RN-SP-52-1238
Issue 1/14: September 10, 2018

RADARSAT-2 PRODUCT DESCRIPTION

Summary: This document defines the characteristics of RADARSAT-2 products.

IMPORTANT NOTES:

This document describes the characteristics of RADARSAT-2 Products. The product characteristics and operating modes are subject to change without notice or obligation.

Maxar Technologies Ltd. reserves the right to update the product characteristics without giving prior notice. Maxar Technologies Ltd. assumes no responsibility for the use of the information contained herein and use and application of the information for any purpose whatsoever is at the sole risk of the user.

The RADARSAT-2 System is subject to the operating license issued by the Government of Canada. Product characteristics and the distribution of products are subject to the terms of that license.

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CHANGE RECORD

ISSUE	DATE	PAGE(S)	DESCRIPTION	RELEASE
1/1	Feb 28, 2004	All	First External Release of Document	
1/2	May 2, 2005	All	First Issue/Second Revision Updated to clarify polarization options available in different modes. Deleted contents of Section 2.2 - not required. Changes as per ECN-353.	
1/3	Oct. 10, 2006	All	First Issue/Third Revision Minor editorial updates [PS_V_1_2]	
1/4	July 31, 2007	All	First Issue, Fourth Revision Added Spotlight mode. Deleted the SGC product type. Minor editorial updates.	
1/5	Aug. 19, 2008	All	First Issue, Fifth Revision Detailed product characteristics updated as a result of Post-Launch and Commissioning Phase analysis	
1/6	Nov. 2, 2009	All	First Issue, Sixth Revision Detailed product characteristics updated as a result the following changes to the RSAT-2 Operating License: • Amendment #11 – Revision 3: Addition of Multi-Look Fine SLC Product Type, • Amendment #11 – Revision 5: Extension of Ultra-Fine Incidence Angle Range, • Amendment #11 – Revision 6: Relaxation of Resolution Restrictions (updates to Spotlight, Ultra-Fine, Fine Quad-Pole, Standard Quad-Pole product characteristics),	

ISSUE	DATE	PAGE(S)	DESCRIPTION	RELEASE
			• Amendment #11 – Revision 7: Extension of Standard Quad-Pole and Fine Quad-Pole Incidence Angle Ranges. Corrected terminology for Extended High and Extended Low beam modes.	
1/7	Jan. 18, 2011		First Issue, Seventh Revision Detailed product characteristics updated as a result the following changes to the RSAT-2 Operating License Amendment #11 – Revision 12, addition of: • Wide Ultra-Fine mode, • Wide Multi-Look Fine mode, • Wide Fine mode, • Wide Standard Quad-Polarization mode, • Wide Fine Quad-Polarization mode.	
1/8	Apr. 15, 2011	As noted	First Issue, Eight Revision Updates to Table 1-3: • Wide Fine nominal scene size • Update selected column names • Updated Note#8 • Added Note#10 Updated NESZ values for Wide Ultra-Fine, Wide Multi-Look Fine, Wide Fine, Wide Standard Quad-Polarization, and Wide Fine Quad-Polarization modes in detailed product description tables. Detailed product characteristics updated as a result of the following change to the RSAT-2 Operating License Amendment #11 – Revision 12, addition of: • Standard Beam S8	

ISSUE	DATE	PAGE(S)	DESCRIPTION	RELEASE
1/9	Aug. 23, 2011		First Issue, Ninth Revision	
			Merged portions of RN-RP-52-9169 and RN-RP-52-9170 into this document.	
			Added ScanSAR noise subtraction updates, SCF and SCS products.	
			Minor updates to reflect latest beam modes.	
1/10	Oct. 31, 2013		First Issue, Tenth Revision	
			Added content for increased Ultra-Fine and Spotlight maximum incidence angle (to 54 deg).	
			Added content for new Extra-Fine beam mode.	
			Added content for new products that may use the BigTIFF variant of GeoTIFF format.	
			Added appendix containing NESZ plots.	
			Added information on Block Adaptive Quantization (BAQ).	
			Updated overview figures and text in Section 1.	
			Clarified meaning of image quality terms.	
			Minor miscellaneous corrections and clarifications throughout document.	
1/11	May 5, 2014		First Issue, Eleventh Revision	
			Updates for commercial availability of Extra-Fine mode.	
			Corrected Extra-Fine nominal scene sizes.	
			Corrected location error for SGF in Wide mode.	
			Miscellaneous minor clarifications.	

ISSUE	DATE	PAGE(S)	DESCRIPTION	RELEASE
1/12	Sept. 28, 2015		First Issue, Twelfth Revision Updated web site address. Added Ocean Surveillance and Ship Detection (Detection of Vessels) beam modes. Noted the presence of grating lobe ambiguities in EH mode above 54 degrees incidence angle. Clarified statements on radiometric and geolocation accuracy. Added selectable 8-bit format to SSG and SPG product tables. Added resolutions for Extra-Fine multi-looked products. Refined product characteristics based on ongoing image quality monitoring results.	
1/13	Mar. 21, 2016		First Issue, Thirteenth Revision Updated ground range pixel spacing values in SSG and SPG Product Description tables for standard quad-pol and wide standard quad-pol product types Clarified elevation correction methods for geocoded products	
1/14	Sept. 10, 2018		First Issue, Fourteenth Revision Clarified use of polarization channels for ship detection in OSVN mode Clarified geocorrection options for SSG products Corrected Standard Quad Pol SLC range resolution in Table 2-2 Updated pixel spacing of Standard Quad Pol geocorrected products Corrected incidence angle range for W1 beam in Appendix A	

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ACRONYMS AND ABBREVIATIONS

BAQ	Block Adaptive Quantization
BigTIFF	Big Tagged Image File Format
dB	decibel
DEM	Digital Elevation Model
DVD-ROM	Digital Versatile Disk – Read Only Memory
DVWF	Detection of Vessels Wide Far
EH	Extended coverage Extended High beam
EL	Extended coverage Extended Low beam
F	Fine resolution beam
FQ	Fine resolution Quad-polarization beam
GeoTIFF	Geographic extensions to the Tagged Image File Format
H	Horizontal polarization
Hz	Hertz
HH	Horizontal polarization on transmit, Horizontal polarization on receive
HV	Horizontal polarization on transmit, Vertical polarization on receive
I	In-phase
km	Kilometres
MBytes	Unit of data volume equal to 2^{20} bytes (= 2^{23} bits)
MDA	MDA Geospatial Services Inc., a subsidiary of Maxar Technologies Ltd.
MF	Multi-Look Fine resolution beam
NESZ	Noise-Equivalent Sigma-Zero
NITF	National Imagery Transmission Format
OSVN	Ocean Surveillance Very-wide Near
PRF	Pulse Repetition Frequency
Q	Quadrature phase
S	Standard beam
SAR	Synthetic Aperture Radar
SCF	ScanSAR Fine product

SCN	ScanSAR Narrow product
SCNA	ScanSAR Narrow A
SCNB	ScanSAR Narrow B
SCS	ScanSAR Sampled product
SCW	ScanSAR Wide product
SCWA	ScanSAR Wide A
SCWB	ScanSAR Wide B
SGF	SAR Georeferenced Fine product (also known as Path Image)
SGX	SAR Georeferenced Extra product (also known as Path Image Plus)
SLA	Spotlight-A
SLC	Single Look Complex product
SPG	SAR Precision Geocorrected product (also known as Precision Map Image)
SSG	SAR Systematic Geocorrected product (also known as Map Image)
SQ	Standard Quad-polarization beam
U	Ultra-Fine resolution beam
USGS	United States Geological Service
TIFF	Tagged Image File Format
V	Vertical polarization
VH	Vertical polarization on transmit, Horizontal polarization on receive
VV	Vertical polarization on transmit, Vertical polarization on receive
W	Wide swath beam
XF	Extra-Fine beam
XML	Extensible Markup Language

1 OVERVIEW OF RADARSAT-2 PRODUCTS

This document describes RADARSAT-2 products. It covers products that are commercially available, or that are expected to become so in the foreseeable future. It provides an overview of the products followed by detailed descriptions.

In addition to the RADARSAT-2 products described in this document, MDA provides a range of derived image products, value-added products and information products based on RADARSAT-2 sensor data that can be adapted to suit client needs.

Additional information on the RADARSAT-2 mission as well as the associated products and services can be obtained as follows:

Web: gs.mdacorporation.com

Email: clientservices@mdacorporation.com

The remainder of this section provides general product characteristics, identifies and classifies the products, and describes their associated sensor-related characteristics. Detailed descriptions of the products are provided in Section 2.

1.1 General Product Characteristics

A RADARSAT-2 product consists of SAR image or signal data, and accompanying metadata, stored on a computer medium. Products may be supplied using a file transfer protocol (push or pull) or on different media including local disk devices and DVD-ROM.

RADARSAT-2 products can be generated in one of two formats. The first format consists of GeoTIFF image data (very large products may use the BigTIFF variant of GeoTIFF), with accompanying XML format metadata, as defined in the RADARSAT-2 Product Format Definition (RN-TP-51-2713). The second format consists of NITF 2.1 format image data with accompanying XML format metadata, as defined in the RADARSAT-2 NITF 2.1 Product Format Definition (RN-SP-52-8207).

RADARSAT-2 products are characterized by the payload configuration (beam mode, beam position, polarization setting) used by the satellite, as well as the level of processing that has been applied to the data.

Some RADARSAT-2 products, using some beam modes, or beams, or covering certain areas, may not be available to all customers. Further details on product availability can be obtained by contacting MDA Client Services as indicated above.

1.2 Beam Modes

The space segment of the RADARSAT-2 SAR system includes a radar transmitter, a radar receiver and a data downlink transmitter. The radar transmitter and receiver operate through an electronically steerable antenna that directs the transmitted energy in a narrow beam (which may be a physical radar beam, or a conceptual beam consisting of two or more physical beams) approximately normal to the satellite track. The elevation angle and the elevation profile of the beam are adjusted so that the beam intercepts the earth's surface over a certain range of incidence angles.

Imaging can be carried out in one of several different beam modes, each of which offers a unique set of imaging characteristics. These characteristics include nominal swath widths, pulse bandwidths, sampling rates, and a specific set of available beams at specific incidence angles. The RADARSAT-2 beam modes used to generate the products described in this document are shown in Figure 1-1.

During imaging in a given beam mode, the receiver detects echoes resulting from reflection or scattering of the transmitted signals from the earth's surface. The detected signals are then digitized, recorded and encoded prior to transmission to the on-ground data reception facility. Data transmission may occur in near real-time while the data are being collected, or the data may be stored in the on-board solid-state recorders for later transmission.

Subsequent processing of the signal allows the formation of high-resolution radar images of the earth's surface. These image products, which are the subject of this document, can be analyzed directly, or can be used to generate higher level, valued-added products to meet specialist application needs. This process may include special processing and/or merging with other remote sensing data. The resulting value-added products are outside the scope of this document.

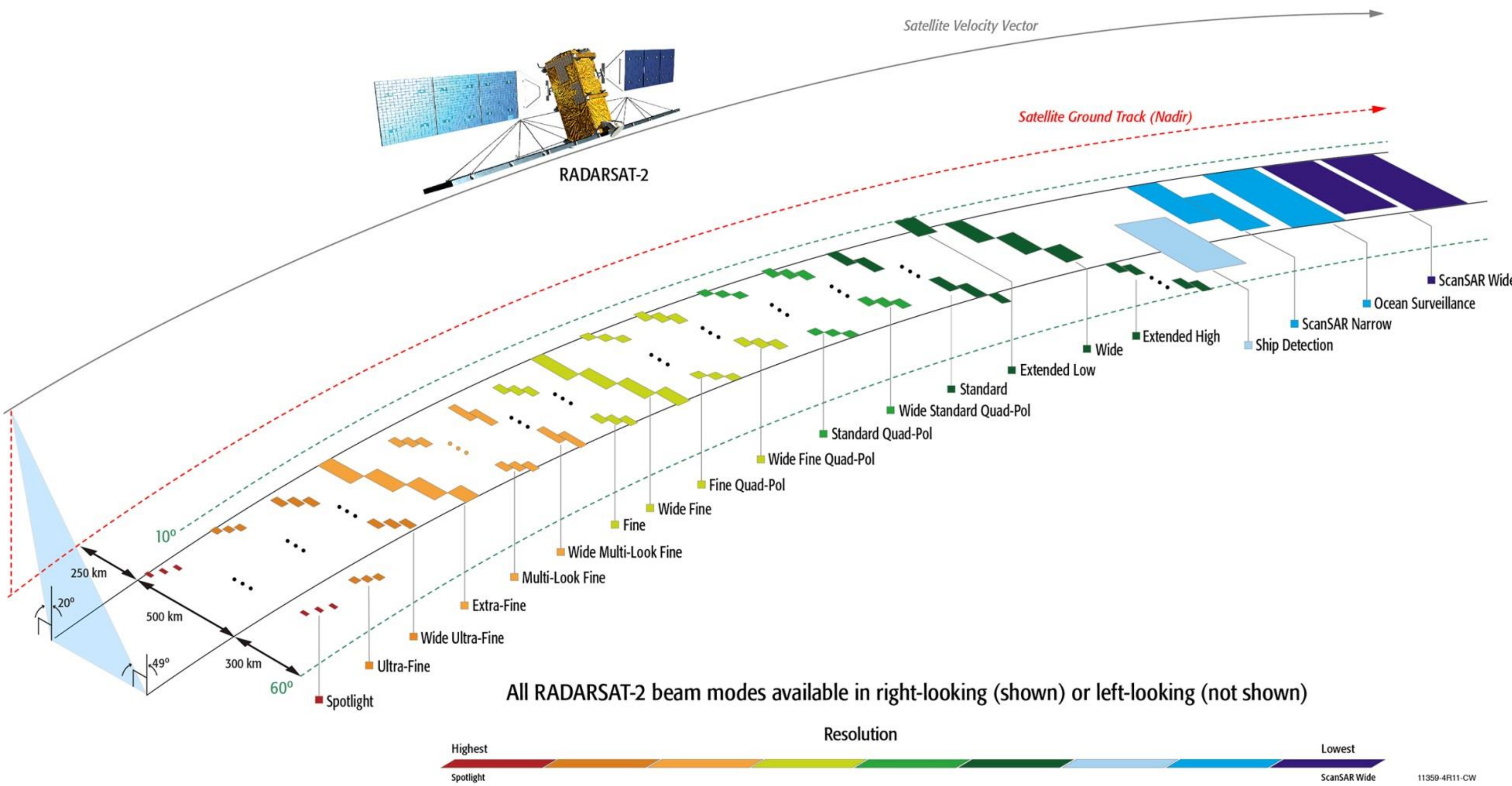


Figure 1-1 RADARSAT-2 SAR Beam Modes

During imaging, the SAR instrument may be operated in one of three fundamental imaging sensor modes:

- Single Beam
- ScanSAR
- Spotlight

The figure below shows the relationships between the beam modes and the sensor modes that they use. The placement of each beam mode within the figure gives an indication of both its nominal swath width and the finest nominal resolution cell size that its products can offer. The figure also indicates the available *beam positions* for each beam mode (in parentheses), where each beam position refers to a specific satellite imaging configuration in terms of swath width, pulse bandwidth, sampling rate, incidence angle, and physical radar beam(s) used.

(Note that in RADARSAT nomenclature a 'beam' is a generic term that may refer to a physical radar beam, a beam position, or a beam mode, depending on the context. A beam position is also sometimes called a swath position, or a mode, and the name of a beam position is sometimes referred to as its beam/mode mnemonic.)

The following sections further describe the three fundamental imaging sensor modes and their constituent beam modes. Key properties of products in these modes are summarized in Table 1-3.

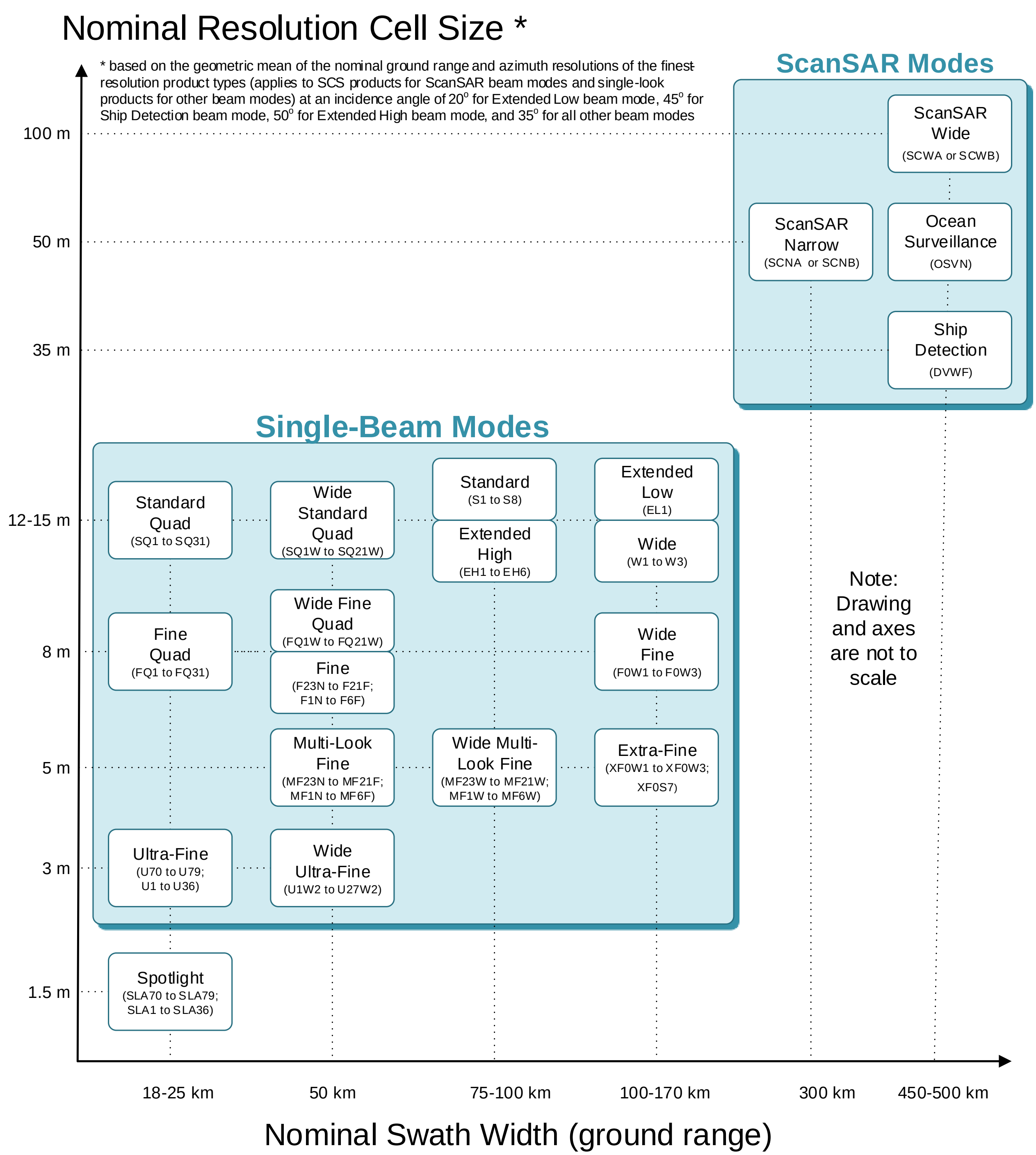


Figure 1-2 Sensor Modes, Beam Modes and Beam Positions in terms of their Nominal Swath Width and Achievable Product Resolution

1.2.1 Single Beam Modes

Single Beam modes are strip-map SAR modes. In Single Beam operation, the beam elevation and profile are maintained constant throughout the data collection period.

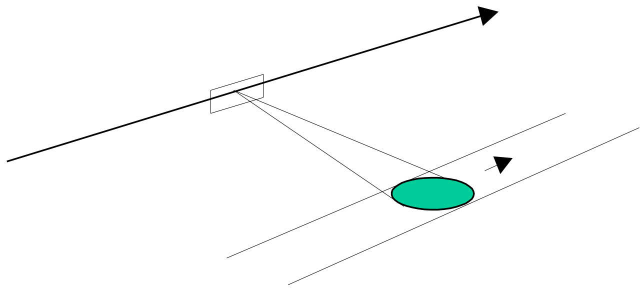


Figure 1-3 Single Beam Mode

In Single Beam imaging, the following beam modes are available:

a) Standard

Standard Beam Mode allows imaging over a wide range of incidence angles with a set of image quality characteristics which provides a balance between fine resolution and wide coverage, and between spatial and radiometric resolutions. Standard Beam Mode operates with any one of eight beams, referred to as S1 to S8. The nominal incidence angle range covered by the full set of beams is 20 degrees (at the inner edge of S1) to 52 degrees (at the outer edge of S8). Each individual beam covers a nominal ground swath of 100 km within the total standard beam accessibility swath of more than 500 km. Standard Beam Mode products can be generated either with a single linear co-polarization (HH or VV), or with a single linear cross-polarization (HV or VH), or with dual co- and cross-polarizations (HH+HV or VV+VH).

b) Wide

The Wide Swath Beam Mode allows imaging of wider swaths than Standard Beam Mode, but at the expense of slightly coarser spatial resolution in some cases. The three Wide Swath beams, W1, W2 and W3, provide swaths of approximately 170 km, 150 km and 130 km in width respectively, and collectively span a total incidence angle range from 20 degrees to 45 degrees. Wide Swath Beam Mode products can be generated either with a single linear co-polarization (HH or VV), or with a single linear cross-polarization (HV or VH), or with dual co- and cross-polarizations (HH+HV or VV+VH).

c) Fine

The Fine Resolution Beam Mode is intended for applications which require finer spatial resolution than Standard Beam Mode. Products from this beam mode have a nominal ground swath of 50 km. Nine Fine Resolution physical beams, F23 to

F21, and F1 to F6 are available to cover the incidence angle range from 30 to 50 degrees. For each of these beams, the swath can optionally be centered with respect to the physical beam or it can be shifted slightly to the near or far range side. Thanks to these additional swath positioning choices, overlaps of more than 50% are provided between adjacent swaths. Fine Resolution Beam Mode products can be generated either with a single linear co-polarization (HH or VV), or with a single linear cross-polarization (HV or VH), or with dual co- and cross-polarizations (HH+HV or VV+VH).

d) Wide Fine

The Wide Fine Resolution Beam Mode is intended for applications which require both a finer spatial resolution and a wide swath. Products from this beam mode have a nominal ground swath equivalent to the ones offered by the Wide Swath Beam Mode (170 km, 150 km and 120 km) and a spatial resolution equivalent to the ones offered by the Fine Resolution Beam Mode, at the expense of somewhat higher noise levels. Three Wide Fine Resolution beam positions, F0W1 to F0W3 are available to cover the incidence angle range from 20 to 45 degrees. Wide Fine Resolution Beam Mode products can be generated either with a single linear co-polarization (HH or VV), or with a single linear cross-polarization (HV or VH), or with dual co- and cross-polarizations (HH+HV or VV+VH).

e) Multi-Look Fine

The Multi-Look Fine Resolution Beam Mode covers the same swaths as the Fine Resolution Beam Mode. Products with multiple looks in range and azimuth are generated at approximately the same spatial resolution as Fine Resolution Beam mode products, but with multiple looks and therefore improved radiometric resolution. Single look products are generated at finer spatial resolutions than Fine Resolution Beam Mode products. In order to obtain the multiple looks without a reduction in swath width, this beam mode operates with higher data acquisition rates and noise levels than Fine Resolution Beam Mode. Like in the Fine Resolution Beam Mode, nine physical beams are available to cover the incidence angle range from 30 to 50 degrees, and additional near and/or far range swath positioning choices are available to provide additional overlap. Multi-Look Fine Resolution Beam Mode products can only be generated in a single polarization, which can be either a linear co-polarization (HH or VV) or a linear cross-polarization (HV or VH).

f) Wide Multi-Look Fine

The Wide Multi-Look Fine Resolution Beam Mode offers a wider coverage alternative to the regular Multi-Look Fine Beam Mode, while preserving the same spatial and radiometric resolution, but at the expense of higher data compression ratios (which leads to higher signal-dependent noise levels). The nominal swath width is 90km compared to 50km for the Multi-Look Fine Beam Mode. The nine physical beams are the same as in the Multi-Look Fine Beam Mode, covering incidence angles from approximately 30 to 50 degrees, but the additional near and far range swath positioning choices available in the Multi-Look Fine Beam Mode are not needed because the beam centered swaths are wide enough to overlap by more than 50%. Wide Multi-Look Fine Resolution Beam Mode products can only be generated in a single polarization, which can be either a linear co-polarization (HH or VV) or a linear cross-polarization (HV or VH).

g) Extra-Fine

The Extra-Fine Resolution Beam Mode nominally provides similar swath width and incidence angle coverage as the Wide Fine Beam Mode, at even finer resolutions, but with higher data compression ratios and noise levels. The four Extra-Fine beams provide coverage of swaths of approximately 160 km, 124 km, 120 km and 108 km in width respectively, and collectively span a total incidence angle range from 22 to 49 degrees. This beam mode also offers additional optional processing parameter selections that allow for reduced-bandwidth single-look products, 4-look, and 28-look products. Extra-Fine Beam Mode products can only be generated in a single polarization, which can be either a linear co-polarization (HH or VV) or a linear cross-polarization (HV or VH).

h) Ultra-Fine

The Ultra-Fine Resolution Beam Mode is intended for applications which require very high spatial resolution. The set of Ultra-Fine Resolution Beams cover any area within the incidence angle range from 20 to 50 degrees (soon to be extended to 54 degrees). Each beam within the set images a swath width of at least 20 km. Ultra-Fine Resolution Beam Mode products can only be generated in a single polarization, which can be either a linear co-polarization (HH or VV) or a linear cross-polarization (HV or VH).

i) Wide Ultra-Fine

The Wide Ultra-Fine Resolution Beam Mode provides the same spatial resolution as the Ultra-Fine mode as well as wider coverage, but at the expense of higher data compression ratios (which leads to higher signal-dependent noise levels). The set of Wide Ultra-Fine Resolution Beams cover any area within the incidence angle range from 30 to 50 degrees. Each beam within the set images a swath width of approximately 50 km. Wide Ultra-Fine Resolution Beam Mode products can only be generated in a single polarization, which can be either a linear co-polarization (HH or VV) or a linear cross-polarization (HV or VH).

j) Extended High (High Incidence)

In the Extended High Incidence Beam Mode, six Extended High Incidence Beams, EH1 to EH6, are available for imaging in the 49 to 60 degree incidence angle range. Since these beams operate outside the optimum scan angle range of the SAR antenna, some degradation of image quality can be expected when compared with the Standard Beams. In particular, the 4th, 5th and 6th beams are designed for imaging near the North and South poles and are not recommended for other regions due to grating lobe ambiguities, which may appear at incidence angles above 54 degrees and become progressively more severe with increasing incidence angle. Swath widths are restricted to a nominal 80 km for the inner three beams, and 70 km for the outer beams. Extended High Incidence Beam Mode products can only be generated in HH polarization.

k) Extended Low (Low Incidence)

In the Extended Low Incidence Beam Mode, a single Extended Low Incidence Beam, EL1, is provided for imaging in the incidence angle range from 10 to 23 degrees with nominal ground swath coverage of 170 km. Some minor degradation of image quality can be expected due to operation of the antenna beyond its optimum scan angle range. Extended Low Incidence Beam Mode products can only be generated in HH polarization.

l) Standard Quad Polarization

In the Quad Polarization Beam Mode, the radar transmits pulses alternately in horizontal (H) and vertical (V) polarizations, and receives the return signals from each pulse in both H and V polarizations separately but simultaneously. This beam mode therefore enables full polarimetric (HH+VV+HV+VH) image products to be generated. The Standard Quad Polarization Beam Mode operates with the same pulse bandwidths as the Standard Beam Mode. Products with swath widths of approximately 25 km can be obtained covering any area within the region from an incidence angle of 18 degrees to at least 49 degrees.

m) Wide Standard Quad Polarization

The Wide Standard Quad Polarization Beam Mode operates the same way as the Standard Quad Polarization Beam Mode but with higher data acquisition rates, and offers wider swaths of approximately 50 km at equivalent spatial resolution. Twenty one beams are available covering any area from 18 degrees to 42 degrees, ensuring overlaps of about 50% between adjacent swaths.

n) Fine Quad Polarization

The Fine Quad Polarization Beam Mode provides full polarimetric imaging with the same spatial resolution as the Fine Resolution Beam Mode. Fine Quad Polarization Beam Mode products with swath widths of approximately 25 km can be obtained covering any area within the region from an incidence angle of 18 degrees to at least 49 degrees.

o) Wide Fine Quad Polarization

The Wide Fine Quad Polarization Beam Mode operates the same way as the Fine Quad Polarization Beam Mode but with higher data acquisition rates, and offers a wider swath of approximately 50 km at equivalent spatial resolution. Twenty one beams are available covering any area from 18 degrees to 42 degrees, ensuring overlaps of about 50% between adjacent swaths.

