	1.5
Slant azimuth pixel spacing [m]	2.2	2.2
Ground range resolution [m]	3.6	3.6
Ground azimuth resolution [m]	2.6	2.6
Ground range pixel spacing [m]	5.0	5.0
Ground azimuth pixel spacing [m]	5.0	5.0
Looks	2	2
Polarization	VV	VV

* Analysis value at an off-nadir angle of 30 degrees.

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. Sliding Spotlight mode provides the nominal slant-range resolution of 0.5 meter and a nominal slant-azimuth resolution of 0.9 meter.

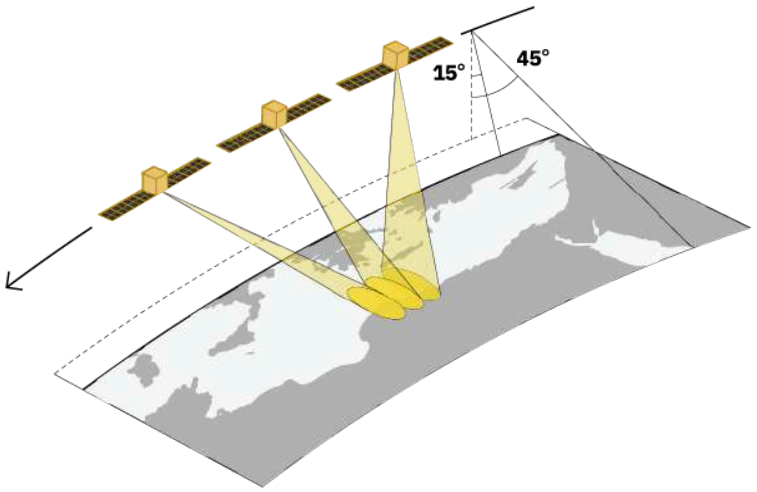


Figure 2.2　Sliding Spotlight mode

The specifications of Sliding Spotlight are provided in Table 2.2.

Table 2.2　Specifications of Sliding Spotlight mode

Parameters	StriX-α	StriX-β, StriX-1, StriX-3
Nominal swath width [km]	10（Nominal）	10（Nominal）
Nominal product length [km]	10	10
Off-nadir angle [deg]	15-45	15-45
NESZ [dB]	-18.4*	-17.4*
Azimuth S/A (ASAR) [dB]	13.2*	13.2*
Range S/A (RSAR) [dB]	23.5*	23.5*
Slant range resolution [m]	0.5	0.5
Slant azimuth resolution [m]	0.9	0.9
Slant range pixel spacing [m]	0.4	0.4
Slant azimuth pixel spacing [m]	0.8	0.8
Ground range resolution [m]	0.9	0.9
Ground azimuth resolution [m]	0.9	0.9

Ground range pixel spacing [m]	1.0	1.0
Ground azimuth pixel spacing [m]	1.0	1.0
Looks	1	1
Polarization	VV	VV

* Analysis value at an off-nadir angle of 30 degrees.

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 three processing levels: Single Look Complex (SLC), Ground Range Detected (GRD), and SUPER-RESOLUTION GROUND RANGE DETECTED (SR-GRD).

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.