1.2.2 ScanSAR Modes

The ScanSAR beam modes provide images of very wide swaths in a single pass of the satellite, and are intended for use in applications requiring large-scale area coverage such as monitoring applications.

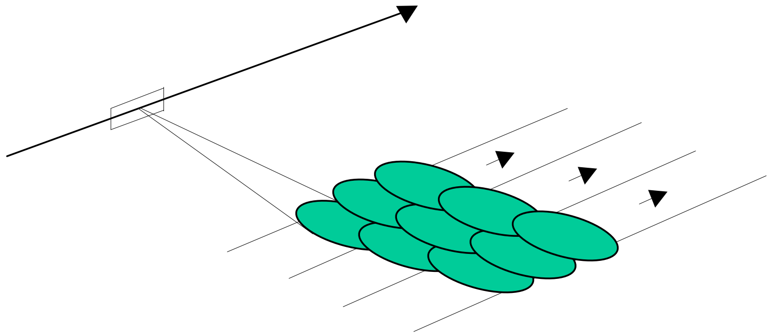


Figure 1-4 ScanSAR Mode

In the ScanSAR modes, two or more of the single physical beams covering adjoining swaths are used in combination. The beams are operated sequentially, each for a series of pulse transmissions and receptions, so that data are collected from a wider swath than is possible with a single beam, and this beam sequence is repeated in cycles. The beam switching rates are chosen to ensure that the blocks of imagery produced from successive sets of pulse returns from each beam provide unbroken along-track coverage. Each product is formed by merging many of these image blocks together.

The beam multiplexing inherent in ScanSAR operation reduces the available Doppler bandwidth of the signal from each point on the ground. The increased swath coverage is therefore obtained at the expense of spatial resolution.

Standard ScanSAR

For the standard RADARSAT-2 ScanSAR modes, the radar beam switching has been chosen to provide two “natural” azimuth looks per beam for all points, which is to say that each point is imaged during two consecutive ScanSAR beam cycles, and the overlapping regions between beam cycles are combined during product processing. The following standard ScanSAR beam modes are available:

a) ScanSAR Narrow

The ScanSAR Narrow Beam Mode provides coverage of a ground swath approximately double the width of the Wide Swath Beam Mode swaths. Two swath positions with different combinations of physical beams can be used:

- SCNA, which uses physical beams W1 and W2
- SCNB, which uses physical beams W2, S5, and S6

Both options provide coverage of swath widths of about 300 km. The SCNA combination provides coverage over the incidence angle range from 20 to 39 degrees. The SCNB combination provides coverage over the incidence angle range 31 to 47 degrees. ScanSAR Narrow images can be generated either with a single linear co-polarization, or with a single linear cross-polarization, or with dual co- and cross-polarizations.

b) ScanSAR Wide

The ScanSAR Wide Beam Mode provides coverage of a ground swath approximately triple the width of the Wide Swath Beam Mode swaths. Two swath positions with different combinations of physical beams can be used:

- SCWA, which uses physical beams W1, W2, W3, and S7
- SCWB, which uses physical beams W1, W2, S5 and S6

The SCWA combination allows imaging of a swath of more than 500 km covering an incidence angle range of 20 to 49 degrees. The SCWB combination allows imaging of a swath of more than 450 km covering the incidence angle range from 20 to 46 degrees. ScanSAR Wide images can be generated either with a single linear co-polarization, or with a single linear cross-polarization, or with dual co- and cross-polarizations.

Maritime Satellite Surveillance Radar (MSSR) ScanSAR

In addition to the standard ScanSAR modes, RADARSAT-2 now provides two additional MSSR ScanSAR beam modes, which are designed for improved ship detection performance. Each of these beam modes is optimized to detect smaller ships over large areas, and provides nearly uniform detectable ship length across the swath.

Since ship detection performance is clutter limited at near range and noise limited at far range, these improvements are achieved using finer azimuth resolution at near range and carefully controlled noise characteristics at far range. The radar beam switching has been chosen to provide a single “natural” azimuth look per beam for all points, which is to say that each point is imaged once, during a single ScanSAR beam cycle (any overlapping regions between beam cycles are not combined during product processing). The following MSSR ScanSAR beam modes are available:

a) Ship Detection (Detection of Vessels)

The Ship Detection (also called Detection of Vessels) ScanSAR Beam Mode provides images of very wide swaths similar to ScanSAR Wide, but is designed primarily for ship detection purposes, and is not expected to be used for other applications. This beam mode uses the highest data compression ratios, so it has the highest signal-dependent noise levels, and is designed to sacrifice visual appeal in order to provide the most effective detection of small ships over very wide areas. Images in this beam mode are available in any single polarization (HH or

HV or VH or VV), but HH is favoured for ship detection purposes, so only the HH channel is expected to be used and use of the other channels is not recommended.

The following single Detection of Vessels ScanSAR swath position can be used:

- Detection of Vessels Wide Far (DVWF)

The DVWF swath position provides coverage of a ground swath of approximately 450 km using seven specially optimized beams operated with the 30 MHz pulse bandwidth, providing coverage over the range of incidence angles from 35 to 56 degrees.

b) Ocean Surveillance

The Ocean Surveillance ScanSAR Beam Mode provides images of very wide swaths similar to ScanSAR Wide, yet with finer resolution and improved ship detection performance similar to ScanSAR Narrow, albeit not quite with the same visual appeal as standard ScanSAR modes. As such, this mode offers a balance between enhanced ship detection capability on one hand and suitability for other applications on the other hand. Ocean Surveillance images can be generated either with a single linear co-polarization, or with a single linear cross-polarization, but usually with dual co- and cross-polarizations. For ship detection, (HH+HV) is favoured where the HH channel should be used for incidence angles greater than 30 to 35 degrees, and the HV channel should be used for incidence angles less than 30 to 35 degrees. For wind, wake and oil detection, (VV+VH) is favoured.

The following single Ocean Surveillance ScanSAR swath position can be used:

- Ocean Surveillance Very-wide Near (OSVN)

The Ocean Surveillance Very-wide Near swath position provides coverage of a ground swath of more than 500 km using eight optimized beams operated with the 17.28 MHz pulse bandwidth, providing coverage over the range of incidence angles from 20 to 50 degrees.

1.2.3 Spotlight Mode

The Spotlight Beam Mode is intended for applications which require the best spatial resolution available from the RADARSAT-2 SAR system. In this beam mode, the beam is steered electronically in order to dwell on the area of interest over longer aperture times, which allows products to be processed to finer azimuth resolution than in other modes. Unlike in other modes, Spotlight images are of fixed size in the along track direction.

The set of Spotlight beams cover any area within the incidence angle range from 20 to 50 degrees (soon to be extended to 54 degrees). Each beam within the set images a swath width of at least 18 km. Spotlight Beam Mode products can only be generated in a single polarization, which can be either a linear co-polarization (HH or VV) or a linear cross-polarization (HV or VH).

The commercial Spotlight mode is sometimes referred to as “Spotlight-A” (SLA) mode. This is to distinguish it from other internal or future Spotlight modes, which may have different properties.

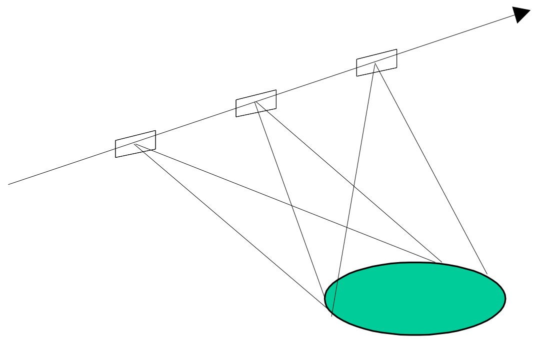


Figure 1-5 Spotlight Mode

1.3 Polarization

The RADARSAT-2 SAR sensor is able to transmit horizontal (H) or vertical (V) linear polarizations. The sensor is able to receive either H or V polarized signals, and for some beams, as listed in the “Dual” and “Quad” columns of Table 1-1, is able to receive both H and V signals simultaneously. In addition to the RADARSAT-1 imaging modes (with H polarization for both transmit and receive), therefore, new cross-polarization, dual-polarization and quad-polarization products can be created.

Single co-polarization products are obtained by operating the radar with the same (H or V) polarization on both transmit and receive. Single cross-polarization products are obtained by operating the radar with one (H or V) polarization on transmit and the other (V or H) on receive. Dual-polarization products are obtained by operating the radar with one (H or V) polarization on transmit and both simultaneously on receive. Quad-polarization products are obtained by operating the radar with H and V polarizations for alternate pulses on transmit, with both simultaneously on receive.

Multi-polarization products are provided in the form of multiple layers each corresponding to a different polarization channel (HH, VV, HV or VH). The layers all have the same characteristics and are co-registered.

Complex-valued Quad Polarization products contain the inter-channel phase information which enables complex-valued polarimetry to be performed. Multi-polarization SAR allows the user to measure the polarization properties of the terrain and not simply the backscatter at a single polarization. Ground targets have distinctive polarization signatures in the same way that they have distinctive spectral signatures. For example, volume scatterers have different polarization properties than surface scatterers. Multi-polarization SAR products therefore provide improved classification of point targets and distributed target areas.

Table 1-1 RADARSAT-2 Polarization Options per Beam Mode

BEAM MODE	POLARIZATION OPTIONS						
	Single Co		Single Cross		Dual		Quad
	HH	VV	HV	VH	HH+HV	VV+VH	HH+VV+HV+VH
Spotlight	✓	✓	✓	✓			
Ultra-Fine	✓	✓	✓	✓			
Wide Ultra-Fine	✓	✓	✓	✓			
Multi-Look Fine	✓	✓	✓	✓			
Wide Multi-Look Fine	✓	✓	✓	✓			
Extra-Fine	✓	✓	✓	✓			
Fine	✓	✓	✓	✓	✓	✓	
Wide Fine	✓	✓	✓	✓	✓	✓	
Standard	✓	✓	✓	✓	✓	✓	
Wide	✓	✓	✓	✓	✓	✓	
Extended High	✓						
Extended Low	✓						
Fine Quad-Pol							✓
Wide Fine Quad-Pol							✓
Standard Quad-Pol							✓
Wide Standard Quad-Pol							✓
ScanSAR Narrow	✓	✓	✓	✓	✓	✓	
ScanSAR Wide	✓	✓	✓	✓	✓	✓	
Ship Detection (Detection of Vessels)	✓	✓	✓	✓			
Ocean Surveillance	✓	✓	✓	✓	✓	✓	

Notes:

1. Polarization is shown as Transmit - Receive with H = Horizontal and V = Vertical.
2. Single co-polarization refers to the same polarization on both transmit and receive (HH or VV).
3. Single cross-polarization refers to one polarization on transmit and the other on receive (HV or VH).
4. Two co-registered images are provided with the Dual Polarization option and four co-registered images are provided with the Quad Polarization option.

1.4 Block Adaptive Quantization (BAQ)

During RADARSAT-2 data acquisition on the spacecraft, the SAR signals are digitized using 8-bit Analog to Digital converters followed by Block Adaptive Quantization (BAQ) coding. The BAQ coding is done to reduce on-board data storage and downlink rates and is capable of producing outputs with either 1-, 2-, 3- or 4-bit representation for each In-phase (I) value and each Quadrature phase (Q) value of each complex SAR data sample. During ground processing, the encoded samples are then decoded, albeit with some information loss.

BAQ is a lossy data compression technique based on the principles of minimum mean-squared error quantization. During BAQ coding, distortion is introduced into the data in the form of quantization noise. The goal of the compression algorithm is to minimize the mean squared error of the quantization noise, while nonetheless preserving the mean radiometric level of the signal. The BAQ levels, in bits per I or Q sample, for each RADARSAT-2 beam mode are provided in Table 1-3. Typical BAQ noise levels are estimated as approximately -19 dB times the mean signal level for 4-bit BAQ acquisitions; -14 dB times the mean signal level for 3-bit BAQ acquisitions; and -9 dB times the mean signal level for 2-bit BAQ acquisitions. BAQ noise levels for 1-bit acquisitions are higher than for 2-bit acquisitions.

1.5 Product Types and Processing Levels

Three types of SAR products are produced: Slant Range, Ground Range, and Geocorrected. Table 1-2 provides a summary of these product types with a mapping to processing levels, which are based on the RADARSAT-1 processing levels. A mapping to product descriptive names used by RADARSAT-1 end user groups is also given.

Slant Range and Ground Range products are oriented along the satellite path, and are Georeferenced using orbit and attitude data from the satellite, thus allowing latitude and longitude information to be calculated for each pixel. In Slant Range products, range coordinates are given in radar slant range rather than ground range, i.e. the range pixel spacing and range resolution are measured along a slant path perpendicular to the track of the sensor.

Geocorrected products are geocoded to a map projection. Systematic geocoding is done without the aid of ground control points. Precision geocoding is done with the aid of ground control points.

These product types are described in further detail in Section 2.

Table 1-2 RADARSAT-2 Product Types

Product Types		Abbreviation	Processing Level	Product Descriptive Name
Slant Range	Single Look Complex	SLC	Georeferenced	Single Look Complex
Ground Range	SAR Georeferenced Extra	SGX	Georeferenced	Path Image Plus
	SAR Georeferenced Fine	SGF	Georeferenced	Path Image
	ScanSAR Narrow Beam	SCN	Georeferenced	Path Image
	ScanSAR Wide Beam	SCW	Georeferenced	Path Image
	ScanSAR Fine	SCF	Georeferenced	Path Image
	ScanSAR Sampled	SCS	Georeferenced	Path Image
Geocorrected	SAR Systematic Geocorrected	SSG	Systematic Geocoded	Map Image
	SAR Precision Geocorrected	SPG	Precision Geocoded	Precision Map Image

1.6 Products Summary

Table 1-3 lists the applicable beam modes for RADARSAT-2 products. The beam modes for which dual- or quad-polarization options are available are indicated.

Table 1-3 Summary of RADARSAT-2 Beam Modes and Product Characteristics

BEAM MODE	PRODUCT [1, 2]	Nominal Pixel Spacing [3,4] [Rng × Az] (m)	Nominal Resolution [5] [Rng x Az] (m)	Nominal Scene Size [6] [Rng x Az] (km)	Nominal Incidence Angle Range [deg]	No. Looks [Rng x Az]	Polarization Options	BAQ Level (bits)
Spotlight	SLC	1.3 x 0.4	1.6 x 0.8	18 x 8	20 to 54 [(7)]	1 x 1	Single Co or Cross (HH or VV or HV or VH)	3
	SGX	1 or 0.8 x 1/3	4.6 – 2.0 x 0.8					
	SGF	0.5 x 0.5						
	SSG, SPG	0.5 x 0.5						
Ultra-Fine	SLC	1.3 x 2.1	1.6 x 2.8	20 x 20	20 to 54 [(7)]	1 x 1	Single Co or Cross (HH or VV or HV or VH)	3
	SGX	1 x 1 or 0.8 x 0.8	4.6 – 2.0 x 2.8					
	SGF	1.56 x 1.56						
	SSG, SPG	1.56 x 1.56						
Wide Ultra-Fine	SLC	1.3 x 2.1	1.6 x 2.8	50 x 50	29 to 50	1 x 1	Single Co or Cross (HH or VV or HV or VH)	2
	SGX	1 x 1	3.3 – 2.1 x 2.8					
	SGF	1.56 x 1.56						
	SSG, SPG	1.56 x 1.56						
Multi-Look Fine	SLC	2.7 x 2.9	3.1 x 4.6	50 x 50	30 to 50	1 x 1	Single Co or Cross (HH or VV or HV or VH)	3
	SGX	3.13 x 3.13	10.4 – 6.8 x 7.6			2 x 2		
	SGF	6.25 x 6.25						
	SSG, SPG	6.25 x 6.25						
Wide Multi-Look Fine	SLC	2.7 x 2.9	3.1 x 4.6	90 x 50	29 to 50	1 x 1 2 x 2	Single Co or Cross (HH or VV or HV or VH)	2
	SGX	3.13 x 3.13	10.8 – 6.8 x 7.6					
	SGF	6.25 x 6.25						
	SSG, SPG	6.25 x 6.25						
Extra-Fine	SLC (Full Res)	2.7 x 2.9	3.1 x 4.6	125 x 125	22 to 49	1 x 1	Single Co or Cross (HH or VV or HV or VH)	2
	SLC (Fine Res)	4.3 x 5.8	5.2 x 7.6					
	SLC (Std Res)	7.1 x 5.8	8.9 x 7.6					
	SLC (Wide Res)	10.6 x 5.8	13.3 x 7.6					
	SGX (1 look)	2.0 x 2.0	8.4 – 4.1 x 4.6			1 x 1		
	SGX (4 looks)	3.13 x 3.13	14 – 6.9 x 7.6			2 x 2		
	SGX (28 looks)	5.0 x 5.0	24 – 12 x 23.5			4 x 7		
	SGF (1 look)	3.13 x 3.13	8.4 – 4.1 x 4.6			1 x 1		
	SGF (4 looks)	6.25 x 6.25	14 – 6.9 x 7.6			2 x 2		
	SGF (28 looks)	8.0 x 8.0	24 – 12 x 23.5			4 x 7		
	SSG, SPG	3.13 x 3.13	8.4 – 4.1 x 4.6			1 x 1		
Fine	SLC	4.7 x 5.1	5.2 x 7.7	50 x 50	30 to 50	1 x 1	Single Co or Cross (HH or VV or HV or VH) or Dual (HH+HV or VV+VH)	3
	SGX	3.13 x 3.13	10.4 – 6.8 x 7.7					
	SGF	6.25 x 6.25						
	SSG, SPG	6.25 x 6.25						
Wide Fine	SLC	4.7 x 5.1	5.2 x 7.7	150 x 150	20 to 45	1 x 1	Single Co or Cross (HH or VV or HV or VH) or Dual (HH+HV or VV+VH)	3
	SGX	3.13 x 3.13	14.9 – 7.3 x 7.7					
	SGF	6.25 x 6.25						
	SSG, SPG	6.25 x 6.25						
Standard	SLC	8 or 11.8 x 5.1	9.0 or 13.5 x 7.7	100 x 100	20 to 52	1 x 1	Single Co or Cross (HH or VV or HV or VH) or Dual (HH+HV or VV+VH)	3
	SGX	8 x 8	26.8 – 17.3 x 24.7			1 x 4		
	SGF	12.5 x 12.5						
	SSG, SPG	12.5 x 12.5						
Wide	SLC	11.8 x 5.1	13.5 x 7.7	150 x 150	20 to 45	1 x 1	Single Co or Cross (HH or VV or HV or VH) or Dual (HH+HV or VV+VH)	3
	SGX	10 x 10	40.0 – 19.2 x 24.7			1 x 4		
	SGF	12.5 x 12.5						
	SSG, SPG	12.5 x 12.5						

BEAM MODE	PRODUCT [1, 2]	Nominal Pixel Spacing [3,4] [Rng × Az] (m)	Nominal Resolution [5] [Rng x Az] (m)	Nominal Scene Size [6] [Rng x Az] (km)	Nominal Incidence Angle Range [deg]	No. Looks [Rng x Az]	Polarization Options	BAQ Level (bits)
Extended High	SLC	11.8 x 5.1	13.5 x 7.7	75 x 75	49 to 60	1 x 1	Single (HH only)	3
	SGX	8 x 8	18.2 – 15.9 x 24.7			1 x 4		
	SGF	12.5 x 12.5						
	SSG, SPG	12.5 x 12.5						
Extended Low	SLC	8.0 x 5.1	9.0 x 7.7	170 x 170	10 to 23	1 x 1	Single (HH only)	3
	SGX	10 x 10	52.7 – 23.3 x 24.7			1 x 4		
	SGF	12.5 x 12.5						
	SSG, SPG	12.5 x 12.5						
Fine Quad-Pol	SLC	4.7 x 5.1	5.2 x 7.6	25 x 25	18 to 49	1 x 1	Quad (HH+VV+HV+VH)	3
	SGX	3.13 x 3.13	16.5 – 6.8 x 7.6					
	SSG, SPG	3.13 x 3.13						
Wide Fine Quad-Pol	SLC	4.7 x 5.1	5.2 x 7.6	50 x 25	18 to 42	1 x 1	Quad (HH+VV+HV+VH)	3
	SGX	3.13 x 3.13	17.3–7.8 x 7.6					
	SSG, SPG	3.13 x 3.13						
Standard Quad-Pol	SLC	8 or 11.8 x 5.1	9.0 or 13.5 x 7.6	25 x 25	18 to 49	1 x 1	Quad (HH+VV+HV+VH)	3
	SGX	8 x 3.13	28.6 – 17.7 x 7.6					
	SSG, SPG	8 x 3.13						
Wide Standard Quad-Pol	SLC	8 or 11.8 x 5.1	9.0 or 13.5 x 7.6	50 x 25	18 to 42	1 x 1	Quad (HH+VV+HV+VH)	3
	SGX	8 x 3.13	30.0 –16.7 x 7.6					
	SSG, SPG	8 x 3.13						
ScanSAR Narrow	SCN, SCF, SCS	25 x 25	81–38 x 40-70	300 x 300	20 to 46	2 x 2	Single Co or Cross (HH or VV or HV or VH) or Dual (HH+HV or VV+VH)	SCNA:4 SCNB:3
ScanSAR Wide	SCW, SCF, SCS	50 x 50	163–73 x 78-106	500 x 500	20 to 49	4 x 2	Single Co or Cross (HH or VV or HV or VH) or Dual (HH+HV or VV+VH)	4
Ship Detection (Detection of Vessels)	SCF	40 x 40	103-71 x 40-81	450 x 500	35 to 56	16 x 2 [(8)]	Single (HH only)	1
	SCS	20 x 20	33-23 x 19-77			5 x 1		
Ocean Surveillance	SCF	50 x 50	118-53 x 53-104	500 x 500	20 to 50	6 x 2 [(8)]	Single Co or Cross (HH or VV or HV or VH) or Dual (HH+HV or VV+VH)	2
	SCS	35 x 25	80-36 x 27-99			4 x 1		

NOTES:

1. Products available: Single Look Complex (SLC); Path Image Plus (SGX); Path Image (SGF); ScanSAR Narrow (SCN); ScanSAR Wide (SCW); ScanSAR Fine (SCF); ScanSAR Sampled (SCS); Map Image (SSG); Precision Map Image (SPG).
2. SLC, SGX, SGF, SCN, SCW, SCF and SCS are georeferenced and aligned with the satellite track. SSG and SPG are geocorrected on a map projection (SPG requires ground control points).
3. For SLC products the range pixel spacing is in radar slant range. For other georeferenced products (i.e. for ground range products) the range pixel spacing is in ground range. For geocorrected products the pixel spacings are in map projected coordinates (horizontal x vertical).
4. For SLC products the azimuth pixel spacing depends on the pulse repetition frequency.
5. Range resolution is in radar slant range for SLC products and ground range for all other products. Ground range resolution varies with incidence angle.
6. Actual scene size may vary with incidence angle.
7. Incidence angles above 50 degrees in the Spotlight and Ultra-Fine beam modes are not yet available commercially.
8. For Ship Detection and Ocean Surveillance modes, azimuth multi-looking of SCF products is done by spatial averaging and decimation by a factor of 2.
9. All modes and product characteristics are subject to change. Some restrictions may apply.
10. The RADARSAT-2 SAR sensor is extremely flexible and programmable post-launch; nominal resolution and swath width are examples of programmable characteristics. Custom and new beam modes will be introduced in response to client needs and market conditions.

2 DETAILED RADARSAT-2 PRODUCT DESCRIPTIONS

This section contains detailed descriptions of each of the RADARSAT-2 products. A standardized form of table is used to characterize each of the product types, and the first subsection defines each of the parameters included in these tables. The following subsections describe respectively the slant range and ground range georeferenced products, and the geocorrected products.

2.1 Product Description Terms

This subsection explains the terms used in the tables in the following subsections, which describe the various data product types available for the RADARSAT-2 beam modes. These definitions are split into three sets corresponding to the main divisions in the product description tables: Product Characteristics, Processing Parameters, and Typical Image Quality Characteristics.

2.1.1 Product Characteristics

Coordinate System

All georeferenced products are produced in 'zero Doppler' orientation, i.e. with each row of pixels representing points along a line perpendicular to the sub-satellite track. Georeferenced products can be in either one of two coordinate systems: ground range or slant range. Products in ground range coordinates use uniform pixel spacing, whereas products in slant range coordinates maintain the natural pixel spacing of the signal data. This spacing is not uniform measured in ground range distance on the Earth's surface: pixels representing the near side of the image cover a larger ground area than those representing the far side.

Geocorrected products can be represented in any one of the map projections supported by the USGS. Additional map projections can be supported as required.

Nominal Image Coverage

The image coverage is the area on the ground surface which is represented in the image, and is stated in terms of ground range (across-track) and azimuth (along-track) dimensions. The exact range dimension of any given image is chosen so as to contain the full width that can be generated from the raw signal, and will therefore vary from image to image. Within some groups of beams, such as the Wide Swath and Extended High Beams for example, some beams give wider coverage than others, and a nominal average value is given in the table. In most beam modes, the nominal length for each product is defined to be equal to the nominal width in ground range.

Pixel Spacing

Pixel spacing is the distance between adjacent pixels measured in metres. This is the same as the pixel size. The pixel spacing may be different for range and azimuth. Range pixel spacing may be stated either in ground range or slant range distance as appropriate to the product type.