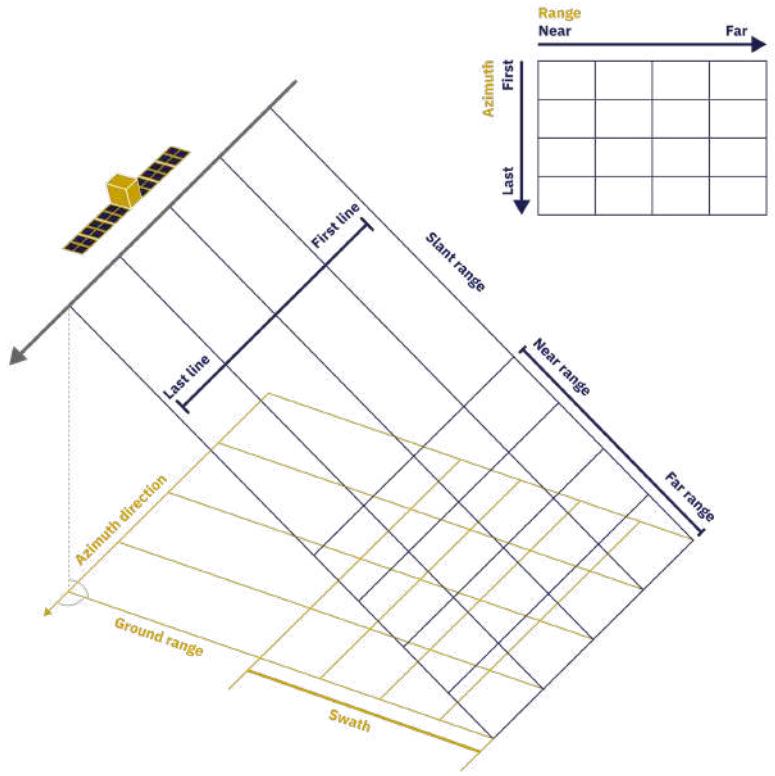


Figure 3.1 Definition of slant range and ground range

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 mode are multi-look processed, therefore speckle is reduced. Sliding Spotlight mode's products are single-look processed.

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).

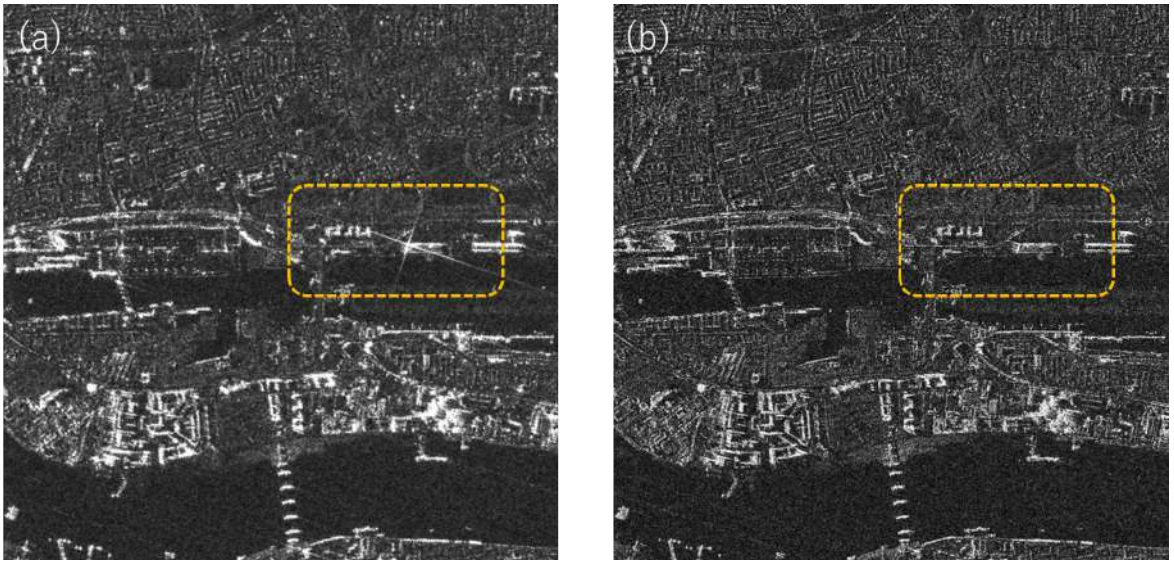


Figure 3.2 (a) 5m x 5m GRD image; (b) 1m x 1m SR-GRD image(Stripmap).
The suppression of sidelobes is clearly noticeable for the bright target in the dashed rectangle.

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. The pixel size of SR-GRD images is set to 1m x 1m (Stripmap) and 0.5m x 0.5 m (Sliding Spotlight). The full list of parameters of SR-GRD images is shown in Table 3.1.

Table 3.1 Specifications of SR-GRD for StriX-β, StriX-1, StriX-3

Parameters	Stripmap	Sliding Spotlight
Swath width [km]	10-30（Nominal 20）	10（Nominal）
Nominal product length [km]	50-70	10
Off-nadir angle [deg]	15-45	15-45
NESZ [dB]	-21.7*	-17.4*
Azimuth S/A (ASAR) [dB]	Not applicable**	Not applicable**
Range S/A (RSAR) [dB]	Not applicable**	Not applicable**
Ground range resolution [m]	3.6	0.9
Ground azimuth resolution [m]	2.6	0.9
Ground range pixel spacing [m]	1.0	0.5
Ground azimuth pixel spacing [m]	1.0	0.5
Looks	1	1
Polarization	VV	VV

* Analysis value at an off-nadir angle of 30 degrees.

**SVA sets sidelobes equal to zero thus producing ambiguity ratio approaching infinity

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	
	SLC	GRD, SR-GRD
Stripmap	CEOS or SICD	GeoTIFF + XML
Sliding Spotlight	CEOS or SICD	GeoTIFF + XML

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

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.

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


Synspective
Synthetic data for perspective