Generally, the pixel spacing in the range or azimuth dimension of complex-valued images is similar in magnitude to the resolution in the same dimension, whereas the pixel spacing in each dimension of detected images is similar in magnitude to half the resolution distance in that dimension. In order for the full information content of the image to be retained, the pixel sampling must meet the Nyquist criterion, which is that the spatial sampling rate must exceed the bandwidth of the spatial frequency content in the image. For all RADARSAT-2 modes, this requires pixel spacings which are slightly smaller than the resolution distance for complex images, and slightly smaller than half the resolution distance for detected images. The SLC and SGX products are defined to meet the Nyquist criterion. The other products are generally somewhat undersampled relative to the Nyquist criterion.

Pixel Data Representation

A pixel can be represented by either a complex or a real-valued number. The complex-valued representation consists of two signed integers (one each for the real I and imaginary Q parts) of 16 bits each. The real-valued representation consists of a single unsigned integer (8 or 16 bits) corresponding to the magnitude of the complex number:

$$Magnitude = \sqrt{I^2 + Q^2}$$

The magnitude of a pixel can be further converted into calibrated physical units using information provided in the product metadata.

Nominal Image Size

The nominal image size is the number of pixels per line multiplied by the number of lines, where the number of pixels per line can be calculated using:

$$PixelsPerLine = \frac{\text{Image Range}}{\text{Range Pixel Spacing}} ,$$

where Image Range is the nominal image coverage in the range dimension, in units of slant range for SLC products and ground range for other products. Similarly the number of lines in an image is given by:

$$Lines = \frac{\text{Image Azimuth}}{\text{Azimuth Pixel Spacing}},$$

where Image Azimuth is the nominal image coverage in the azimuth dimension.

The nominal numbers of pixels and image sizes stated in the Product Description tables are approximate values based on the Nominal Image Coverage, and correspond to typical imaging parameters for the group of beams. The exact image dimensions depend on the raw signal data available and on the length specified in the product order. Where products may contain data for more than one polarization, the nominal image size is given per polarization channel.

Nominal Product Volume

The nominal product volume is calculated as follows:

$$Volume = PixelsPerLine * Lines * BytesPerPixel,$$

where, for the purposes of calculating the values given in the Product Description tables, *BytesPerPixel* is 2 for detected products (however note that for some products a user may alternately request 8-bit pixels, in which case *BytesPerPixel* would then be 1 and the volume would be approximately half the volume given) and 4 for complex products.

The volumes given in the tables correspond to the Nominal Image Sizes except in Spotlight mode where it corresponds to a typical range. The volumes are approximate and may be rounded up or down. Actual product volumes will vary. The auxiliary data attached to the image is not included in these volumes.

Where products may contain data for more than one polarization, the product volume is given per polarization channel.

GeoTIFF-format products whose volume approaches or exceeds 4000 MBytes per polarization may use the BigTIFF variant of the GeoTIFF format.

2.1.2 Processing Terms

Number of Range Looks

The number of range looks is the number of distinct or partially overlapping coherently processed looks extracted from the pulse bandwidth which are combined after detection to form the image.

Number of Azimuth Looks

The number of azimuth looks is the number of distinct or overlapping coherently processed looks extracted from the Doppler spectrum which are combined after detection to form the image.

Unless otherwise specified, azimuth looks are distinct or only partially overlapping in the Doppler spectrum. The exception is that for SCF products in the Ship Detection and Ocean Surveillance beam modes, azimuth multi-looking is done by spatial averaging, that is by averaging pixels 2 at a time in the spatial azimuth direction after image formation, while decimating in azimuth by a factor of 2. In this case the looks effectively overlap completely in the Doppler spectrum but are shifted in the spatial domain.

Range Look Bandwidth

The range look bandwidth is the bandwidth of the segment of the total pulse bandwidth which is coherently processed for each individual range look.

Azimuth Look Bandwidth

The azimuth look bandwidth is the processed Doppler bandwidth for each individual azimuth look. In Spotlight mode, it is taken to mean the Doppler bandwidth of each target in the scene.

For ScanSAR products, this bandwidth varies from one physical beam to the next, decreases from the near edge to the far edge of any one beam, and also changes slightly around the orbit. The values given in the tables are for a point close to the far edge of each beam assuming a nominal orbit.

Number of Samples per Azimuth Look (ScanSAR only)

The number of azimuth samples (pulse returns) processed coherently in each ScanSAR azimuth look depends on the ScanSAR swath position and beam. The ScanSAR azimuth look bandwidth and azimuth resolution depend on this number, among other factors.

Range and Azimuth Spectral Weighting

The modified Kaiser-Bessel weighting function is used for both range and azimuth spectral weighting. This function is referred to simply as ‘Kaiser’ in the detailed product description tables, where the value of the weighting parameter is also given.

2.1.3 Image Quality Terms

The Image Quality Characteristics sections in the Product Description tables are provided as guidance on the image quality that can be expected in the products. The values in this section are not specifications on the system.

Nominal Incidence Angles

Nominal incidence angle is specified at the near and far edge of each beam. The incidence angle is the angle between the incident SAR beam and the axis perpendicular to the local geodetic ground surface. The values in the tables are nominal in that they are calculated assuming that the local surface follows the geoid, without any adjustment for local terrain height.

Nominal Resolution

The nominal resolution represents the nominal 3 dB Impulse Response Width in either the range or azimuth direction where:

The Impulse Response Function is the two-dimensional function resulting from the compression of returned energy from a point target in a processed image that meets the Nyquist sampling criterion.

The Impulse Response Width is defined as the distance between the points in a cut through the impulse response function which are 3 dB below the peak of the function.

Range resolution is stated either in ground range or slant range coordinates, depending on the product type. Where applicable, nominal range and azimuth resolution values are stated for the near and far edges of each beam.

For products that are undersampled relative to the Nyquist sampling criterion (including SGF, SCN, SCW, SCF, SCS, and most SSG and SPG products), the nominal resolutions do not include the effects of the undersampling.

Noise-Equivalent Sigma-Zero

Noise-Equivalent Sigma-Zero (NESZ) is a measure of the sensitivity of the radar to areas of low backscatter. The NESZ is defined to be the scattering cross-section coefficient (σ_o) of an area which contributes a mean level in the image equal to the signal-independent additive noise level. Any features which have backscatter lower than this level may be difficult to discern in the image.

These estimates are nominal and do not include any effects of BAQ noise or other forms of signal-dependent noise.

The NESZ level varies across the swath for any beam, and is generally lower (i.e. better) near the middle. For the Spotlight, Ocean Surveillance and Ship Detection (Detection of Vessels) beam modes, the NESZ level also varies along the length of the image.

Appendix C provides plots of these estimated variations for each beam or swath position of each beam mode. The values given in the tables are intended to be typical values across the swath width and set of beams.

Radiometric Error

The radiometric error is the error in the mean energy ratio between two areas of uniform distributed target, as measured from the image product within a region equal in size to the nominal image coverage of the product.

The radiometric corrections applied during product processing assume that the Earth's surface follows the shape of an ellipsoid inflated to a constant base elevation, which may be specified in the Production Order. The radiometric error estimates in the tables do not include errors caused by differences between this base elevation and the true elevation of the surface. In general, such errors can be minimized by setting the base elevation to the mean surface height of each scene.

Radiometric error estimates exclude any effects of instrument noise (NESZ, BAQ noise) in the image data.

Equivalent Number of Independent Looks

The image speckle statistics for areas of distributed target are determined by the multi-looking used in image generation. The 'equivalent number of independent looks' for a given product type is intended to correspond to the number of equally-weighted, statistically independent looks which would produce the same speckle statistics as the processing used to generate that product. In an image of a perfectly homogeneous area of distributed target generated using equal independent looks (in the absence of noise), the ratio of the mean pixel energy squared to the pixel energy variance is equal to the number of looks. This ratio is therefore used to define the equivalent number of independent looks for the general case when the looks are not equally weighted and statistically independent. The equivalent number of independent looks will normally be less than the total number of looks because of the partial overlapping of the looks and the unequal weights.

In practice, real targets are not perfectly homogeneous, so the values shown in the tables are based on simulations of ideal targets (using a conservative model of the system's ability to balance the look weighting).

Absolute Location Error

The absolute location error is the distance along the ground between the actual geographical location of a point within a processed image and the location as determined from the product (including GeoTIFF tags, as well as tiepoint, orbit state vector, timing, and rational function metadata, although the latter are also subject to additional rational function fitting errors). The typical accuracy values in the tables are based on use of the orbit data included in the X-band downlinked data without the use of ground truth data. The use of Definitive Orbit Data, which are typically available 24 to 48 hours after acquisition and typically provide spacecraft position accuracies better than 1 metre, will further improve these accuracies. All location error values are subject to the conditions explained in the following paragraphs.

Except for geocoded products corrected with a Digital Elevation Model (DEM) or with ground control points, the tiepoints and rational functions in the product metadata, as well as in GeoTIFF tags, are calculated assuming that the Earth's surface follows the shape of an ellipsoid inflated to a constant base elevation, as selected in the Production Order. The values in the tables do not include location errors arising from this assumption. Such location errors can be expressed in ground range units as dH divided by the tangent of the incidence angle, where dH is the difference between the true elevation of the surface and the base elevation specified in the Production Order (targets higher than the base elevation are shifted towards the sensor ground track and vice versa).

For geocoded products corrected with a DEM, there are additional location errors that depend on the accuracy of the DEM, which are not included in the tabled values. Such location errors can be expressed in ground range units as dH divided by the tangent of the incidence angle, where dH is the difference between the true elevation of the surface and the elevation specified in the DEM (targets higher than their DEM elevations are shifted towards the sensor ground track and vice versa).

For moving objects, there is an additional location error that depends on the speed and direction of the object, which is not included in the tabled values.

Relative Phase Error

Information on relative phase error is only applicable to products containing data in complex (I and Q) form.

The phase error is the deviation between the measured and predicted relative phases of two point targets within a complex image. The values stated in the table are the maximum (or 3-sigma) relative phase errors within a region equal in size to the nominal image coverage area for the given product. For Quad-Polarization products, values are also given for the inter-channel phase error.

2.2 Slant Range Products

2.2.1 SLC Product (Single Look Complex)

In SLC products, each image pixel is represented by a complex (real I and imaginary Q) magnitude value. No interpolation into ground range coordinates is performed during processing for SLC image products, and so the range coordinate is given in radar slant range rather than ground range, i.e. the range pixel spacing and range resolution are measured along a slant path perpendicular to the track of the sensor. Pixel spacings are determined by the radar range sampling rate and pulse repetition frequency (PRF). The pixel spacing values given in Table 2-1 are typical values, since the PRF varies with beam and altitude. The processing for all SLC products covers a single look in each dimension. For dual or quad polarization SLC products, the images for different polarization channels are co-registered.

The phase of each pixel in a SLC product represents the zero-Doppler phase, nominally defined as:

$$\frac{4\pi R_0 f_c}{c} + \Delta\varphi$$

where R_0 is the slant range of closest approach, f_c is the carrier frequency, c is the speed of light, and $\Delta\varphi$ represents a target-dependent phase change upon reflection. Under this definition, SLC data frequency spectra are nominally centered at zero frequency in the range domain and at the Doppler centroid frequency in the Doppler domain. In Single Beam SLC products, the Doppler centroid frequency nominally varies in range but not in azimuth. In Spotlight SLC products, the Doppler centroid frequency of the SLC data nominally varies in both range and azimuth.

A comparative description of slant range SLC products is provided in Table 2-1.

Table 2-1 SLC Product Description 1/2

	Standard	Fine	Wide Fine	Multi-Look Fine	Wide Multi-Look Fine	Ultra-Fine	Wide Ultra-Fine	Wide	Extended High	Extended Low
Pixel Data Representation	16-bit I and 16-bit Q									
Product Characteristics										
Nominal Image Coverage (ground range x azimuth)	100 km x 100 km	50 km x 50 km	150 km x 150 km	50 km x 50 km	90 km x 50 km	20 km x 20 km	50 km x 50 km	150 km x 150 km	75 km x 75 km	170 km x 170 km
Approximate Pixel Spacing (slant range x azimuth)	8.0 m x 5.1m (S1-2) 11.8 m x 5.1m (S3-8)	4.7 m x 5.1 m	4.7 m x 5.1 m	2.7 m x 2.9 m	2.7 m x 2.9 m	1.3 m x 2.1 m	1.3 m x 2.1 m	11.8 m x 5.1 m	11.8 m x 5.1 m	8.0 m x 5.1 m
Approximate Image Size (pixels x lines)	6000 x 20000	8000 x 10000	24000 x 30000	14000 x 17000	25000 x 17000	9000 x 9500	24000 x 24000	7000 x 30000	5600 x 15000	6200 x 33000
Nominal Product Volume	460 MBytes per polarization	300 MBytes per polarization	2800 Mbytes per polarization	900 MBytes	1600 MBytes	350 MBytes	2200 MBytes	800 MBytes per polarization	320 MBytes	780 MBytes
Processing Parameters										
Number of Range Looks	1	1	1	1	1	1	1	1	1	1
Number of Azimuth Looks	1	1	1	1	1	1	1	1	1	1
Range Look Bandwidth	17.3 MHz (S1-2) 11.6 MHz (S3-8)	30 MHz	30 MHz	50 MHz	50 MHz	100 MHz	100 MHz	11.6 MHz	11.6 MHz	17.3 MHz
Azimuth Look Bandwidth	900 Hz	900 Hz	900 Hz	1500 Hz	1500 Hz	2430 Hz	2430 Hz	900 Hz	900 Hz	900 Hz
Range Spectral Weighting	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)
Azimuth Spectral Weighting	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)
Typical Image Quality Characteristics										
Nominal Slant Range Resolution	9.0 m (S1-2) 13.5 m (S3-8)	5.2 m	5.2 m	3.1 m	3.1 m	1.6 m	1.6 m	13.5 m	13.5 m	9.0 m
Nominal Azimuth Resolution	7.7 m	7.7 m	7.7 m	4.6 m	4.6 m	2.8 m	2.8 m	7.7 m	7.7 m	7.7 m
Equiv. No. of Independent Looks	1	1	1	1	1	1	1	1	1	1
Noise-Equivalent Sigma-Zero	-29±2.5 dB	-26±3.5 dB	-24±2 dB	-20±4 dB	-19±5 dB	-26.5±5 dB	-22±7 dB	-28±2 dB	-28±4 dB	-27±2 dB
Radiometric Error	<1 dB	<1 dB	<1 dB	<1 dB	<1.5 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB
Absolute Location Error	< 20 m	< 15 m	< 15 m	< 15 m	< 15 m	< 15 m	< 15 m	< 20 m	< 20 m	< 30 m
Relative Phase Error	$<3^{o}$	$<3^{o}$	$<3^{o}$	$<3^{o}$	$<3^{o}$	$<3^{o}$	$<3^{o}$	$<3^{o}$	$<3^{o}$	$<3^{o}$

Table 2-2 SLC Product Description 2/2

	Standard Quad Pol.	Wide Standard Quad Pol.	Fine Quad Pol.	Wide Fine Quad Pol.	Spotlight	Extra-Fine (Full Res)	Extra-Fine (Fine Res)	Extra-Fine (Std Res)	Extra-Fine (Wide Res)
Pixel Data Representation	16-bit I and 16-bit Q								
Product Characteristics									
Nominal Image Coverage (ground range x azimuth)	25 km x 25 km	50 km x 25 km	25 km x 25 km	50 km x 25 km	18 km x 8 km	125 km x 125 km	125 km x 125 km	125 km x 125 km	125 km x 125 km
Approximate Pixel Spacing (slant range x azimuth)	8.0 m x 5.1m (near) 11.8 m x 5.1m (far)	8.0mx5.1m (near) 11.8mx5.1m (far)	4.7 m x 5.1 m	4.7 m x 5.1 m	1.3 m x 0.4 m	2.7 x 2.9	4.3 x 5.8	7.1 x 5.8	10.6 x 5.8
Approximate Image Size (pixels x lines)	1500 x 5000	3000 x 5000	3300 x 5000	6600 x 5000	8000 x 20000	27000 x 43000	17000 x 22000	10000 x 22000	7000 x 22000
Nominal Product Volume	30 MBytes per polarization	60 MBytes per polarization	60 MBytes per polarization	130 MBytes per polarization	400 to 1500 MBytes	4600 MBytes	1500 MBytes	900 MBytes	600 MBytes
Processing Parameters									
Number of Range Looks	1	1	1	1	1	1	1	1	1
Number of Azimuth Looks	1	1	1	1	1	1	1	1	1
Range Look Bandwidth	17.3 MHz (near) 11.6 MHz (far)	17.3 MHz (near) 11.6 MHz (far)	30 MHz	30 MHz	100MHz	50 MHz	30 MHz	17.3 MHz	11.6 MHz
Azimuth Look Bandwidth	900 Hz	900 Hz	900 Hz	900 Hz	9400 Hz	1500 Hz	900 Hz	900 Hz	900 Hz
Range Spectral Weighting	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)
Azimuth Spectral Weighting	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (3.5)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)
Typical Image Quality Characteristics									
Nominal Slant Range Resolution	9.0m (SQ1-SQ11) 13.5m (SQ12-SQ31)	9.0m (SQ1W-SQ11W) 13.5m (SQ12W-SQ21W)	5.2 m	5.2 m	1.6 m	3.1 m	5.2 m	8.9 m	13.3 m
Nominal Azimuth Resolution	7.6 m	7.6 m	7.6 m	7.6 m	0.8 m	4.6 m	7.6 m	7.6 m	7.6 m
Equiv. No. of Independent Looks	1	1	1	1	1	1	1	1	1
Noise-Equivalent Sigma-Zero	-38±3 dB	-35±6 dB	-35±4 dB	-33±6 dB	Centre: -28.5 ± 4.5dB Corners: -19.5 ± 3.5dB	-21±2.5 dB	-23±2.5 dB	-23±2.5 dB	-23±2.5 dB
Radiometric Error	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB
Absolute Location Error	< 20 m	< 20 m	< 15 m	< 15 m	< 15 m	< 15 m	< 15 m	< 15 m	< 15 m
Relative Phase Error	$<3^{o}$,5^{o} inter-pol	$<3^{o}$,5^{o} inter-pol	$<3^{o}$,5^{o} inter-pol	$<3^{o}$,$<5^{o}$ inter-pol	$<3^{o}$	$<3^{o}$	$<3^{o}$	$<3^{o}$	$<3^{o}$

2.3 Ground Range Products

In ground range products, the range pixel spacing and range resolution are measured in ground range coordinates, i.e. along an assumed Earth's surface that follows the shape of the ellipsoid at a local elevation height as selected in the Production Order. All ground range products contain magnitude detected pixels represented as unsigned integers.

Single Beam ground range products are available in two forms, which differ principally in the pixel spacing: SGF provides standard pixel spacing and SGX provides the finest sampling. Exceptions are products of the Standard and Fine Quad-Polarization beam modes, which are not available in SGF form.

Spotlight mode ground range products are also available in SGF and SGX forms.

ScanSAR products are available in either SCN form for ScanSAR Narrow Beam Mode, or in SCW form for ScanSAR Wide Beam Mode, as well as in both SCF and SCS forms for all ScanSAR beam modes. SCF and SCS are similar to SCN or SCW (as appropriate for the beam mode), but support additional processing options and metadata fields. Table 2-3 below summarizes the relationship between the ScanSAR beam modes and the ScanSAR product types.

Table 2-3 Overview of ScanSAR Product Types and Beam Modes

Beam Mode: / Product Type:	SCN	SCW	SCF	SCS
ScanSAR Narrow	√		√	√
ScanSAR Wide		√	√	√
Ship Detection (Detection of Vessels)			√	√
Ocean Surveillance			√	√

2.3.1 SGX Product (Path Image Plus)

SGX products have very fine pixel spacing that is chosen to meet the Nyquist criterion in all areas of the image. This ensures that all image information is preserved and makes the imagery suitable for post-processing.

A comparative description of ground range SGX products is provided in Table 2-4.

Table 2-4 SGX Product Description 1/2

	Standard	Fine (F) and Multi-Look Fine (MF)	Wide Fine	Wide Multi-Look Fine	Ultra-Fine	Wide Ultra-Fine	Wide	Extended High	Extended Low
Pixel Data Representation	16-bit unsigned integer (magnitude detected)								
Product Characteristics									
Nominal Image Coverage (ground range x azimuth)	100 km x 100 km	50 km x 50 km	150 km x 150 km	90 km x 50 km	20 km x 20 km	50 km x 50 km	150 km x 150 km	75 km x 75 km	170 km x 170 km
Pixel Spacing (ground range x azimuth)	8 m x 8 m	3.125 m x 3.125 m	3.125 m x 3.125 m	3.125 m x 3.125 m	1.0 m x 1.0 m or 0.8 m x 0.8 m[1]	1.0 m x 1.0 m	10 m x 10 m	8 m x 8 m	10 m x 10 m
Nominal Image Size (pixels x lines)	12500 x 12500	16000 x 16000	48000 x 48000	28800 x 16000	20000 x 20000	50000 x 50000	15000 x 15000	9400 x 9400	17000 x 17000
Nominal Product Volume	300 MBytes per polarization	500 Mbytes per polarization	4400 Mbytes per polarization	900 Mbytes	800 Mbytes	4700 Mbytes	430 Mbytes per polarization	200 MBytes	550 MBytes
Processing Parameters									
Number of Range Looks	1	1 (F), 2 @ 33% overlap (MF)	1	2 @ 33% overlap	1	1	1	1	1
Number of Azimuth Looks	4 with 39% overlap	1 (F), 2 @ 33% overlap (MF)	1	2 @ 33% overlap	1	1	4 with 39% overlap	4 with 39% overlap	4 with 39% overlap
Range Look Bandwidth	17.3 MHz (S1-2) 11.6 MHz (S3-8)	30 MHz	30 MHz	30 MHz	100 MHz	100 MHz	11.6 MHz	11.6 MHz	17.3 MHz
Azimuth Look Bandwidth	293 Hz	900 Hz	900 Hz	900 Hz	2430 Hz	2430 Hz	293 Hz	293 Hz	293 Hz
Range Spectral Weighting	Kaiser (2.8)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.8)	Kaiser (2.8)	Kaiser (2.8)
Azimuth Spectral Weighting	Kaiser (2.9)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.9)	Kaiser (2.9)	Kaiser (2.9)
Typical Image Quality Characteristics									
Nominal Range Resolution	See Appendix A								
Nominal Azimuth Resolution	24.7 m	7.7 m (F) 7.6 m (MF)	7.7 m	7.6 m	2.8 m	2.8 m	24.7 m	24.7 m	24.7 m
Noise-Equivalent Sigma-Zero	-29±2.5 dB	-26±3.5 dB (F) -20±4 dB (MF)	-24±2 dB	-19±5 dB	-26.5±5 dB	-22±7 dB	-28±2 dB	-28±4 dB	-27±2 dB
Radiometric Error	<1 dB	<1 dB	<1 dB	<1.5 dB	<1 dB	< 1 dB	<1 dB	<1 dB	<1 dB
Equiv. No. of Independent Looks	3.4	1 (F), 3.4 (MF)	1	3.4	1	1	3.4	3.4	3.4
Absolute Location Error	< 20 m	< 15 m	< 15 m	< 15 m	< 15 m	< 15 m	< 20 m	< 20 m	< 30 m

[1] 1.0 m x 1.0 m for incidence angles less than or equal to 48 degrees. 0.8 m x 0.8 m for incidence angles greater than 48 degrees.

Table 2-5 SGX Product Description 2/2

	Standard Quad-Pol	Wide Standard Quad-Pol	Fine Quad-Pol	Wide Fine Quad-Pol	Spotlight	Extra-Fine (1 look)	Extra-Fine (4 looks)	Extra-Fine (28 looks)
Pixel Data Representation	16-bit unsigned integer (magnitude detected)							
Product Characteristics								
Nominal Image Coverage (ground range x azimuth)	25 km x 25 km	50 km x 25 km	25 km x 25 km	50 km x 25 km	18 km x 8 km	125 km x 125 km	125 km x 125 km	125 km x 125 km
Pixel Spacing (ground range x azimuth)	8 m x 3.125 m	8 m x 3.125 m	3.125 m x 3.125 m	3.125 m x 3.125 m	1.0 or 0.8 m[2] x 1/3 m	2 m x 2 m	3.125 m x 3.125 m	5 m x 5 m
Nominal Image Size (pixels x lines)	3130 x 8000	6250 x 8000	8000 x 8000	16000 x 8000	18000 x 25000	60000 x 60000	40000 x 40000	25000 x 25000
Nominal Product Volume	50 MBytes per polarization	100 Mbytes per polarization	120 MBytes per polarization	240 MBytes per polarization	900 to 1600 MBytes	8000 Mbytes	3200 Mbytes	1200 MBytes
Processing Parameters								
Number of Range Looks	1	1	1	1	1	1	2 with 33% overlap	4 with 37% overlap
Number of Azimuth Looks	1	1	1	1	1	1	2 with 33% overlap	7 with 39% overlap
Range Look Bandwidth	17.3MHz (near) 11.6 MHz (far)	17.3MHz (near) 11.6 MHz (far)	30 MHz	30 MHz	100 MHz	50 MHz	30 MHz	17.3 MHz
Azimuth Look Bandwidth	900 Hz	900 Hz	900 Hz	900 Hz	9400 Hz	1500 Hz	900 Hz	293 Hz
Range Spectral Weighting	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)
Azimuth Spectral Weighting	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (3.5)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)
Typical Image Quality Characteristics								
Nominal Range Resolution	See Appendix A							
Nominal Azimuth Resolution	7.6 m	7.6 m	7.6 m	7.6 m	0.8 m	4.6 m	7.6 m	23.5 m
Noise-Equivalent Sigma-Zero	-38±3 dB	-35±6 dB	-35±4 dB	-33±6 dB	Centre: -28.5 ± 4.5dB Corners: -19.5 ± 3.5dB	-21±2.5 dB	-21±2.5 dB	-21±2.5 dB
Radiometric Error	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB
Equiv. No. of Independent Looks	1	1	1	1	1	1	3.4	20
Absolute Location Error	< 20 m	< 20 m	< 15 m	< 15 m	< 15 m	< 15 m	< 15 m	< 15 m

[2] Range pixel spacing is 1.0 m for incidence angles less than or equal to 48 degrees and 0.8 m for incidence angles greater than 48 degrees.

2.3.2 SGF Product (Path Image)

For modes for which both SGX and SGF products are available, the SGF images are the same as the SGX products in all respects except for the pixel spacings. The SGF product is generated with standard ground coordinate pixel dimensions which are in general larger than those of the corresponding SGX products. The image scene coverage for SGF products is the same as for the SGX products, but the product volumes are in general significantly smaller. Because the SGF pixel spacing does not meet the Nyquist criterion in all areas of the image, a small amount of the information content is not retained. The SGF products are therefore appropriate for applications where the reduction in product volume is important, and where the full precision is not needed. No SGF products are offered for the Quad-Polarization modes.

Spotlight mode is a special case. Spotlight SGX products have asymmetric pixel spacing because the Nyquist spacing is much finer in the azimuth direction than in the range direction. Spotlight SGF products, on the other hand, are resampled to a square pixel spacing for greater ease of use in certain applications. The SGF products do not meet the Nyquist criterion in the azimuth direction but are significantly oversampled relative to the Nyquist criterion in the range direction, which makes them larger in volume than their SGX counterparts.

A comparative description of Single Beam and Spotlight ground range SGF products is provided in Table 2-6.

Table 2-6 Single Beam and Spotlight SGF Product Description 1/2

	Standard	Fine (F) and Multi-Look Fine (MF)	Wide Fine	Wide Multi-Look Fine	Ultra-Fine	Wide Ultra-Fine	Wide	Extended High	Extended Low	Spotlight
Pixel Data Representation	16-bit unsigned integer (magnitude detected)									
Product Characteristics										
Nominal Image Coverage (range x az)	100 km x 100 km	50 km x 50 km	150 km x 150 km	90 km x 50 km	20 km x 20 km	50 km x 50 km	150 km x 150 km	75 km x 75 km	170 km x 170 km	18 km x 8 km
Pixel Spacing (range x azimuth)	12.5 m x12.5 m	6.25 m x 6.25 m	6.25 m x 6.25 m	6.25 m x 6.25 m	1.5625 m x 1.5625 m	1.5625 m x 1.5625 m	12.5 m x 12.5 m	12.5 m x 12.5 m	12.5 m x 12.5 m	0.5 m x 0.5 m
Nominal Image Size (pixels x lines)	8000 x 8000	8000 x 8000	24000 x 24000	14400 x 8000	13000 x 13000	32500 x 32500	12000 x 12000	6000 x 6000	13600 x 13600	36000 x 16000
Nominal Product Vol.	120 MBytes per polarization	120 MBytes per polarization	1100 Mbytes per polarization	220 Mbytes	340 MBytes	1540 Mbytes	270 MBytes per polarization	70 MBytes	350 MBytes	1300 to 1900 Mbytes
Processing Parameters										
Number of Range Looks	1	1 (F), 2 @ 33% overlap (MF)	1	2 @ 33% overlap	1	1	1	1	1	1
Number of Azimuth Looks	4 with 39% overlap	1 (F), 2 @ 33% overlap (MF)	1	2 @ 33% overlap	1	1	4 with 39% overlap	4 with 39% overlap	4 with 39% overlap	1
Range Look Bandwidth	17.3 MHz (S1-2) 11.6 MHz (S3-8)	30 MHz	30 MHz	30 MHz	100 MHz	100 MHz	11.6 MHz	11.6 MHz	17.3 MHz	100 MHz
Az. Look Bandwidth	293 Hz	900 Hz	900 Hz	900 Hz	2430 Hz	2430 Hz	293 Hz	293 Hz	293 Hz	9400 Hz
Range Spectral Weighting	Kaiser (2.8)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.8)	Kaiser (2.8)	Kaiser (2.8)	Kaiser (2.4)
Azimuth Spectral Weighting	Kaiser (2.9)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.9)	Kaiser (2.9)	Kaiser (2.9)	Kaiser (3.5)
Typical Image Quality Characteristics										
Nominal Range Resolution	See Appendix A									
Nominal Azimuth Resolution	24.7 m	7.7 m (F) 7.6 m (MF)	7.7 m	7.6 m	2.8 m	2.8 m	24.7 m	24.7 m	24.7 m	0.8 m
Noise-Equivalent Sigma-Zero	-29±2.5 dB	-26±3.5 dB (F) -20±4 dB (MF)	-24±2 dB	-19±5 dB	-26.5±5 dB	-22±7 dB	-28±2 dB	-28±4 dB	-27±2 dB	Centre: -26.5 ± 4.5dB Corners: -19.5 ± 3.5dB
Radiometric Error	<1 dB	<1 dB	<1 dB	<1.5 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB
Equiv. No. of Independent Looks	3.4	1 (F), 3.4 (MF)	1	3.4	1	1	3.4	3.4	3.4	1
Absolute Location Error	< 20 m	< 15 m	< 15m	< 15m	< 15 m	< 15m	< 20 m	< 20 m	< 30 m	< 15 m

Table 2-7 Single Beam and Spotlight SGF Product Description 2/2

	Extra-Fine (1 look)	Extra-Fine (4 looks)	Extra-Fine (28 looks)
Pixel Data Representation	16-bit unsigned integer (magnitude detected)		
Product Characteristics			
Nominal Image Coverage (range x az)	125 km x 125 km	125 km x 125 km	125 km x 125 km
Pixel Spacing (range x azimuth)	3.125 m x 3.125 m	6.25 m x 6.25 m	8 m x 8 m
Nominal Image Size (pixels x lines)	40000 x 40000	20000 x 20000	16000 x 16000
Nominal Product Volume	3200 Mbytes	800 Mbytes	500 MBytes
Processing Parameters			
Number of Range Looks	1	2 with 33% overlap	4 with 37% overlap
Number of Azimuth Looks	1	2 with 33% overlap	7 with 39% overlap
Range Look Bandwidth	50 MHz	30 MHz	17.3 MHz
Az. Look Bandwidth	1500 Hz	900 Hz	293 Hz
Range Spectral Weighting	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)
Azimuth Spectral Weighting	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)
Typical Image Quality Characteristics			
Nominal Range Resolution	See Appendix A		
Nominal Azimuth Resolution	4.6 m	7.6 m	23.5 m
Noise-Equivalent Sigma-Zero	-21±2.5 dB	-21±2.5 dB	-21±2.5 dB
Radiometric Error	<1 dB	<1 dB	<1 dB
Equiv. No. of Independent Looks	1	3.4	20
Absolute Location Error	< 15m	< 15m	< 15m

2.3.3 SCN Product (ScanSAR Narrow)

The SCN product type is a conceptual ground range coordinate multi-look image product type that (for historical reasons) is used to refer to SGF products produced from data obtained in the ScanSAR Narrow Beam Mode, using either two or three physical beams. Image pixels are 25 m square and scenes are nominally 300 km in each dimension. In general, the pixel spacing does not meet the Nyquist sampling criterion, like in Single Beam and Spotlight mode SGF products. SCN products are generated using two looks in range and two looks in azimuth for a total of four looks.

A description of SCN products is provided in Table 2-8. Beam mode applicable characteristics are included in Table 2-9.

2.3.4 SCW Product (ScanSAR Wide)

The SCW product type is a ground range coordinate multi-look image product type that (for historical reasons) is used to refer to SGF products produced from data obtained in ScanSAR Wide Beam Mode using four physical beams. Image pixels are 50 m square and scenes are nominally 500 km in each dimension. In general, the pixel spacing does not meet the Nyquist sampling criterion, like in Single Beam and Spotlight mode SGF products. SCW products are generated using four looks in range and two looks in azimuth for a total of eight looks.

A description of SCW products is provided in Table 2-8. Beam mode applicable characteristics are included in Table 2-10.

2.3.5 SCF and SCS Products (ScanSAR Fine, ScanSAR Sampled)

2.3.5.1 Standard ScanSAR Beam Modes

For the standard ScanSAR beam modes (ScanSAR Narrow and ScanSAR Wide), SCF and SCS are similar to SCN or SCW (as appropriate for the beam mode), except that they support additional processing options and metadata fields (while SCN and SCW products provide backwards compatibility with existing processes and applications).

Currently, the only additional processing option available is noise subtraction, whose objective is to reduce image artifacts caused by variations in the system noise floor in the ScanSAR modes. Noise subtraction is described in Appendix B.

For the ScanSAR Narrow beam mode, the key product characteristics of SCF and SCS products are defined to be the same as for SCN products, as shown in Table 2-8 and Table 2-9.

Similarly, for the ScanSAR Wide beam mode, the key product characteristics of SCF and SCS products are defined to be the same as for SCW products, as shown in Table 2-8 and Table 2-10.

The nominal resolutions in both of the standard ScanSAR beam modes are plotted as a function of incidence angle in Figure 2-1.

Table 2-8 Product Description for ScanSAR Narrow and ScanSAR Wide Beam Modes

Beam Mode	**ScanSAR Narrow**	**ScanSAR Wide**
Applicable Product Types	**SCN, SCF, SCS**	**SCW, SCF, SCS**
Pixel Data Representation	selectable 8-bit or 16-bit unsigned integer (magnitude detected)	
Product Characteristics		
Nominal Image Coverage (ground range x azimuth)	300 km x 300 km	500 km x 500 km
Pixel Spacing (ground range x azimuth)	25 m x 25 m	50 m x 50 m
Nominal Image Size (pixels x lines)	12000 x 12000	10000 x 10000
Nominal Product Volume (for 16-bit representation)	270 MBytes per polarization	190 MBytes per polarization
Processing Parameters		
Number of Range Looks	2	4
Number of Azimuth Looks	2	2
Range Look Bandwidth	5.8 MHz	2.9 MHz
Number of Samples per Azimuth Look	See Table 2-9	See Table 2-10
Azimuth Look Bandwidth (Hz)	See Table 2-9	See Table 2-10
Range Spectral Weighting	Kaiser (2.8)	Kaiser (2.8)
Azimuth Spectral Weighting	Kaiser (2.9)	Kaiser (2.9)
Typical Image Quality Characteristics		
Nominal Range Resolution	See Table 2-9	See Table 2-10
Nominal Azimuth Resolution	See Table 2-9	See Table 2-10
Noise-Equivalent Sigma-Zero	-28.5±2.5 dB	-28.5±2.5 dB
Radiometric Error	<1 dB	<1 dB
Equiv. No. of Independent Looks *	> 3	> 6
Absolute Location Error	< 50 m	< 50 m
Relative Phase Error	N/A	

* Varies in azimuth

Table 2-9 ScanSAR Narrow Beam Mode Applicable Characteristics

Beam/Swath Position	SCNA		SCNB		
Physical Beams Used	W1	W2	W2	S5	S6
Nominal Incidence Angles (°)	20-31	31-39	31-38	38-42	42-46
Nominal Range Resolution (m)	81-54	54-44	55-45	45-42	42-38
Nominal Azimuth Resolution (m)	40-44	45-50	58-64	58-63	65-70
Number of Samples per Azimuth Look	112		85		
Azimuth Look Bandwidth (Hz)	174	153	116	118	105

Table 2-10 ScanSAR Wide Beam Mode Applicable Characteristics

Beam/Swath Position	SCWA				SCWB			
Physical Beams Used	W1	W2	W3	S7	W1	W2	S5	S6
Nominal Incidence Angles (°)	20-31	31-39	39-45	45-49	20-31	31-38	38-42	41-46
Nominal Range Resolution (m)	163-108	108-88	88-79	79-73	163-108	108-91	91-83	83-77
Nominal Azimuth Resolution (m)	78-84	88-96	78-85	99-106	78-84	88-96	89-95	99-106
Number of Samples per Azimuth Look	58				58			
Azimuth Look bandwidth (Hz)	90	79	90	72	90	79	80	72

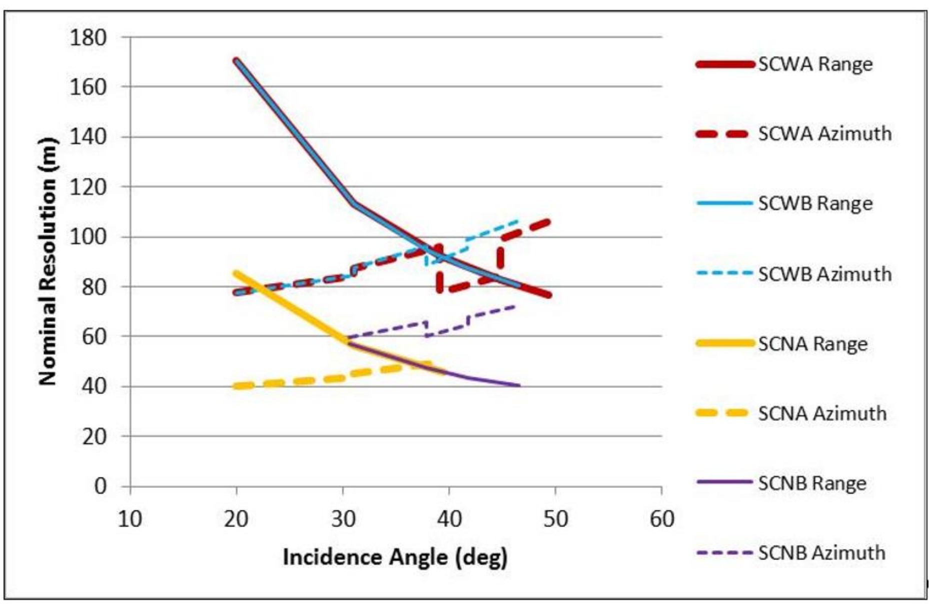


Figure 2-1 Nominal Resolutions in ScanSAR Narrow and ScanSAR Wide Beam Modes

2.3.5.2 MSSR ScanSAR Beam Modes

For the Ocean Surveillance and Ship Detection (Detection of Vessels) ScanSAR beam modes, the SCF and SCS product types are both ground range coordinate multi-look image product types, but they differ in that SCF products are sampled at coarser spacing and are processed with more looks in both range and azimuth directions. The azimuth multi-looking of the SCF product is done by spatial averaging and its effects vary per beam. In general, the pixel spacing does not meet the Nyquist sampling criterion, like in Single Beam and Spotlight mode SGF products.

For the Ship Detection (Detection of Vessels) beam mode, SCS is the recommended product type thanks to its finer resolution, which is of key importance for ship detection. The SCF product is available but is not recommended. The key product characteristics for this beam mode are given in Table 2-11 through Table 2-14.

Table 2-11 Product Description for Ship Detection (Detection of Vessels) Beam Mode

Product Type	**SCF**	**SCS**
Pixel Data Representation	selectable 8-bit or 16-bit unsigned integer (magnitude detected)	
Product Characteristics		
Nominal Image Coverage (ground range x azimuth)	450 km x 500 km	
Pixel Spacing (ground range x azimuth)	40 m x 40 m	20 m x 20 m
Nominal Image Size (pixels x lines)	11000 x 12500	22500 x 25000
Nominal Product Volume (for 16-bit representation)	270 MBytes per polarization	1100 MBytes per polarization
Processing Parameters		
Number of Range Looks	16	5
Number of Azimuth Looks	2 (by spatial averaging)	1
Range Look Bandwidth	2.8 MHz	8.3 MHz
Number of Samples in Azimuth Look	See Table 2-12	
Azimuth Look Bandwidth (Hz)	See Table 2-12	
Range Spectral Weighting	Kaiser (2.4)	Kaiser (2.4)
Azimuth Spectral Weighting	Kaiser (2.4)	Kaiser (2.4)
Typical Image Quality Characteristics		
Nominal Range Resolution	See Table 2-13	See Table 2-14
Nominal Azimuth Resolution	See Table 2-13	See Table 2-14
Noise-Equivalent Sigma-Zero	-25±5 dB	
Radiometric Error	<1.5 dB in HH polarization	
Equiv. No. of Independent Looks	See Table 2-13	4.6
Absolute Location Error	< 50 m	
Relative Phase Error	N/A	

Table 2-12 DVWF Beam Characteristics

Beam Number	1	2	3	4	5	6	7
Near Incidence Angle (deg)	34.9	38.8	42.5	46.2	49.2	51.6	53.5
Far Incidence Angle (deg)	38.8	42.5	46.2	49.2	51.6	53.5	55.8
No. of Samples in Azimuth Look	294	249	163	142	114	117	99
Azimuth Look Bandwidth (Hz) (for SCF products this is before spatial averaging)	368	257	184	135	118	104	94

Table 2-13 DVWF SCF Product Type Applicable Characteristics

Beam Number	1	2	3	4	5	6	7
Range near resolution (m)	103	94	87	81	78	75	73
Range far resolution (m)	94	87	81	78	75	73	71
Azimuth near resolution (m)	40	42	47	57	64	72	78
Azimuth far resolution (m)	41	43	48	60	67	75	81
Equivalent Number of Independent Looks *	27	22	18.7	16.8	16.3	15.9	15.7

* Varies per beam due to the variable effect of spatial averaging. ENIL before spatial averaging is 14.6.

Table 2-14 DVWF SCS Product Type Applicable Characteristics

Beam Number	1	2	3	4	5	6	7
Range near resolution (m)	33	31	28	27	25	24	24
Range far resolution (m)	31	28	27	25	24	24	23
Azimuth near resolution (m)	19	27	37	51	59	68	74
Azimuth far resolution (m)	20	28	40	54	62	70	77

For the Ocean Surveillance beam mode, SCS is the recommended product type thanks to its finer resolution, but has different pixel spacings in the range and azimuth directions. For some applications (other than ship detection), the SCF product may be preferred despite its coarser resolution, thanks to its lower volume, square pixel spacing, and higher equivalent number of looks. The key product characteristics for this beam mode are given in Table 2-15 through Table 2-18.

Table 2-15 Product Description for Ocean Surveillance Beam Mode

Product Type	**SCF**	**SCS**
Pixel Data Representation	selectable 8-bit or 16-bit unsigned integer (magnitude detected)	
Product Characteristics		
Nominal Image Coverage (ground range x azimuth)	500 km x 500 km	
Pixel Spacing (ground range x azimuth)	50 m x 50 m	35 m x 25 m
Nominal Image Size (pixels x lines)	10000 x 10000	15000 x 20000
Nominal Product Volume (for 16-bit representation)	200 MBytes per polarization	600 MBytes per polarization
Processing Parameters		
Number of Range Looks	6	4
Number of Azimuth Looks	2 (by spatial averaging)	1
Range Look Bandwidth	4.1 MHz	5.9 MHz
Number of Samples per Azimuth Look	See Table 2-16	
Azimuth Look Bandwidth (Hz)	See Table 2-16	
Range Spectral Weighting	Kaiser (2.4)	Kaiser (2.4)
Azimuth Spectral Weighting	Kaiser (2.4)	Kaiser (2.4)
Typical Image Quality Characteristics		
Nominal Range Resolution	See Table 2-17	See Table 2-18
Nominal Azimuth Resolution	See Table 2-17	See Table 2-18
Noise-Equivalent Sigma-Zero	-29±5 dB	
Radiometric Error	<1.5 dB	
Equiv. No. of Independent Looks	See Table 2-17	3.7
Absolute Location Error	< 50 m	
Relative Phase Error	N/A	

Table 2-16 OSVN Beam Characteristics

Beam Number	1	2	3	4	5	6	7	8
Near Incidence Angle (deg)	20.0	26.1	31.2	35.8	39.5	42.5	45.2	47.7
Far Incidence Angle (deg)	26.1	31.2	35.8	39.5	42.5	45.2	47.7	50.0
No. of Samples in Azimuth Look	230	154	126	119	115	114	90	90
Azimuth Look Bandwidth (Hz) (for SCF products this is before spatial averaging)	261	158	130	111	110	99	80	73

Table 2-17 OSVN SCF Product Type Applicable Characteristics

Beam Number	1	2	3	4	5	6	7	8
Range near resolution (m)	118	92	78	69	64	60	57	55
Range far resolution (m)	92	78	69	64	60	57	55	53
Azimuth near resolution (m)	53	56	63	70	71	77	93	101
Azimuth far resolution (m)	53	57	65	72	74	80	97	104
Equivalent Number of Independent Looks *	9.7	7.3	6.7	6.4	6.4	6.2	6.0	5.9

* Varies per beam due to the variable effect of spatial averaging. ENIL before spatial averaging is 4.6.

Table 2-18 OSVN SCS Product Type Applicable Characteristics

Beam Number	1	2	3	4	5	6	7	8
Range near resolution (m)	80	62	53	47	43	40	38	37
Range far resolution (m)	62	53	47	43	40	38	37	36
Azimuth near resolution (m)	27	44	53	63	64	70	88	96
Azimuth far resolution (m)	28	46	56	66	67	73	91	99

The nominal resolutions in both of the MSSR ScanSAR beam modes are plotted as a function of incidence angle in Figure 2-2. The SCS product type resolutions are shown in wider lines to emphasize that SCS is the recommended product type.

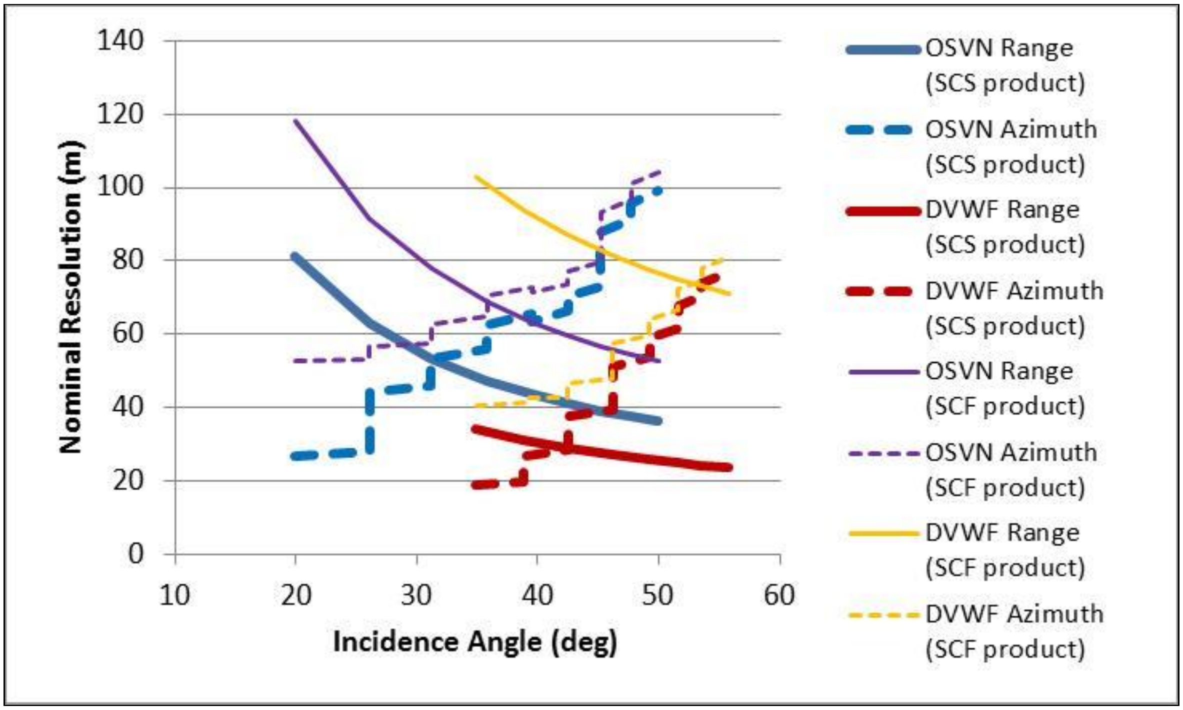


Figure 2-2 Nominal Resolutions in MSSR ScanSAR Beam Modes

2.4 Geocorrected Products

2.4.1 SSG Product (Map Image)

An SSG product is generated by geocorrection of a Single Beam or Spotlight product. The geocorrection process for SSG products does not include the use of any ground control points. Geocorrection with ground control points is included in the generation of SPG products described in Section 2.4.2. The geocorrection may either include ortho-rectification using a DEM, or may be based on a fixed elevation above a reference ellipsoid, as selected by the user. Pixel spacing is the same as for an SGX product for the Quad-Polarization beams, and the same as for an SGF product for all other beams. SSG product dimensions depend on the input data dimensions and orientation, and are chosen so that the full area of the input image is contained after the rotation to the recognised map projection. The portion of the product which is outside the image data area contains blackfill.

A comparative description of SSG products is provided in Table 2-19, for a nominal rotation angle of 10 degrees.

2.4.2 SPG Product (Precision Map Image)

The SPG product bears the same relationship to the input image data as the SSG product described in Section 2.4.1, except that the SPG product is geocorrected using precise ground control points. Pixel spacing is the same as for an SGX product for the Quad-Polarization beams, and the same as for an SGF product for all other beams. SPG product dimensions are chosen so that the full area of the input image is contained after the rotation to the recognised map projection. The portion of the product which is outside the image data area contains blackfill.

A comparative description of geocorrected SPG products is provided in Table 2-20 for a nominal rotation angle of 10 degrees.

Table 2-19 SSG Product Description (1 of 2)

	Standard	Fine (F) and Multi-Look Fine (MF)	Wide Fine	Wide Multi-Look Fine	Ultra-Fine	Wide Ultra-Fine	Wide	Extended High
Pixel Data Representation	Selectable 8-bit or 16-bit unsigned integer (magnitude detected)							
Product Characteristics								
Nominal Image Coverage * (ground range x azimuth)	100 km x 100 km	50 km x 50 km	150 km x 150 km	90 km x 50 km	20 km x 20 km	50 km x 50 km	150 km x 150 km	75 km x 75 km
Pixel Spacing (ground range x azimuth)	12.5 m x12.5 m	6.25 m x 6.25 m	6.25 m x 6.25 m	6.25 m x 6.25 m	1.5625 m x 1.5625 m	1.5625 m x 1.5625 m	12.5 m x 12.5 m	12.5 m x 12.5 m
Nominal Image Size * (pixels x lines)	9300 x 9300	9300 x 9300	28000 x 28000	17000 x 9300	15000 x 15000	37000 x 37000	14000 x 14000	7000 x 7000
Nominal Product Volume *	160 MBytes per polarization	160 MBytes per polarization	1400 Mbytes per polarization	300 Mbytes per polarization	460 MBytes	2900 MBytes per polarization	360 MBytes per polarization	100 MBytes
Processing Parameters								
Number of Range Looks	1	1 (F), 2 @33% overlap (MF)	1	2 @33% overlap	1	1	1	1
Number of Azimuth Looks	4 with 39% overlap	1 (F), 2@ 33% overlap (MF)	1	2 @33% overlap	1	1	4 with 39% overlap	4 with 39% overlap
Range Look Bandwidth	17.3 MHz (S1-2) 11.6 MHz (S3-8)	30 MHz	30 MHz	30 MHz	100 MHz	100 MHz	11.6 MHz	11.6 MHz
Azimuth Look Bandwidth	293 Hz	900 Hz	900 Hz	900 Hz	2430 Hz	2430 Hz	293 Hz	293 Hz
Range Spectral Weighting	Kaiser (2.8)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.8)	Kaiser (2.8)
Azimuth Spectral Weighting	Kaiser (2.9)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.9)	Kaiser (2.9)
Typical Image Quality Characteristics								
Nominal Range Resolution	See Appendix A							
Nominal Azimuth Resolution	24.7 m	7.7 m (F) 7.6 (MF)	7.7 m	7.6 m	2.8 m	2.8 m	24.7 m	24.7 m
Noise-Equivalent Sigma-Zero	-29±2.5 dB	-26±3.5 dB (F) -20±4 dB (MF)	-24±2 dB	-19±5 dB	-26.5±5 dB	-22±7 dB	-28±2 dB	-28±4 dB
Radiometric Error	<1 dB	<1 dB	<1 dB	<1.5 dB	<1 dB	<1 dB	<1 dB	<1 dB
Equiv. No. of Independent Looks	3.4	1 (F), 3.4 (MF)	1	3.4	1	1	3.4	3.4
Absolute Location Error	< 20 m	< 15 m	< 15 m	<15 m	< 15 m	< 15 m	< 25 m	< 20 m

* Image sizes and product volumes given are for a nominal 10-degree rotation and for the 16-bit representation.

Table 2-20 SSG Product Description (2 of 2)

	Extended Low	Standard Quad-Pol	Wide Standard Quad-Pol	Fine Quad-Pol	Wide Fine Quad-Pol	Spotlight	Extra-Fine
Pixel Data Representation	Selectable 8-bit or 16-bit unsigned integer (magnitude detected)						
Product Characteristics							
Nominal Image Coverage * (ground range x azimuth)	170 km x 170 km	25 km x 25 km	50 km x 25 km	25 km x 25 km	50 km x 25 km	18 km x 8 km	125 km x 125 km
Pixel Spacing (ground range x azimuth)	12.5 m x 12.5 m	3.125 m x 3.125 m	3.125 m x 3.125 m	3.125 m x 3.125 m	3.125 m x 3.125 m	0.5 m x 0.5 m	3.125 m x 3.125 m
Nominal Image Size * (pixels x lines)	15800 x 15800	3600 x 9300	7300 x 9300	9300 x 9300	18500 x 9300	60000 x 30000	46000 x 46000
Nominal Product Volume * (Provided as a range for Spotlight)	500 MBytes	60 MB per polarization	120 Mbytes per polarization	160 MB per polarization	320 MBytes per polarization	2000 - 3000 Mbytes	4200 Mbytes
Processing Parameters							
Number of Range Looks	1	1	1	1	1	1	1
Number of Azimuth Looks	4 with 39% overlap	1	1	1	1	1	1
Range Look Bandwidth	17.3 MHz	17.3 MHz (near) 11.6 MHz (far)	17.3MHz (near) 11.6 MHz (far)	30 MHz	30 MHz	100 MHz	50 MHz
Azimuth Look Bandwidth	293 Hz	900 Hz	900 Hz	900 Hz	900 Hz	9400 Hz	1500 Hz
Range Spectral Weighting	Kaiser (2.8)	Kaiser (2.8)	Kaiser (2.8)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)
Azimuth Spectral Weighting	Kaiser (2.9)	Kaiser (2.9)	Kaiser (2.9)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (3.5)	Kaiser (2.4)
Typical Image Quality Characteristics							
Nominal Range Resolution		See Appendix A					
Nominal Azimuth Resolution	24.7 m	7.6 m	7.6 m	7.6 m	7.6 m	0.8 m	4.6 m
Noise-Equivalent Sigma-Zero	-27±2 dB	-38±3 dB	-35±6 dB	-35±4 dB	-33±6 dB	Centre: -28.5 ± 4.5dB Corners: -19.5 ± 3.5dB	-21±2.5 dB
Radiometric Error	< 1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB
Equiv. No. of Independent Looks	3.4	1	1	1	1	1	1
Absolute Location Error	<40 m	< 20 m	< 20 m	< 15 m	< 15 m	< 15 m	< 15 m

*. Image sizes and product volumes given are for a nominal 10-degree rotation and for the 16-bit representation.

Table 2-21 Map Projections Supported for Geocorrected Products

Standard Map Projections
Universal Transverse Mercator
Polar Stereographic
Space Oblique Mercator (A and B)
Additional Map Projections
Albers Conical Equal-Area
Azimuthal Equidistant
Equidistant Conic (A and B)
General Vertical Near-Side Perspective
Gnomonic
Hammer
Interrupted Goode
Interrupt Mollweide
Lambert Azimuthal Equal-Area
Lambert Conformal Conic
Mercator

Miller Cylindrical
Modified Stereographic Conformal (Alaska)
Mollweide
Oblated Equal Area
Oblique Mercator (A and B)
Orthographic
Polyconic
Robinson
Sinusoidal
State Plane Coordinate Systems
Stereographic
Transverse Mercator
Van der Grinten
Wagner IV
Wagner VII

Further projections are available.

Table 2-22 SPG Product Description (1 of 2)

	Standard	Fine (F) and Multi-Look Fine (MF)	Wide Fine	Wide Multi-Look Fine	Ultra-Fine	Wide Ultra-Fine	Wide	Extended High
Pixel Data Representation	Selectable 8-bit or 16-bit unsigned integer (magnitude detected)							
Product Characteristics								
Nominal Image Coverage * (range x azimuth)	100 km x 100 km	50 km x 50 km	150 km x 150 km	90 km x 50 km	20 km x 20 km	50 km x 50 km	150 km x 150 km	75 km x 75 km
Pixel Spacing (ground range x azimuth)	12.5 m x12.5 m	6.25 m x 6.25 m	6.25 m x 6.25 m	6.25 m x 6.25 m	1.5625 m x 1.5625 m	1.5625 m x 1.5625 m	12.5 m x 12.5 m	12.5 m x 12.5 m
Nominal Image Size * (pixels x lines)	9300 x 9300	9300 x 9300	28000 x 28000	17000 x 9300	15000 x 15000	37500 x 37500	14000 x 14000	7000 x 7000
Nominal Product Volume *	160 MBytes per polarization	160 MBytes per polarization	1400 Mbytes per polarization	300 Mbytes per polarization	460 MBytes	2900 MBytes	360 Mbytes per polarization	100 MBytes
Processing Parameters								
Number of Range Looks	1	1 (F), 2 @33% overlap (MF)	1	2 @33% overlap	1	1	1	1
Number of Azimuth Looks	4 with 39% overlap	1 (F), 2@ 33% overlap (MF)	1	2 @33% overlap	1	1	4 with 39% overlap	4 with 39% overlap
Range Look Bandwidth	17.3 MHz (S1-2) 11.6 MHz (S3-8)	30 MHz	30 MHz	30 MHz	100 MHz	100 MHz	11.6 MHz	11.6 MHz
Azimuth Look Bandwidth	293 Hz	900 Hz	900 Hz	900 Hz	2430 Hz	2430 Hz	293 Hz	293 Hz
Range Spectral Weighting	Kaiser (2.8)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.8)	Kaiser (2.8)
Azimuth Spectral Weighting	Kaiser (2.9)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.9)	Kaiser (2.9)
Typical Image Quality Characteristics								
Nominal Range Resolution	See Appendix A.							
Nominal Azimuth Resolution	24.7 m	7.7 m (F) 7.6 (MF)	7.7 m	7.6 m	2.8 m	2.8 m	24.7 m	24.7 m
Noise-Equivalent Sigma-Zero	-29±2.5 dB	-26±3.5 dB (F) -20±4 dB (MF)	-24±2 dB	-19±5 dB	-26.5±5 dB	-22±7 dB	-28±2 dB	-28±4 dB
Radiometric Error	<1 dB	<1 dB	<1 dB	<1.5 dB	<1 dB	<1 dB	<1 dB	<1 dB
Equiv. No. of Independent Looks	3.4	1 (F), 3.4 (MF)	1	3.4	1	1	3.4	3.4
Absolute Location Error	Achieved geolocation accuracy is dependent on the number and accuracy of control points used as well as the quality of the DEM used.							

* Image sizes and product volumes given are for a nominal 10-degree rotation and for the 16-bit representation.

Table 2-23 SPG Product Description (2 of 2)

	Extended Low	Standard Quad-Pol	Wide Standard Quad-Pol	Fine Quad-Pol	Wide Fine Quad-Pol	Spotlight	Extra-Fine
Pixel Data Representation	Selectable 8-bit or 16-bit unsigned integer (magnitude detected)						
Product Characteristics							
Nominal Image Coverage * (ground range x azimuth)	170 km x 170 km	25 km x 25 km	50 km x 25 km	25 km x 25 km	50 km x 25 km	18 km x 8 km	125 km x 125 km
Pixel Spacing (ground range x azimuth)	12.5 m x 12.5 m	3.125 m x 3.125 m	3.125 m x 3.125 m	3.125 m x 3.125 m	3.125 m x 3.125 m	0.5 m x 0.5 m	3.125 m x 3.125 m
Nominal Image Size * (pixels x lines)	15800 x 15800	3600 x 9300	7300 x 9300	9300 x 9300	18500 x 9300	60000 x 30000	46000 x 46000
Nominal Product Volume * (Provided as a range for Spotlight)	500 MBytes	60 MB per polarization	120 Mbytes per polarization	160 MB per polarization	320 MBytes per polarization	2000 - 3000 Mbytes	4200 Mbytes
Processing Parameters							
Number of Range Looks	1	1	1	1	1	1	1
Number of Azimuth Looks	4 with 39% overlap	1	1	1	1	1	1
Range Look Bandwidth	17.3 MHz	17.3 MHz (near) 11.6 MHz (far)	17.3MHz (near) 11.6 MHz (far)	30 MHz	30 MHz	100 MHz	50 MHz
Azimuth Look Bandwidth	293 Hz	900 Hz	900 Hz	900 Hz	900 Hz	9400 Hz	1500 Hz
Range Spectral Weighting	Kaiser (2.8)	Kaiser (2.8)	Kaiser (2.8)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)
Azimuth Spectral Weighting	Kaiser (2.9)	Kaiser (2.9)	Kaiser (2.9)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (3.5)	Kaiser (2.4)
Typical Image Quality Characteristics							
Nominal Range Resolution		See Appendix A					
Nominal Azimuth Resolution	24.7 m	7.6 m	7.6 m	7.6 m	7.6 m	0.8 m	4.6 m
Noise-Equivalent Sigma-Zero	-27±2 dB	-38±3 dB	-35±6 dB	-35±4 dB	-33±6 dB	Centre: -28.5 ± 4.5dB Corners: -19.5 ± 3.5dB	-21±2.5 dB
Radiometric Error	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB
Equiv. No. of Independent Looks	3.4	1	1	1	1	1	1
Absolute Location Error	Achieved geolocation accuracy is dependent on the number and accuracy of control points used as well as the quality of the DEM used.						

* Image sizes and product volumes given are for a nominal 10-degree rotation and for the 16-bit representation.

A NOMINAL INCIDENCE ANGLES AND GROUND RANGE PRODUCT RESOLUTIONS PER BEAM MODE AND POSITION

A.1 Single Beam Modes

Table A-1 Standard, Wide, Extended Low, Extended High, Fine, Wide Fine Swaths

Beam/ Swath Position	Near Incidence Angle (degs)	Far Incidence Angle (degs)	Nominal Near Range Resolution (m)	Nominal Far Range Resolution (m)		Beam/ Swath Position	Near Incidence Angle (degs)	Far Incidence Angle (degs)	Nominal Near Range Resolution (m)	Nominal Far Range Resolution (m)
S1	20.0	27.2	26.8	20.0		F23	30.0	33.4	10.4	9.4
S2	24.0	31.3	22.6	17.6		F23F	30.8	34.2	10.2	9.3
S3	30.4	37.0	27.0	22.7		F22N	31.6	34.9	9.9	9.1
S4	33.5	39.7	24.8	21.4		F22	32.4	35.7	9.7	8.9
S5	36.3	42.2	23.1	20.3		F22F	33.1	36.4	9.5	8.8
S6	41.2	46.5	20.7	18.8		F21N	33.9	37.1	9.3	8.6
S7	44.4	49.3	19.5	18.0		F21	34.7	37.8	9.1	8.5
S8	48.5	52.1	18.2	17.3		F21F	35.4	38.5	9.0	8.3
						F1N	36.1	39.2	8.8	8.2
W1	20.4	31.9	40.0	25.9		F1	36.9	39.9	8.7	8.1
W2	30.6	39.5	26.9	21.5		F1F	37.7	40.6	8.5	8.0
W3	38.7	45.3	21.9	19.2		F2N	38.5	41.4	8.4	7.9
						F2	39.3	42.1	8.2	7.8
F0W1	20.4	31.9	14.9	9.9		F2F	40.0	42.8	8.1	7.7
F0W2	30.6	39.5	10.2	8.2		F3N	40.7	43.5	8.0	7.6
F0W3	38.7	45.3	8.3	7.3		F3	41.4	44.1	7.9	7.5
						F3F	42.0	44.7	7.8	7.4
EL1	10.0	23.1	52.7	23.3		F4N	42.7	45.3	7.7	7.3
						F4	43.3	45.9	7.6	7.2
EH1	48.5	52.1	18.2	17.3		F4F	43.9	46.5	7.5	7.2
EH2	50.0	53.4	17.8	17.0		F5N	44.5	47.1	7.4	7.1
EH3	51.6	54.9	17.4	16.7		F5	45.2	47.7	7.3	7.0
EH4	54.4	57.0	16.8	16.3		F5F	45.7	48.2	7.3	7.0
EH5	55.5	58.1	16.6	16.1		F6N	46.3	48.7	7.2	6.9
EH6	56.8	59.3	16.3	15.9		F6	46.9	49.3	7.1	6.9
						F6F	47.5	49.9	7.1	6.8

Table A-2 Multi-Look Fine, Wide Multi-Look Fine Swaths

Beam/Swath Position	Near Incidence Angle (degs)	Far Incidence Angle (degs)	Nominal Near Range Resolution (m)	Nominal Far Range Resolution (m)		Beam/Swath Position	Near Incidence Angle (degs)	Far Incidence Angle (degs)	Nominal Near Range Resolution (m)	Nominal Far Range Resolution (m)
MF23	30.0	33.4	10.4	9.4		MF23W	28.9	34.5	10.8	9.2
MF23F	30.8	34.2	10.2	9.3		MF22W	31.3	36.6	10.0	8.7
MF22N	31.6	34.9	9.9	9.1		MF21W	33.6	38.7	9.4	8.3
MF22	32.4	35.7	9.7	8.9		MF1W	35.9	40.8	8.9	8.0
MF22F	33.1	36.4	9.5	8.8		MF2W	38.3	43.0	8.4	7.6
MF21N	33.9	37.1	9.3	8.6		MF3W	40.4	44.9	8.0	7.4
MF21	34.7	37.8	9.1	8.5		MF4W	42.4	46.7	7.7	7.1
MF21F	35.4	38.5	9.0	8.3		MF5W	44.3	48.4	7.4	7.0
MF1N	36.2	39.2	8.8	8.2		MF6W	46.1	50.0	7.2	6.8
MF1	36.9	39.9	8.7	8.1						
MF1F	37.7	40.6	8.5	8.0						
MF2N	38.5	41.4	8.4	7.9						
MF2	39.3	42.1	8.2	7.8						
MF2F	40.0	42.8	8.1	7.7						
MF3N	40.7	43.5	8.0	7.6						
MF3	41.4	44.1	7.9	7.5						
MF3F	42.0	44.7	7.8	7.4						
MF4N	42.7	45.3	7.7	7.3						
MF4	43.3	45.9	7.6	7.2						
MF4F	43.9	46.5	7.5	7.2						
MF5N	44.6	47.1	7.4	7.1						
MF5	45.2	47.7	7.3	7.0						
MF5F	45.7	48.2	7.3	7.0						
MF6N	46.3	48.7	7.2	6.9						
MF6	46.9	49.3	7.1	6.9						
MF6F	47.5	49.9	7.1	6.8						

Table A-3 Extra-Fine Swaths

Beam/Swath Position	Near Incidence Angle (degs)	Far Incidence Angle (degs)	Nominal Near Range Resolution of Single-Look Products (m)	Nominal Far Range Resolution of Single-Look Products (m)	Nominal Near Range Resolution of 4-Look Products (m)	Nominal Far Range Resolution of 4-Look Products (m)	Nominal Near Range Resolution of 28-Look Products (m)	Nominal Far Range Resolution of 28-Look Products (m)
XF0W1	21.8	32.4	8.4	5.8	14.0	9.7	24.3	16.9
XF0W2	31.6	38.7	6.0	5.0	9.9	8.3	17.2	14.4
XF0W3	38.1	44.2	5.1	4.5	8.4	7.5	14.6	12.9
XF0S7	44.0	48.8	4.5	4.1	7.5	6.9	13.0	12.0

Table A-4 Ultra-Fine, Wide Ultra-Fine Swaths

Beam/Swath Position	Near Incidence Angle (degs)	Far Incidence Angle (degs)	Nominal Near Range Resolution (m)	Nominal Far Range Resolution (m)		Beam/Swath Position	Near Incidence Angle (degs)	Far Incidence Angle (degs)	Nominal Near Range Resolution (m)	Nominal Far Range Resolution (m)
U70	19.9	21.5	4.6	4.3						
U71	20.9	22.5	4.4	4.1						
U72	22.0	23.5	4.2	4.0						
U73	23.0	24.5	4.0	3.8						
U74	24.0	25.5	3.9	3.7						
U75	25.0	26.5	3.7	3.5						
U76	26.0	27.5	3.6	3.4						
U77	26.9	28.4	3.5	3.3						
U78	27.9	29.3	3.4	3.2						
U79	28.8	30.3	3.3	3.1						
U1	29.8	31.2	3.2	3.0		U1W2	28.6	32.2	3.3	3.0
U2	30.6	32.0	3.1	3.0		U2W2	29.6	33.0	3.2	2.9
U3	31.5	32.9	3.0	2.9		U3W2	30.4	33.8	3.1	2.8
U4	32.3	33.7	2.9	2.8		U4W2	31.4	34.6	3.0	2.8
U5	33.2	34.5	2.9	2.8		U5W2	32.2	35.3	3.0	2.7
U6	34.0	35.3	2.8	2.7		U6W2	33.1	36.1	2.9	2.7
U7	34.8	36.1	2.8	2.7		U7W2	33.9	36.9	2.8	2.6
U8	35.6	36.9	2.7	2.6		U8W2	34.8	37.6	2.8	2.6
U9	36.4	37.6	2.7	2.6		U9W2	35.6	38.4	2.7	2.5
U10	37.2	38.4	2.6	2.5		U10W2	36.2	39.2	2.7	2.5
U11	37.9	39.1	2.6	2.5		U11W2	37.3	39.7	2.6	2.5
U12	38.7	39.9	2.5	2.5		U12W2	38.1	40.4	2.6	2.4
U13	39.4	40.6	2.5	2.4		U13W2	38.7	41.2	2.5	2.4
U14	40.1	41.3	2.4	2.4		U14W2	39.4	41.9	2.5	2.4
U15	40.8	42.0	2.4	2.4		U15W2	40.3	42.5	2.4	2.3
U16	41.5	42.7	2.4	2.3		U16W2	41.0	43.1	2.4	2.3
U17	42.2	43.3	2.3	2.3		U17W2	41.7	43.8	2.4	2.3

Beam/Swath Position	Near Incidence Angle (degs)	Far Incidence Angle (degs)	Nominal Near Range Resolution (m)	Nominal Far Range Resolution (m)		Beam/Swath Position	Near Incidence Angle (degs)	Far Incidence Angle (degs)	Nominal Near Range Resolution (m)	Nominal Far Range Resolution (m)
U18	42.9	44.0	2.3	2.3		U18W2	42.4	44.5	2.3	2.2
U19	43.6	44.6	2.3	2.2		U19W2	43.0	45.2	2.3	2.2
U20	44.2	45.3	2.3	2.2		U20W2	43.8	45.6	2.3	2.2
U21	44.9	45.9	2.2	2.2		U21W2	44.5	46.3	2.3	2.2
U22	45.5	46.5	2.2	2.2		U22W2	45.1	46.9	2.2	2.2
U23	46.1	47.1	2.2	2.2		U23W2	45.7	47.5	2.2	2.1
U24	46.8	47.7	2.2	2.1		U24W2	46.3	48.2	2.2	2.1
U25	47.4	48.3	2.1	2.1		U25W2	46.9	48.8	2.2	2.1
U26	47.9	48.9	2.1	2.1		U26W2	47.6	49.3	2.1	2.1
U27	48.5	49.5	2.1	2.1		U27W2	48.2	49.8	2.1	2.1
U28*	49.1	50.0	2.1	2.1						
U29*	49.7	50.6	2.1	2.0						
U30*	50.2	51.1	2.0	2.0						
U31*	50.8	51.7	2.0	2.0						
U32*	51.3	52.2	2.0	2.0						
U33*	51.8	52.7	2.0	1.98						
U34*	52.4	53.2	1.99	1.97						
U35*	52.9	53.7	1.98	1.96						
U36*	53.4	54.2	1.97	1.94						

* Not yet available commercially

Table A-5 Standard Quad, Fine Quad Swaths

Beam/ Swath Position	Near Incidence Angle (degs)	Far Incidence Angle (degs)	Nominal Near Range Resolution (m)	Nominal Far Range Resolution (m)		Beam/ Swath Position	Near Incidence Angle (degs)	Far Incidence Angle (degs)	Nominal Near Range Resolution (m)	Nominal Far Range Resolution (m)
SQ1	18.4	20.4	28.6	25.9		FQ1	18.4	20.4	16.5	14.9
SQ2	19.7	21.7	26.8	24.4		FQ2	19.7	21.7	15.4	14.1
SQ3	20.9	22.9	25.3	23.2		FQ3	20.9	22.9	14.6	13.4
SQ4	22.1	24.1	23.9	22.1		FQ4	22.1	24.1	13.8	12.7
SQ5	23.4	25.3	22.8	21.1		FQ5	23.4	25.3	13.1	12.2
SQ6	24.6	26.4	21.7	20.3		FQ6	24.6	26.4	12.5	11.7
SQ7	25.7	27.6	20.8	19.5		FQ7	25.7	27.6	12.0	11.2
SQ8	26.9	28.7	20.0	18.8		FQ8	26.9	28.7	11.5	10.8
SQ9	28.0	29.8	19.2	18.2		FQ9	28.0	29.8	11.1	10.5
SQ10	29.1	30.9	18.5	17.6		FQ10	29.1	30.9	10.7	10.1
SQ11	30.2	32.0	17.9	17.1		FQ11	30.2	32.0	10.3	9.8
SQ12	31.3	33.0	25.9	24.7		FQ12	31.3	33.0	10.0	9.5
SQ13	32.4	34.0	25.2	24.1		FQ13	32.4	34.0	9.7	9.3
SQ14	33.4	35.1	24.5	23.5		FQ14	33.4	35.1	9.4	9.1
SQ15	34.4	36.0	23.8	22.9		FQ15	34.4	36.0	9.2	8.8
SQ16	35.4	37.0	23.2	22.4		FQ16	35.4	37.0	9.0	8.6
SQ17	36.4	38.0	22.7	21.9		FQ17	36.4	38.0	8.8	8.5
SQ18	37.4	38.9	22.2	21.5		FQ18	37.4	38.9	8.6	8.3
SQ19	38.3	39.8	21.7	21.0		FQ19	38.3	39.8	8.4	8.1
SQ20	39.2	40.7	21.3	20.7		FQ20	39.2	40.7	8.2	8.0
SQ21	40.2	41.6	20.9	20.3		FQ21	40.2	41.6	8.1	7.8
SQ22	41.0	42.4	20.5	20.0		FQ22	41.0	42.4	7.9	7.7
SQ23	41.9	43.3	20.2	19.6		FQ23	41.9	43.3	7.8	7.6
SQ24	42.8	44.1	19.8	19.4		FQ24	42.8	44.1	7.7	7.5
SQ25	43.6	44.9	19.5	19.1		FQ25	43.6	44.9	7.5	7.4
SQ26	44.4	45.7	19.2	18.8		FQ26	44.4	45.7	7.4	7.3
SQ27	45.2	46.5	19.0	18.6		FQ27	45.2	46.5	7.3	7.2
SQ28	46.0	47.2	18.7	18.3		FQ28	46.0	47.2	7.2	7.1
SQ29	46.8	48.0	18.5	18.1		FQ29	46.8	48.0	7.1	7.0
SQ30	47.5	48.7	18.3	17.9		FQ30	47.5	48.7	7.1	6.9
SQ31	48.3	49.4	18.1	17.7		FQ31	48.3	49.4	7.0	6.8

Table A-6 Wide Standard Quad, Wide Fine Quad Swaths

Beam/ Swath Position	Near Incidence Angle (degs)	Far Incidence Angle (degs)	Nominal Near Range Resolution (m)	Nominal Far Range Resolution (m)		Beam/ Swath Position	Near Incidence Angle (degs)	Far Incidence Angle (degs)	Nominal Near Range Resolution (m)	Nominal Far Range Resolution (m)
SQ1W	17.5	21.2	30.0	24.9		FQ1W	17.5	21.2	17.3	14.4
SQ2W	19.0	22.7	27.7	23.4		FQ2W	19.0	22.7	16.0	13.5
SQ3W	20.0	23.6	26.3	22.5		FQ3W	20.0	23.6	15.2	13.0
SQ4W	21.3	24.8	24.9	21.5		FQ4W	21.3	24.8	14.3	12.4
SQ5W	22.5	26.0	23.6	20.6		FQ5W	22.5	26.0	13.6	11.9
SQ6W	23.7	27.2	22.4	19.8		FQ6W	23.7	27.2	12.9	11.4
SQ7W	24.9	28.3	21.4	19.0		FQ7W	24.9	28.3	12.3	11.0
SQ8W	26.1	29.4	20.5	18.4		FQ8W	26.1	29.4	11.8	10.6
SQ9W	27.2	30.5	19.7	17.8		FQ9W	27.2	30.5	11.4	10.2
SQ10W	28.4	31.6	19.0	17.2		FQ10W	28.4	31.6	10.9	9.9
SQ11W	29.5	32.6	18.3	16.7		FQ11W	29.5	32.6	10.6	9.6
SQ12W	30.6	33.7	26.5	24.3		FQ12W	30.6	33.7	10.2	9.4
SQ13W	31.7	34.7	25.7	23.7		FQ13W	31.7	34.7	9.9	9.1
SQ14W	32.7	35.7	24.9	23.1		FQ14W	32.7	35.7	9.6	8.9
SQ15W	33.7	36.7	24.3	22.6		FQ15W	33.7	36.7	9.4	8.7
SQ16W	34.8	37.6	23.6	22.1		FQ16W	34.8	37.6	9.1	8.5
SQ17W	35.7	38.6	23.1	21.6		FQ17W	35.7	38.6	8.9	8.3
SQ18W	36.7	39.5	22.5	21.2		FQ18W	36.7	39.5	8.7	8.2
SQ19W	37.7	40.4	22.0	20.8		FQ19W	37.7	40.4	8.5	8.0
SQ20W	38.6	41.3	21.6	20.4		FQ20W	38.6	41.3	8.3	7.9
SQ21W	39.5	42.1	21.2	20.1		FQ21W	39.5	42.1	8.2	7.8

A.2 ScanSAR Modes

Table A-7 ScanSAR Narrow, ScanSAR Wide Swaths

Beam/Swath Position	Physical Beams Used	Near Incidence Angle (degs)	Far Incidence Angle (degs)	Nominal Near Range Resolution of SCS Product (m)	Nominal Far Range Resolution of SCS Product (m)
SCNA	W1 + W2	20.0	39.5	81	44
SCNB	W2 + S5 + S6	30.6	46.5	55	38
SCWA	W1 + W2 + W3 + S7	20.0	49.3	163	73
SCWB	W1 + W2 + S5 + S6	20.0	46.5	163	77
DVWF	7 special purpose beams	34.9	55.8	33	23
OSVN	8 special purpose beams	20.0	50.0	80	36

A.3 Spotlight Mode

Table A-8 Spotlight Swaths

Beam/Swath Position	Near Incidence Angle (degs)	Far Incidence Angle (degs)	Nominal Near Range Resolution (m)	Nominal Far Range Resolution (m)
SLA70	19.9	21.5	4.6	4.3
SLA71	20.9	22.5	4.4	4.1
SLA72	22.0	23.5	4.2	4.0
SLA73	23.0	24.5	4.0	3.8
SLA74	24.0	25.5	3.9	3.7
SLA75	25.0	26.5	3.7	3.5
SLA76	26.0	27.5	3.6	3.4
SLA77	26.9	28.4	3.5	3.3
SLA78	27.9	29.3	3.4	3.2
SLA79	28.8	30.3	3.3	3.1
SLA1	29.8	31.2	3.2	3.0
SLA2	30.6	32.0	3.1	3.0
SLA3	31.5	32.9	3.0	2.9
SLA4	32.3	33.7	2.9	2.8
SLA5	33.2	34.5	2.9	2.8
SLA6	34.0	35.3	2.8	2.7
SLA7	34.8	36.1	2.8	2.7
SLA8	35.6	36.9	2.7	2.6
SLA9	36.4	37.6	2.7	2.6

Beam/Swath Position	Near Incidence Angle (degs)	Far Incidence Angle (degs)	Nominal Near Range Resolution (m)	Nominal Far Range Resolution (m)
SLA10	37.2	38.4	2.6	2.5
SLA11	37.9	39.1	2.6	2.5
SLA12	38.7	39.9	2.5	2.5
SLA13	39.4	40.6	2.5	2.4
SLA14	40.1	41.3	2.4	2.4
SLA15	40.8	42.0	2.4	2.4
SLA16	41.5	42.7	2.4	2.3
SLA17	42.2	43.3	2.3	2.3
SLA18	42.9	44.0	2.3	2.3
SLA19	43.6	44.6	2.3	2.2
SLA20	44.2	45.3	2.3	2.2
SLA21	44.9	45.9	2.2	2.2
SLA22	45.5	46.5	2.2	2.2
SLA23	46.1	47.1	2.2	2.2
SLA24	46.8	47.7	2.2	2.1
SLA25	47.4	48.3	2.1	2.1
SLA26	47.9	48.9	2.1	2.1
SLA27	48.5	49.5	2.1	2.1
SLA28*	49.1	50.0	2.1	2.1
SLA29*	49.7	50.6	2.1	2.0
SLA30*	50.2	51.1	2.0	2.0
SLA31*	50.8	51.7	2.0	2.0
SLA32*	51.3	52.2	2.0	2.0
SLA33*	51.8	52.7	2.0	1.98
SLA34*	52.4	53.2	1.99	1.97
SLA35*	52.9	53.7	1.98	1.96
SLA36*	53.4	54.2	1.97	1.94

* Not yet available commercially

B SCANSAR NOISE SUBTRACTED PRODUCTS

In scenes with low backscatter, the system noise floor may be visible as undulating patterns of brighter and darker areas, which are undesirable for some applications. These artefacts are typically most noticeable in the ScanSAR modes, particularly at the ScanSAR beam or burst boundaries. Accordingly, for ScanSAR SCF and SCS products, a noise subtraction processing option is offered, whose objective is to reduce such artefacts so that they are no longer as evident.

If the noise subtraction processing option is selected when a ScanSAR product is ordered, then during the processing of the product, the expected system noise level will be subtracted from all image pixels. This expected noise level is a local mean noise power value that fluctuates over the image, and is obtained from a model that accounts for the characteristics of the payload, the beam mode, the acquisition, and the ground processing. (Similar methods are used to define the nominal NESZ values that are plotted in Appendix C, and summarized in the product description tables – see also the discussion on Noise Equivalent Sigma Zero in Section 2.1.3 above.)

Since the actual noise level in an individual pixel cannot be known, only the estimated expected noise level can be subtracted. Consequently, some loss of information at signal levels close to the noise floor may occur. Furthermore, because the sensor noise has some distribution, it is possible that the SAR processor computed calibrated value (comprised of both signal and *actual* noise) is below the expected instrument noise level for that pixel, resulting in a negative calibrated value after subtraction. In order to represent such negative values with minimal information loss, after noise subtraction a small constant offset is added to all pixel values before they are output as unsigned integers in the image products.

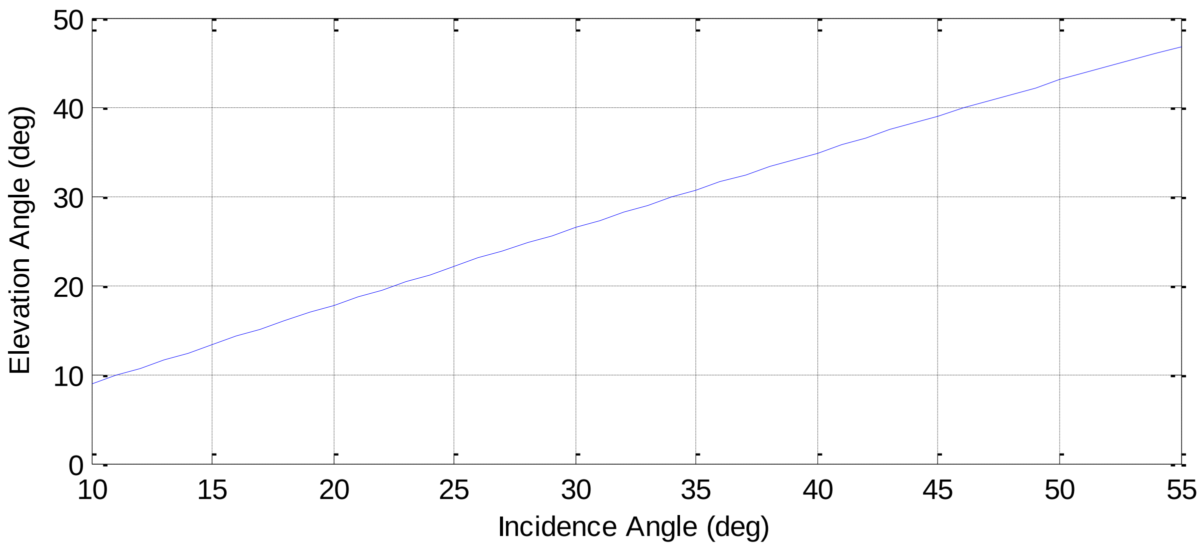
Since the knowledge of the noise level is imperfect, the subtraction will not completely eliminate all visible noise floor artefacts. The severity of the remaining artefacts will depend upon the calibration accuracy, scene content, terrain height variations within the scene, number of azimuth looks and polarization(s) used. The expected sensor noise level is typically known to within 1dB. Similarly, the antenna beam pattern is typically known to better than 1dB.

The noise subtraction processing option is mainly intended as an aid to visual interpretation. Noise subtraction reduces image levels, which can lead to unwanted effects on some user applications such as ship detection for example, and on some radar statistical measures like the equivalent number of independent looks, for example. In general, the benefits of noise subtraction depend on the application.

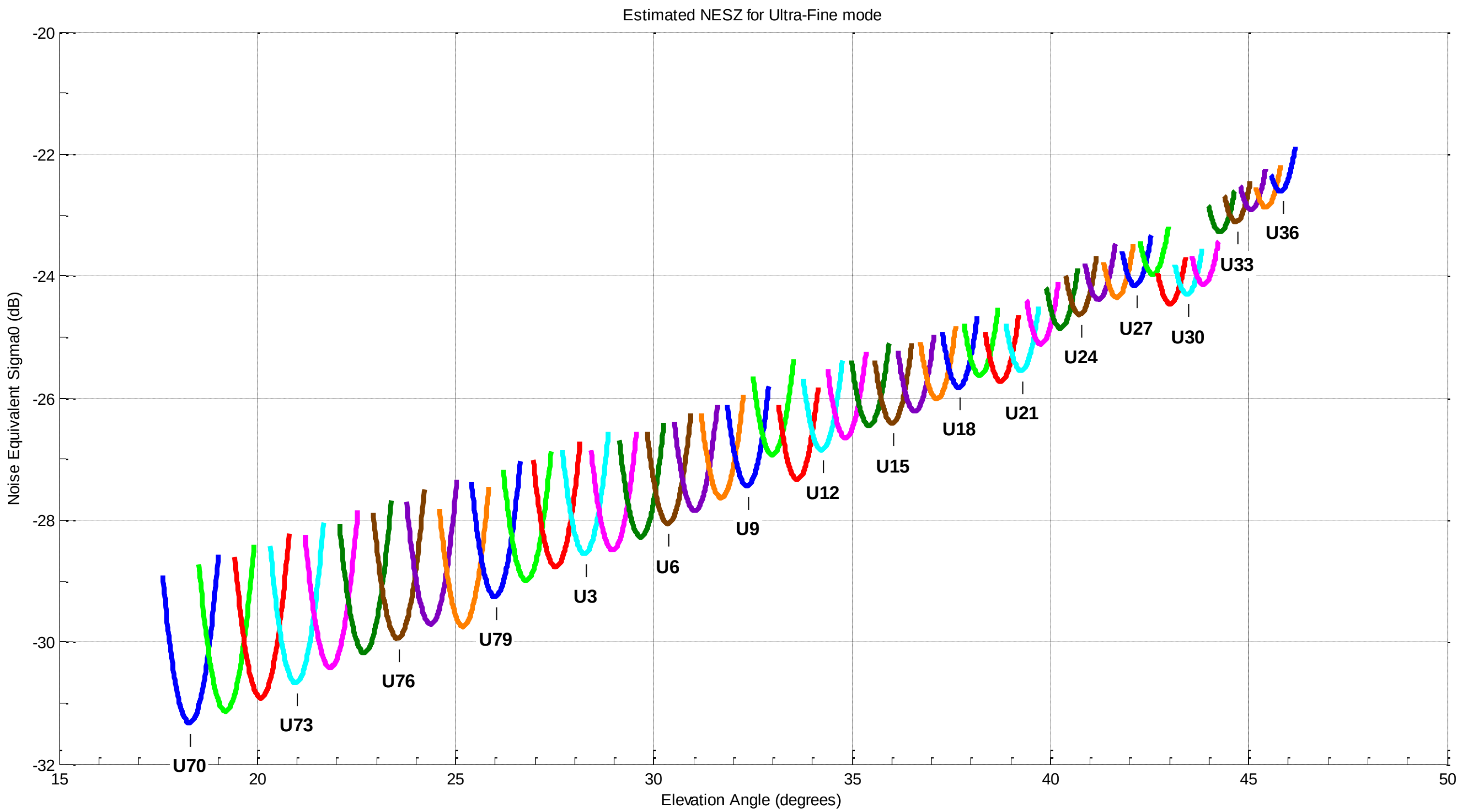
C NOISE-EQUIVALENT SIGMA-ZERO ESTIMATES PER BEAM MODE AND BEAM POSITION

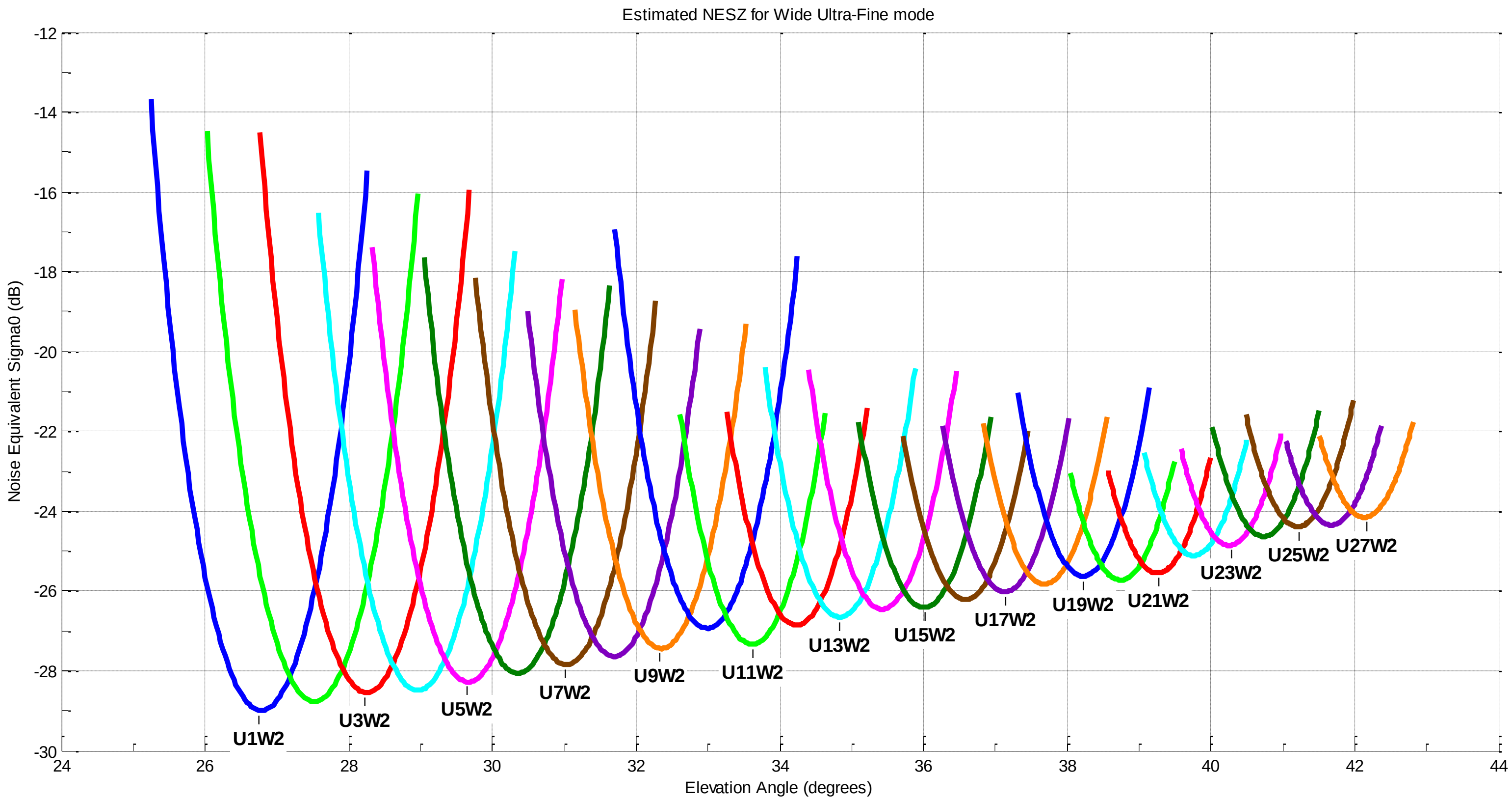
This section contains plots of additive (thermal) Noise-Equivalent Sigma-Zero (NESZ) estimates for each beam mode and beam position, as a function of swath elevation angle (the angle between the radar line of sight and the nadir direction). These estimates are based on models constrained with parameters derived from calibration and are representative of nominal conditions. The relationship between incidence and elevation angles is plotted below.

Actual noise levels may be higher than shown in some cases, particularly at the near and far edges of a beam. Actual noise levels depend on many factors, including polarization, payload component temperatures, earth surface temperatures, and factors that affect radiometric corrections applied during processing such as spacecraft altitude, mean terrain height, pulse repetition frequency, and azimuth processing characteristics (number and placement of azimuth looks, azimuth spectral weighting function).



C.1 Single Beam Modes




Estimated NESZ for Wide Ultra-Fine mode
Noise Equivalent Sigma0 (dB)
Elevation Angle (degrees)
-12
-14
-16
-18
-20
-22
-24
-26
-28
-30
24
26
28
30
32
34
36
38
40
42
44
U1W2
U3W2
U5W2
U7W2
U9W2
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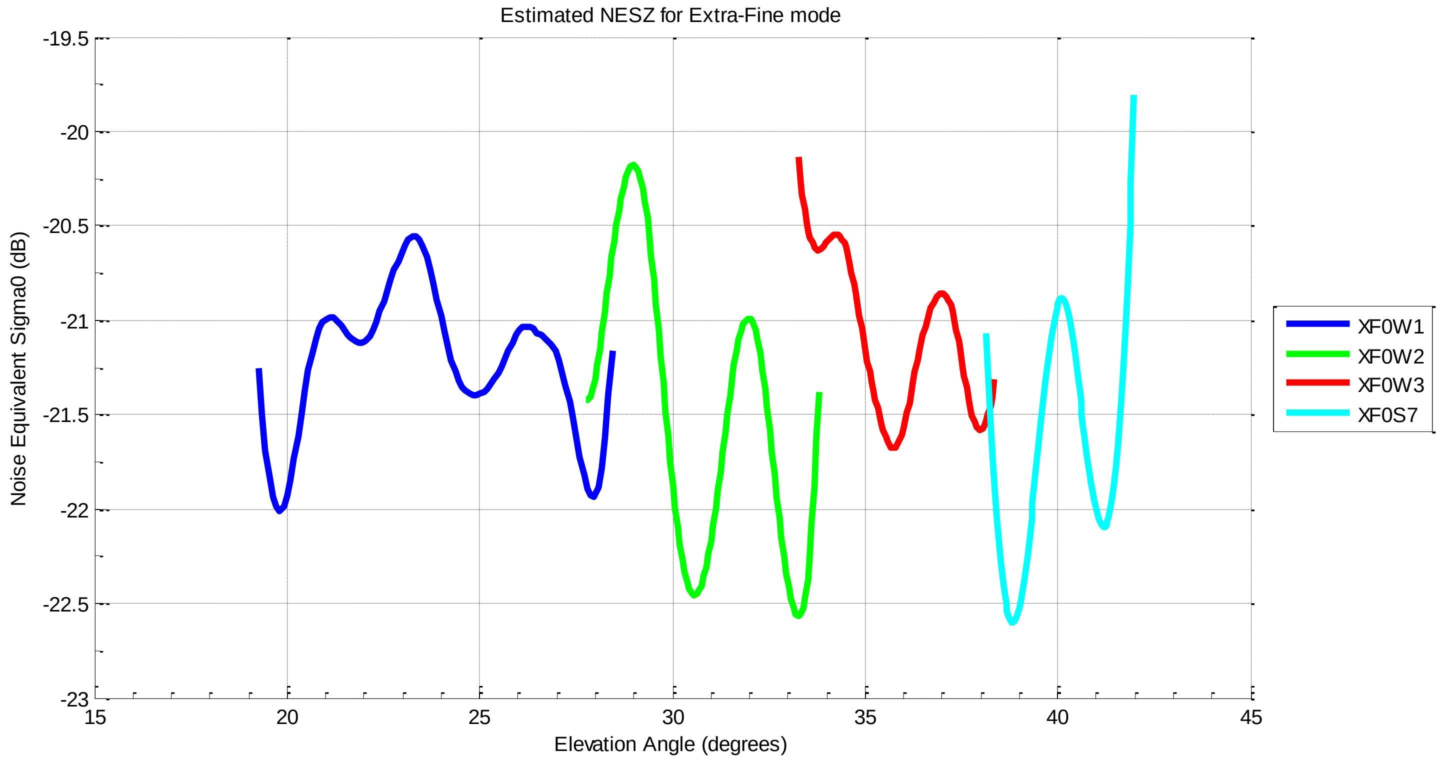
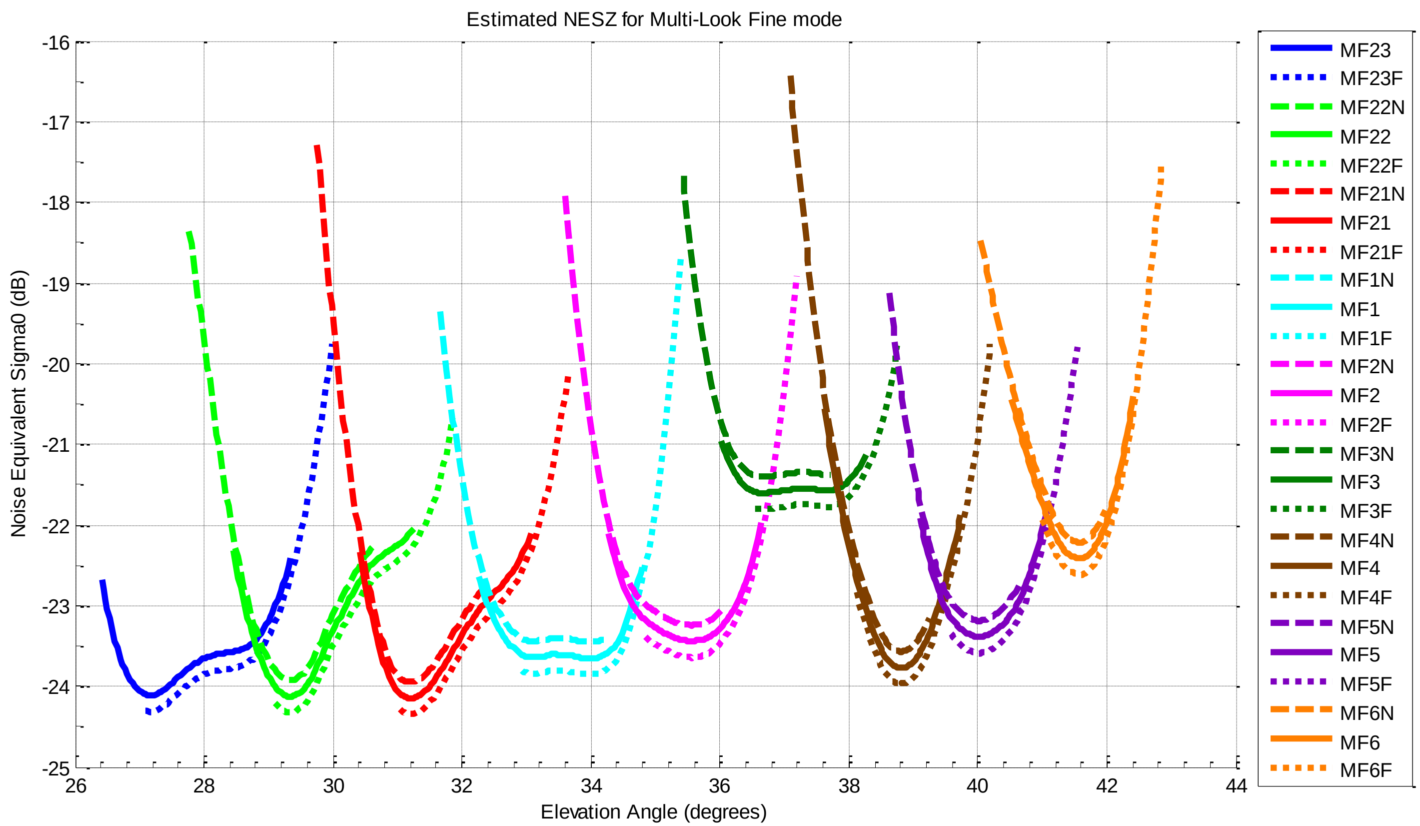
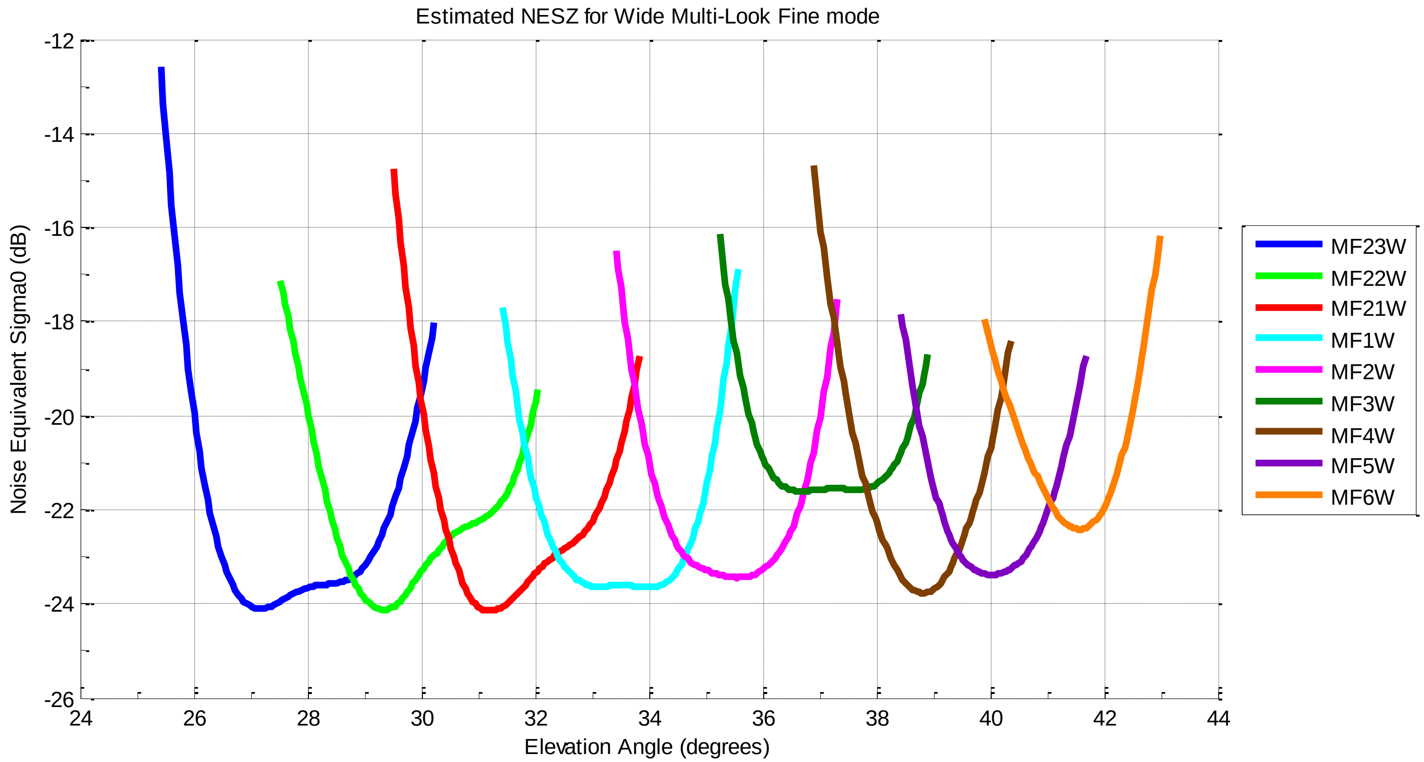
U21W2
U23W2
U25W2
U27W2

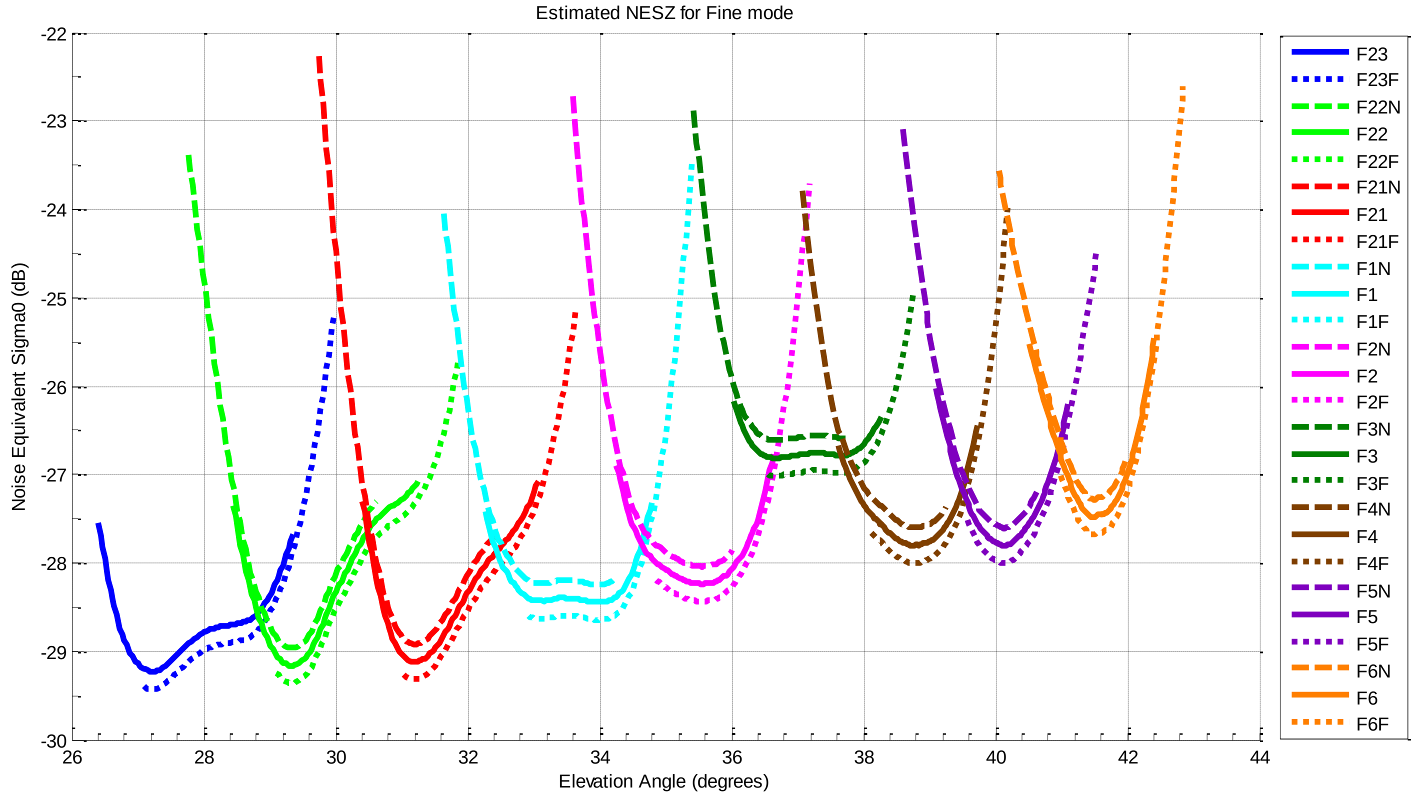


Note: The plot above is for full-resolution Extra-Fine mode products. For reduced-resolution Extra-Fine SLC products, the NESZ is about 2 dB lower than shown above.

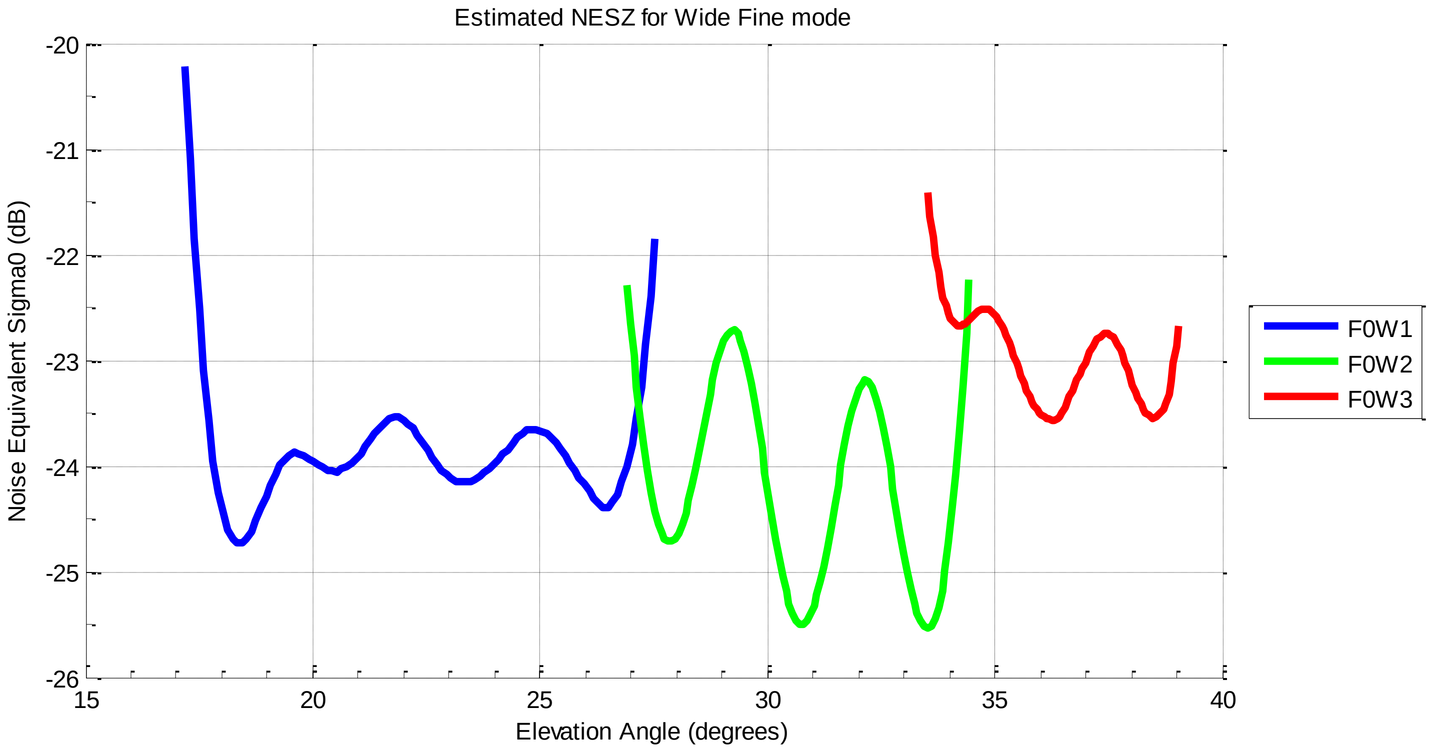


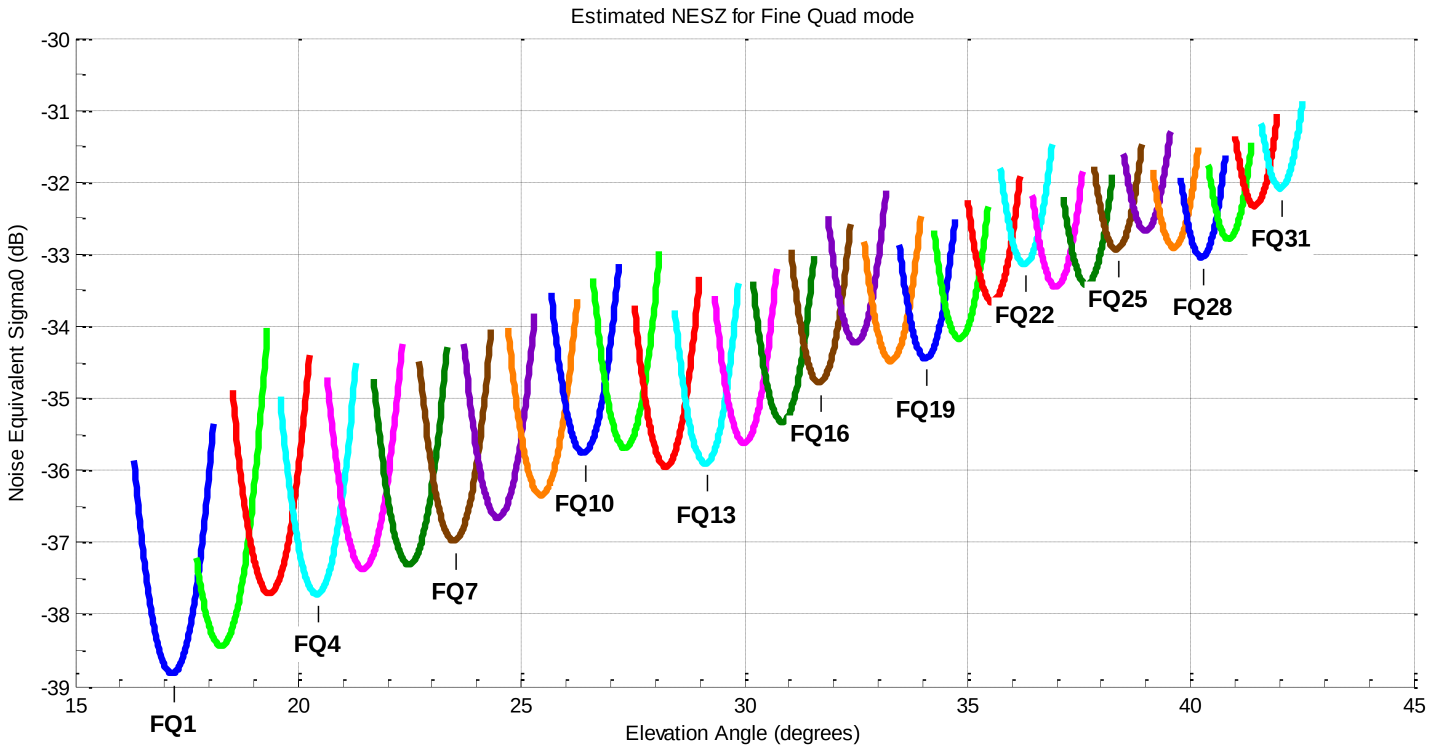
Note: In the figure above, to allow overlapping curves of the same color to be distinguished, the dashed curves are moved 0.2 dB up from their estimated values and the dotted curves are moved 0.2 dB down from their estimated values.

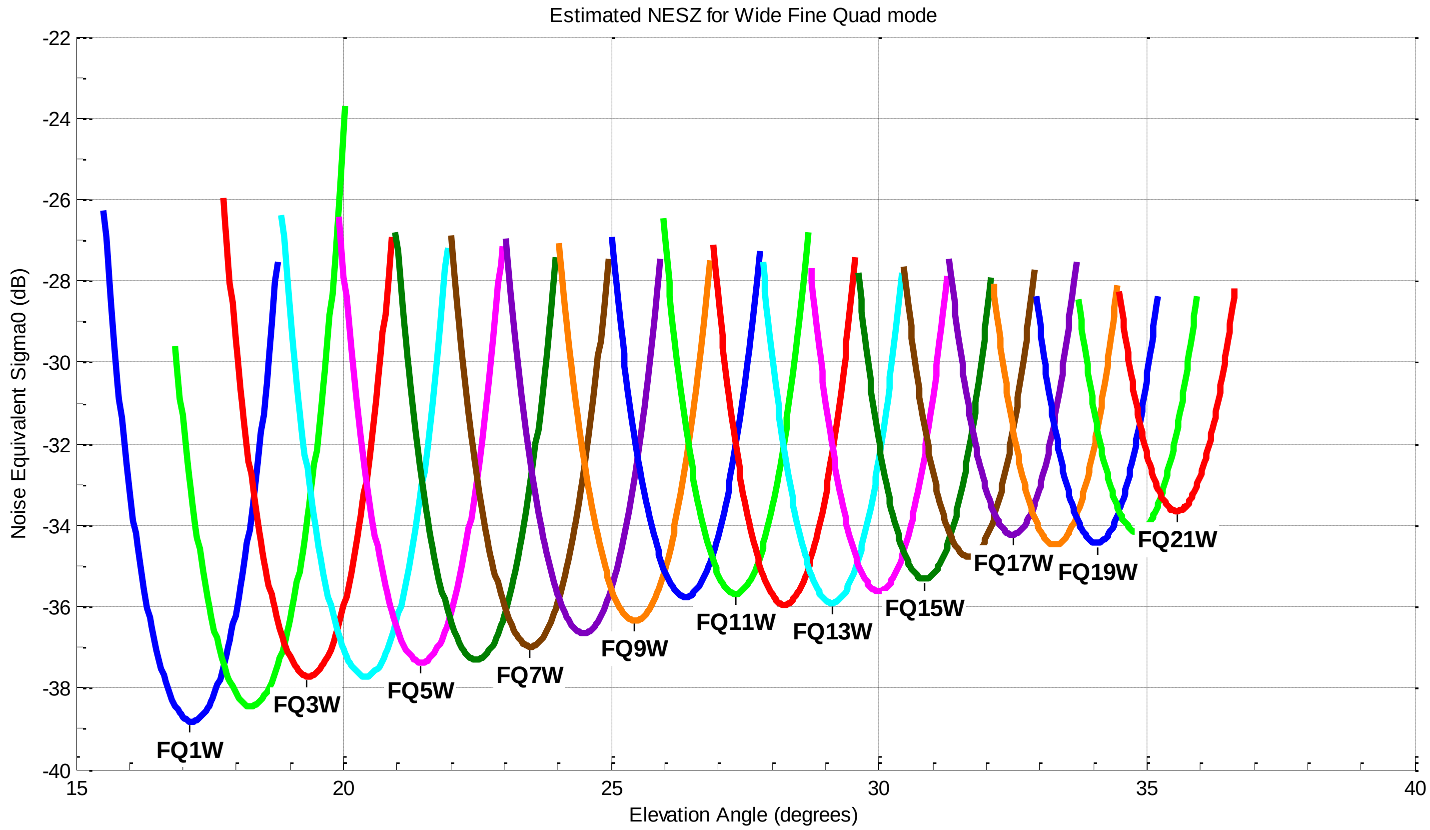

Estimated NESZ for Wide Multi-Look Fine mode
Noise Equivalent Sigma0 (dB)
-12
-14
-16
-18
-20
-22
-24
-26
24
26
28
30
32
34
36
38
40
42
44
Elevation Angle (degrees)
MF23W
MF22W
MF21W
MF1W
MF2W
MF3W
MF4W
MF5W
MF6W

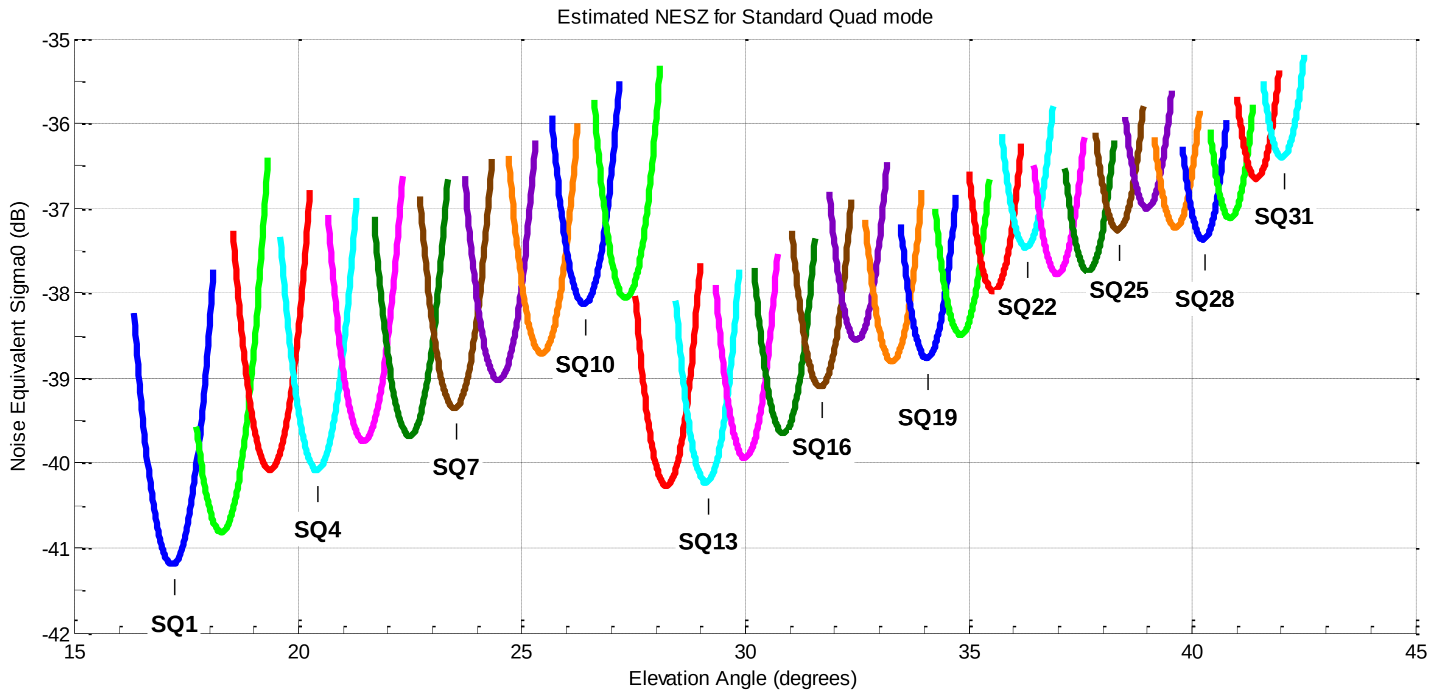


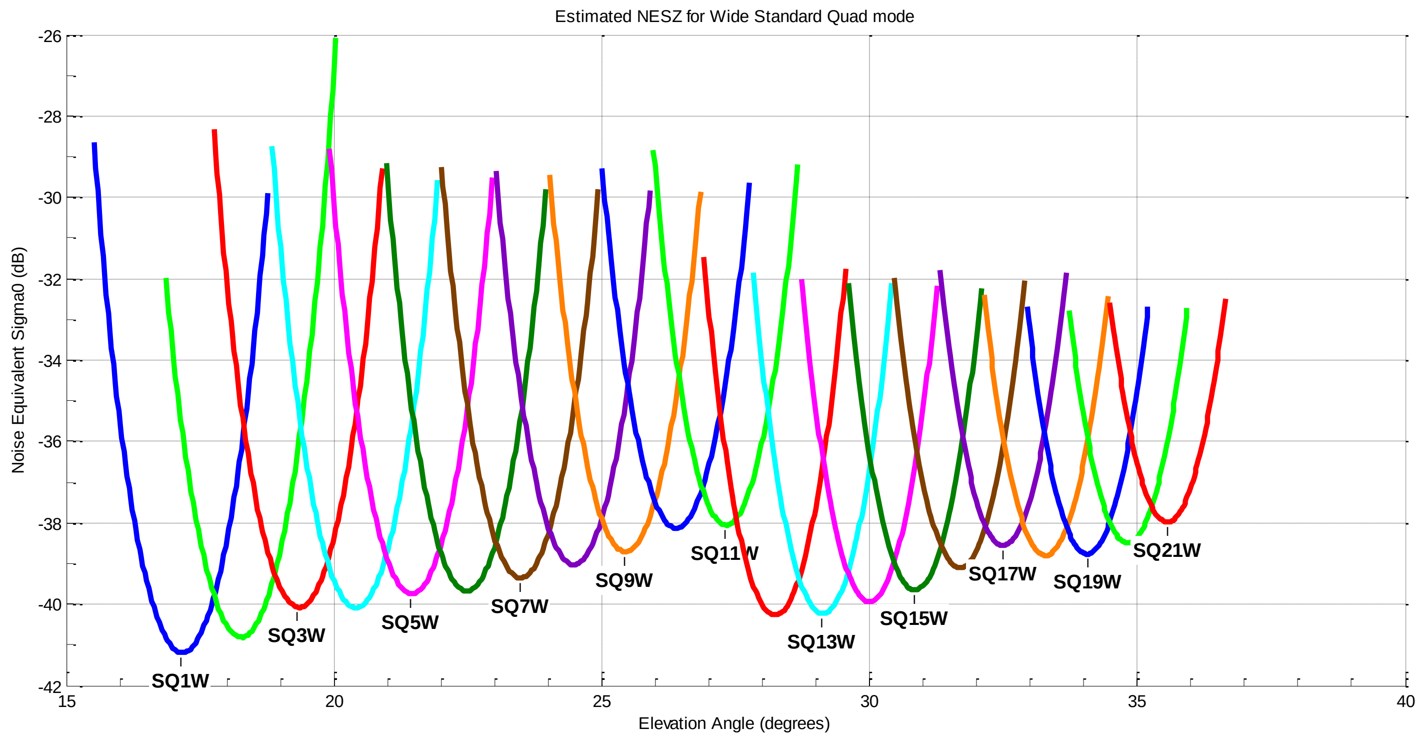
Note: In the figure above, to allow overlapping curves of the same color to be distinguished, the dashed curves are moved 0.2 dB up from their estimated values and the dotted curves are moved 0.2 dB down from their estimated values.

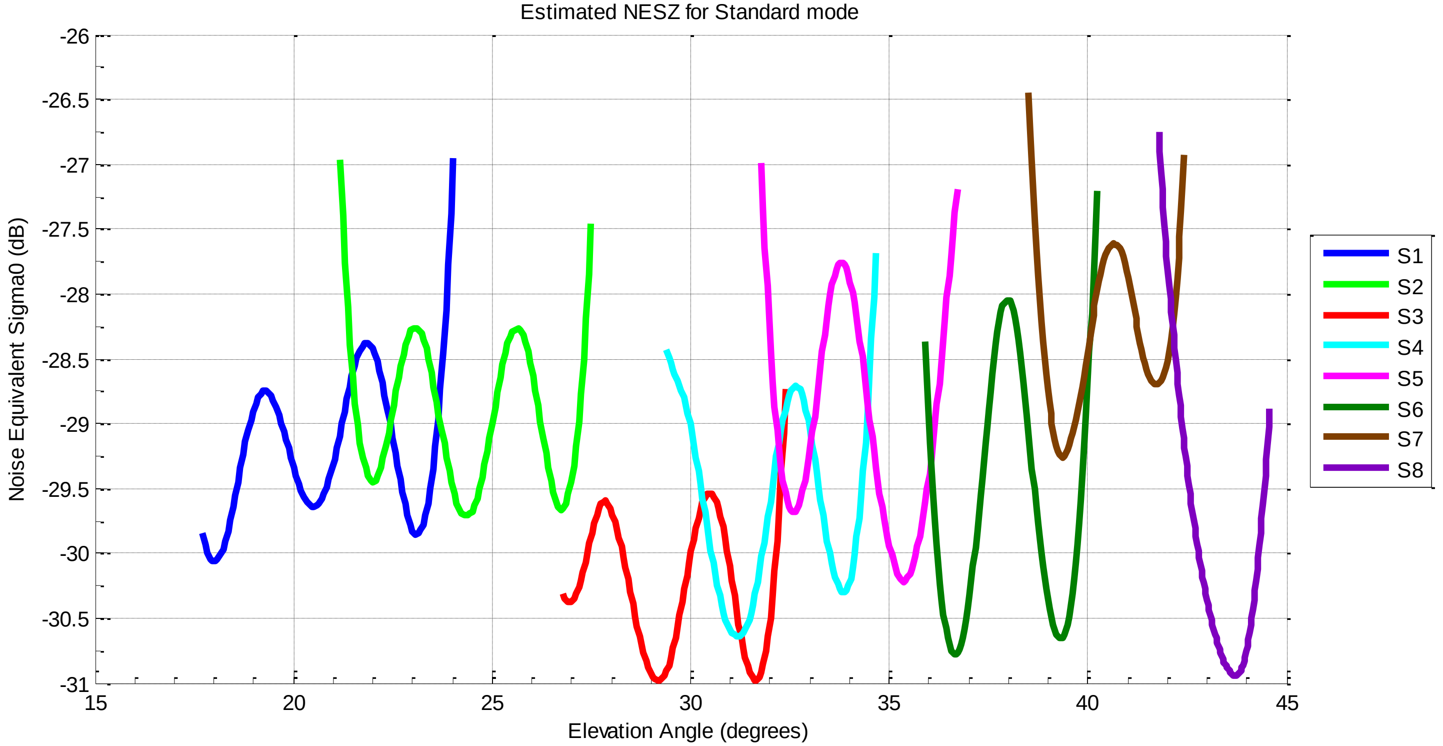

Estimated NESZ for Wide Fine mode
Noise Equivalent Sigma0 (dB)
-20
-21
-22
-23
-24
-25
-26
15
20
25
30
35
40
Elevation Angle (degrees)
F0W1
F0W2
F0W3

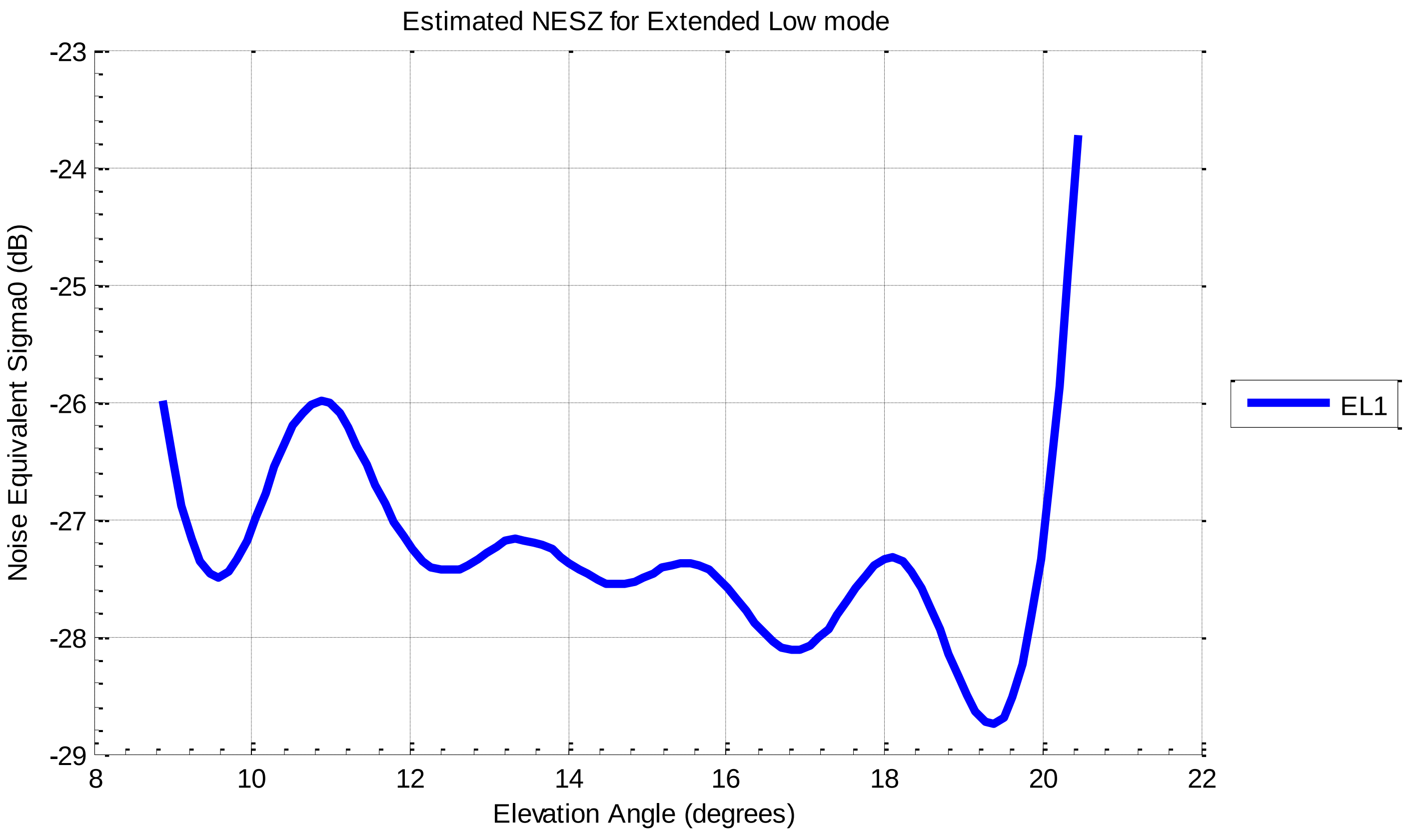

Estimated NESZ for Fine Quad mode
Noise Equivalent Sigma0 (dB)
Elevation Angle (degrees)
-30
-31
-32
-33
-34
-35
-36
-37
-38
-39
15
20
25
30
35
40
45
FQ1
FQ4
FQ7
FQ10
FQ13
FQ16
FQ19
FQ22
FQ25
FQ28
FQ31

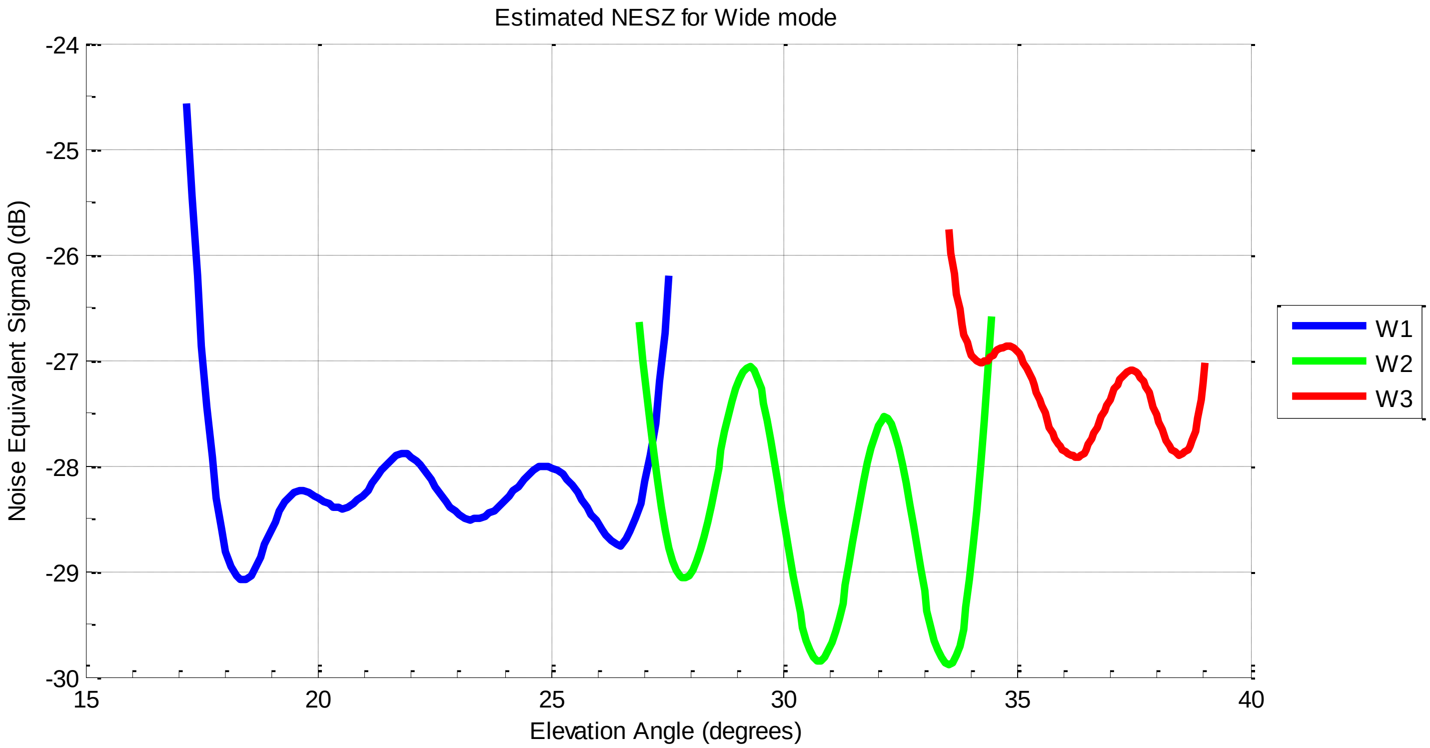

Estimated NESZ for Wide Fine Quad mode
Noise Equivalent Sigma0 (dB)
Elevation Angle (degrees)
-22
-24
-26
-28
-30
-32
-34
-36
-38
-40
15
20
25
30
35
40
FQ1W
FQ3W
FQ5W
FQ7W
FQ9W
FQ11W
FQ13W
FQ15W
FQ17W
FQ19W
FQ21W

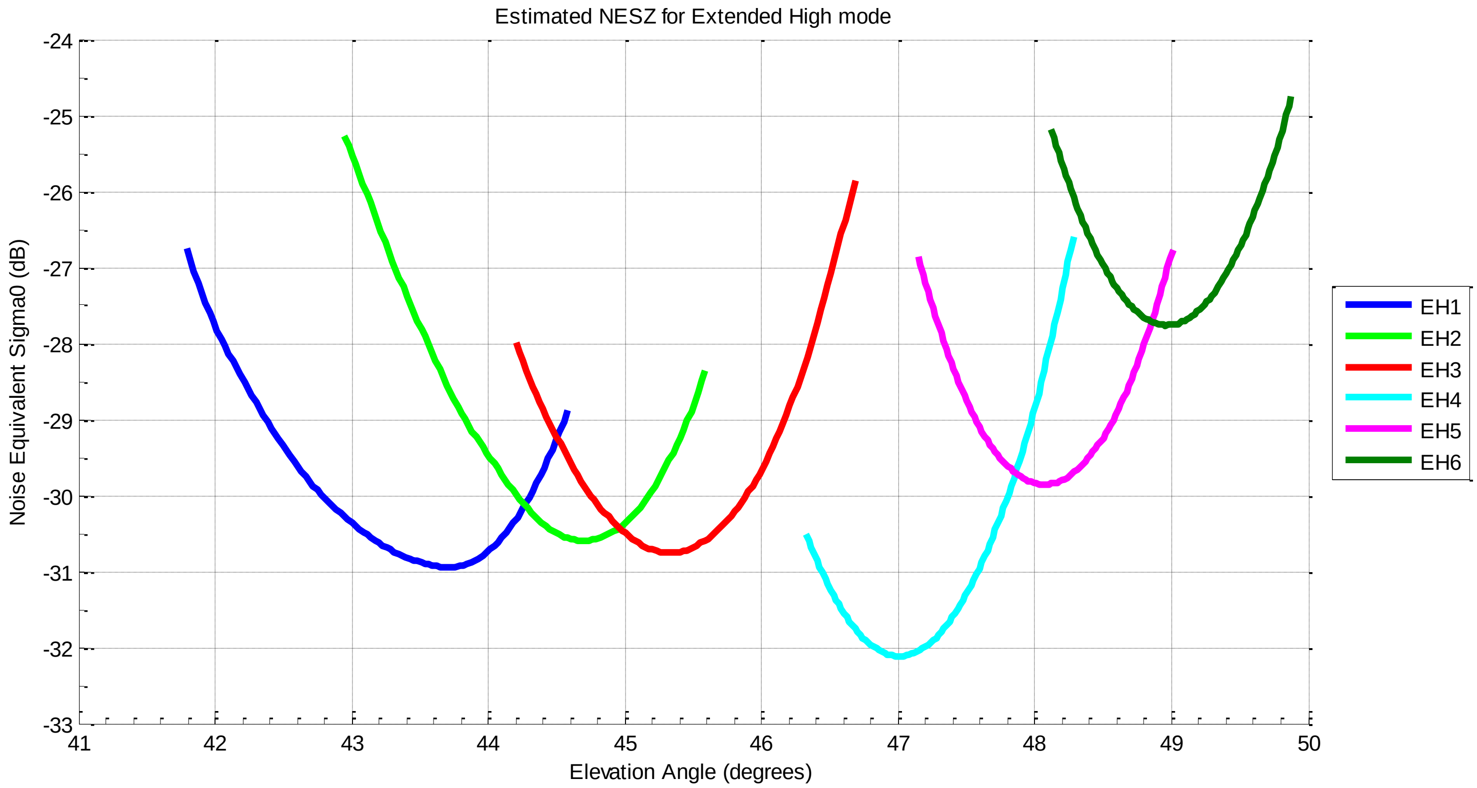

Estimated NESZ for Standard Quad mode
Noise Equivalent Sigma0 (dB)
-35
-36
-37
-38
-39
-40
-41
-42
15
20
25
30
35
40
45
Elevation Angle (degrees)
SQ1
SQ4
SQ7
SQ10
SQ13
SQ16
SQ19
SQ22
SQ25
SQ28
SQ31


Estimated NESZ for Wide Standard Quad mode
Noise Equivalent Sigma0 (dB)
Elevation Angle (degrees)
-26
-28
-30
-32
-34
-36
-38
-40
-42
15
20
25
30
35
40
SQ1W
SQ3W
SQ5W
SQ7W
SQ9W
SQ11W
SQ13W
SQ15W
SQ17W
SQ19W
SQ21W

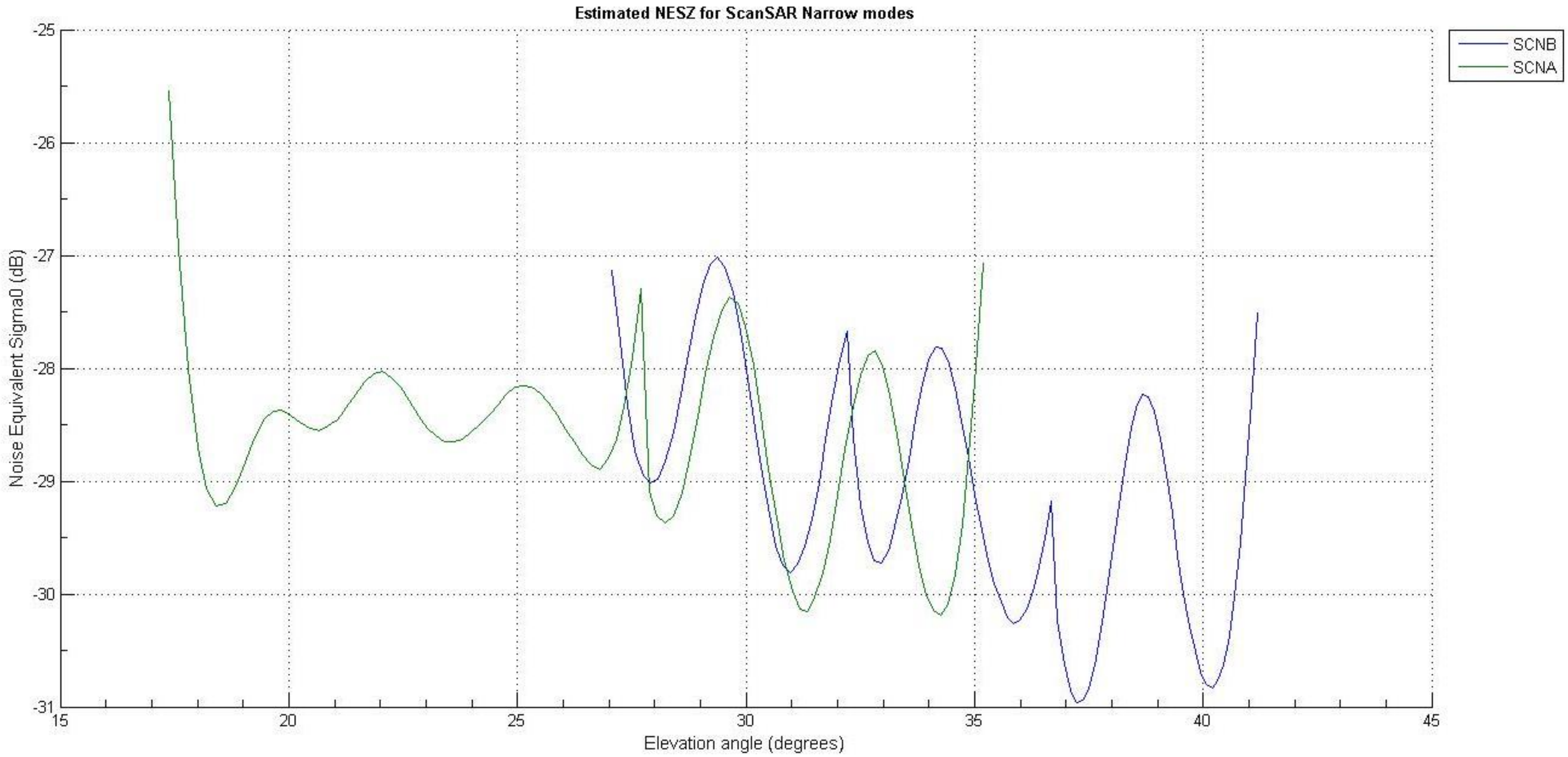

Estimated NESZ for Standard mode
Noise Equivalent Sigma0 (dB)
-26
-26.5
-27
-27.5
-28
-28.5
-29
-29.5
-30
-30.5
-31
15
20
25
30
35
40
45
Elevation Angle (degrees)
S1
S2
S3
S4
S5
S6
S7
S8

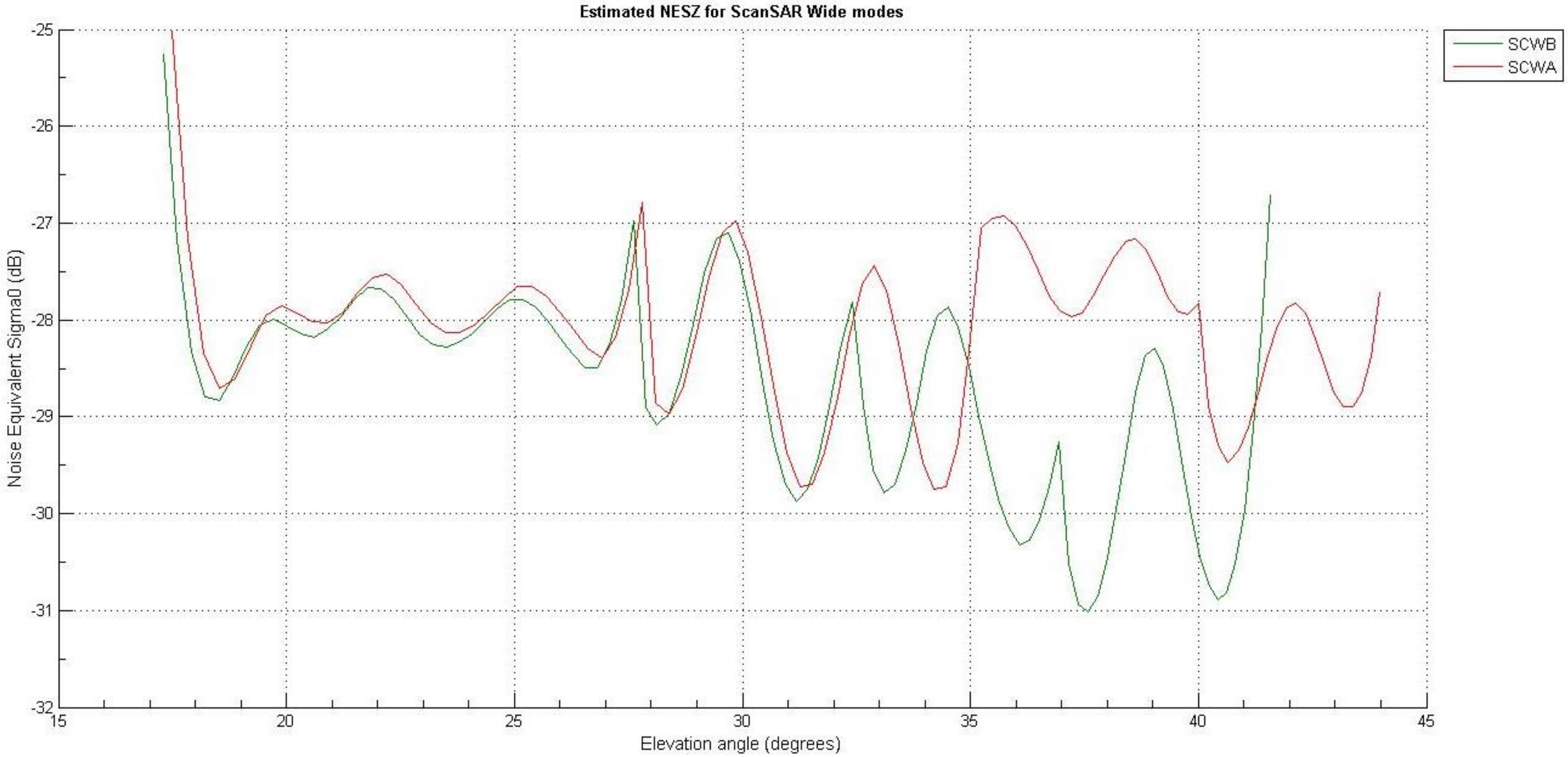

Estimated NESZ for Extended Low mode
-23
-24
-25
-26
-27
-28
-29
8
10
12
14
16
18
20
22
Noise Equivalent Sigma0 (dB)
Elevation Angle (degrees)
EL1

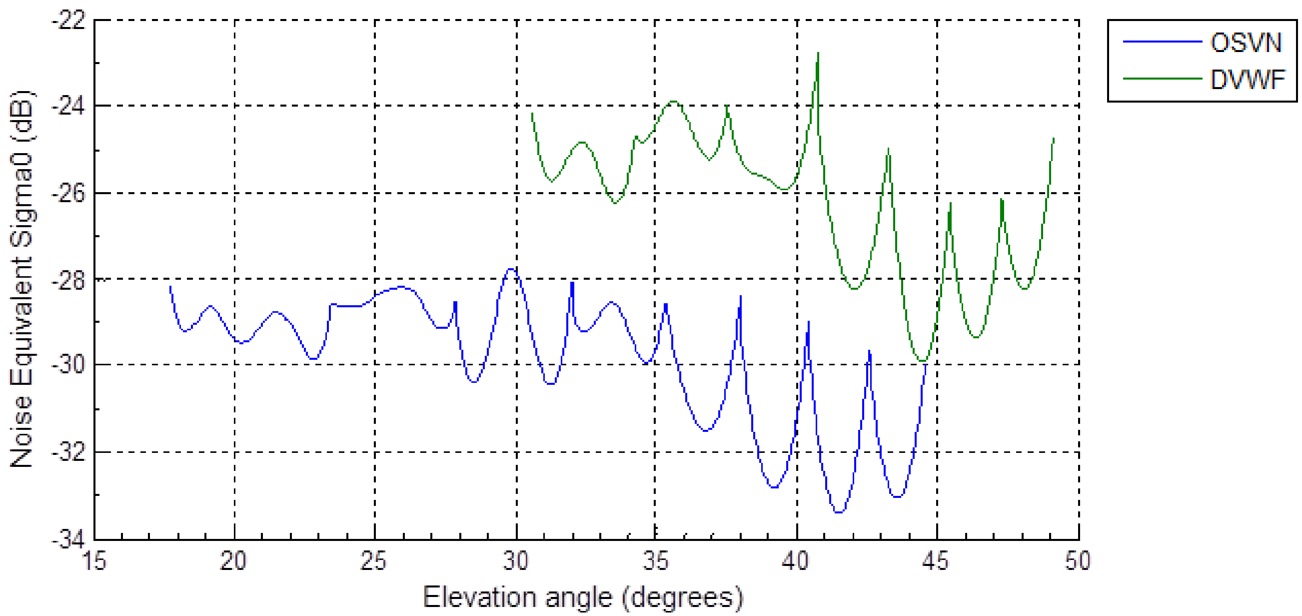

Estimated NESZ for Wide mode
Noise Equivalent Sigma0 (dB)
-24
-25
-26
-27
-28
-29
-30
15
20
25
30
35
40
Elevation Angle (degrees)
W1
W2
W3


Estimated NESZ for Extended High mode
Noise Equivalent Sigma0 (dB)
-24
-25
-26
-27
-28
-29
-30
-31
-32
-33
41
42
43
44
45
46
47
48
49
50
Elevation Angle (degrees)
EH1
EH2
EH3
EH4
EH5
EH6

C.2 ScanSAR Modes



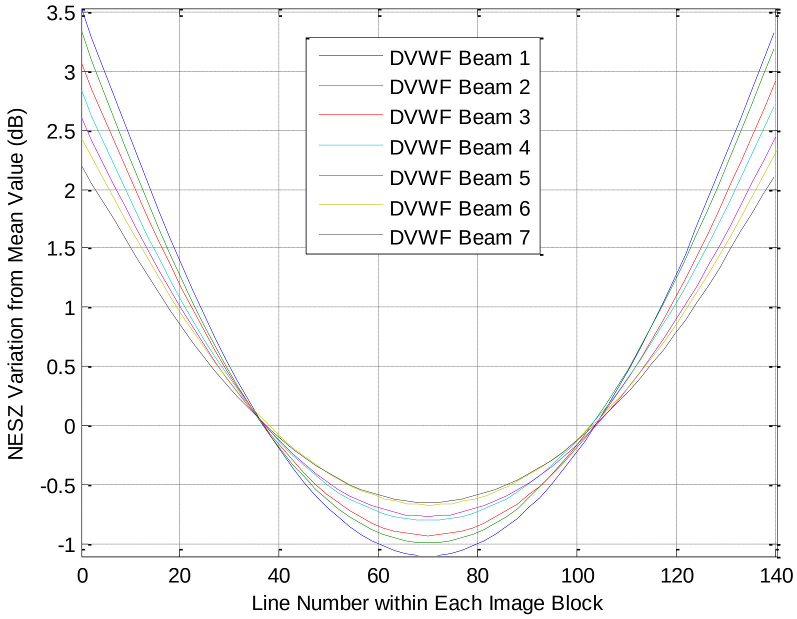

Estimated NESZ for ScanSAR Wide modes
Noise Equivalent Sigma0 (dB)
Elevation angle (degrees)
SCWB
SCWA
-25
-26
-27
-28
-29
-30
-31
-32
15
20
25
30
35
40
45

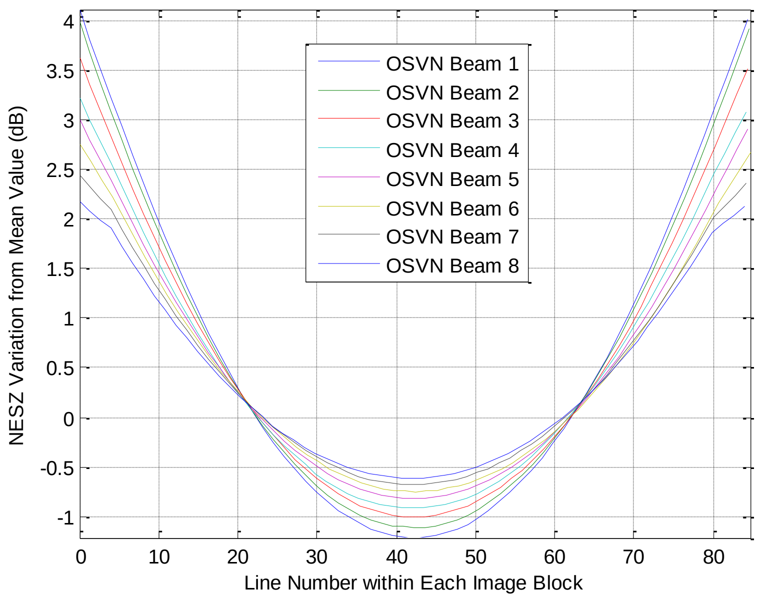


In the Ship Detection (Detection of Vessels) and Ocean Surveillance ScanSAR beam modes, the NESZ varies as a function of azimuth angle as well as elevation angle within each coherently processed output image block (where each output image block represents the area imaged by one ScanSAR physical beam during one ScanSAR beam cycle, and many such image blocks are merged together in the product image data). The NESZ is typically lowest near the centre of an image block and highest near the corners of the image block. The plot above provides the estimated median NESZ values as a function of elevation angle for the OSVN and DVWF modes.

The two plots below show additionally how the NESZ is estimated to vary on average over the azimuth extent of each image block in DVWF and OSVN modes. Each curve is normalized to 0 dB at the median NESZ value for the elevation angle of interest. For example, for OSVN mode at 30 degrees elevation angle, the median NESZ is -28 dB (based on the figure above), and the NESZ additionally varies in azimuth from approximately 1 dB below this median value to 3 dB above this median value within each ScanSAR image block (based on the right-hand figure below), that is from approximately -29 dB at the middle line of each block to -25 dB near the top and bottom lines of the block.

Overall, the NESZ varies from a minimum of approximately -34 dB to a maximum of about -24 dB in OSVN mode, and from -31 dB to -20 dB in DVWF mode.

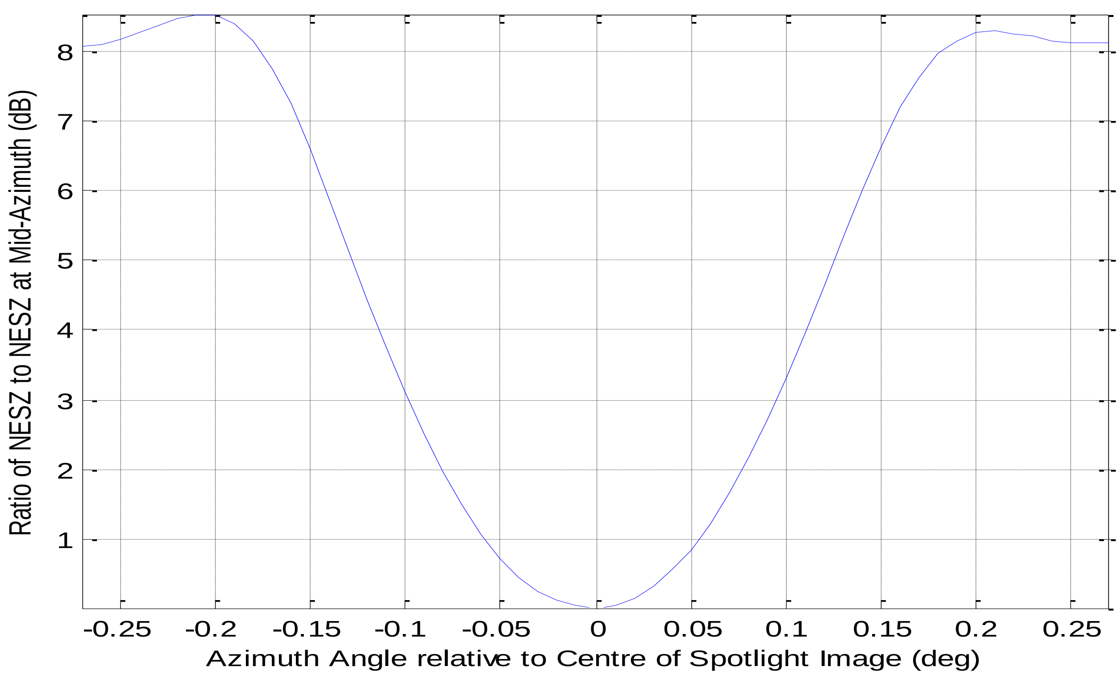


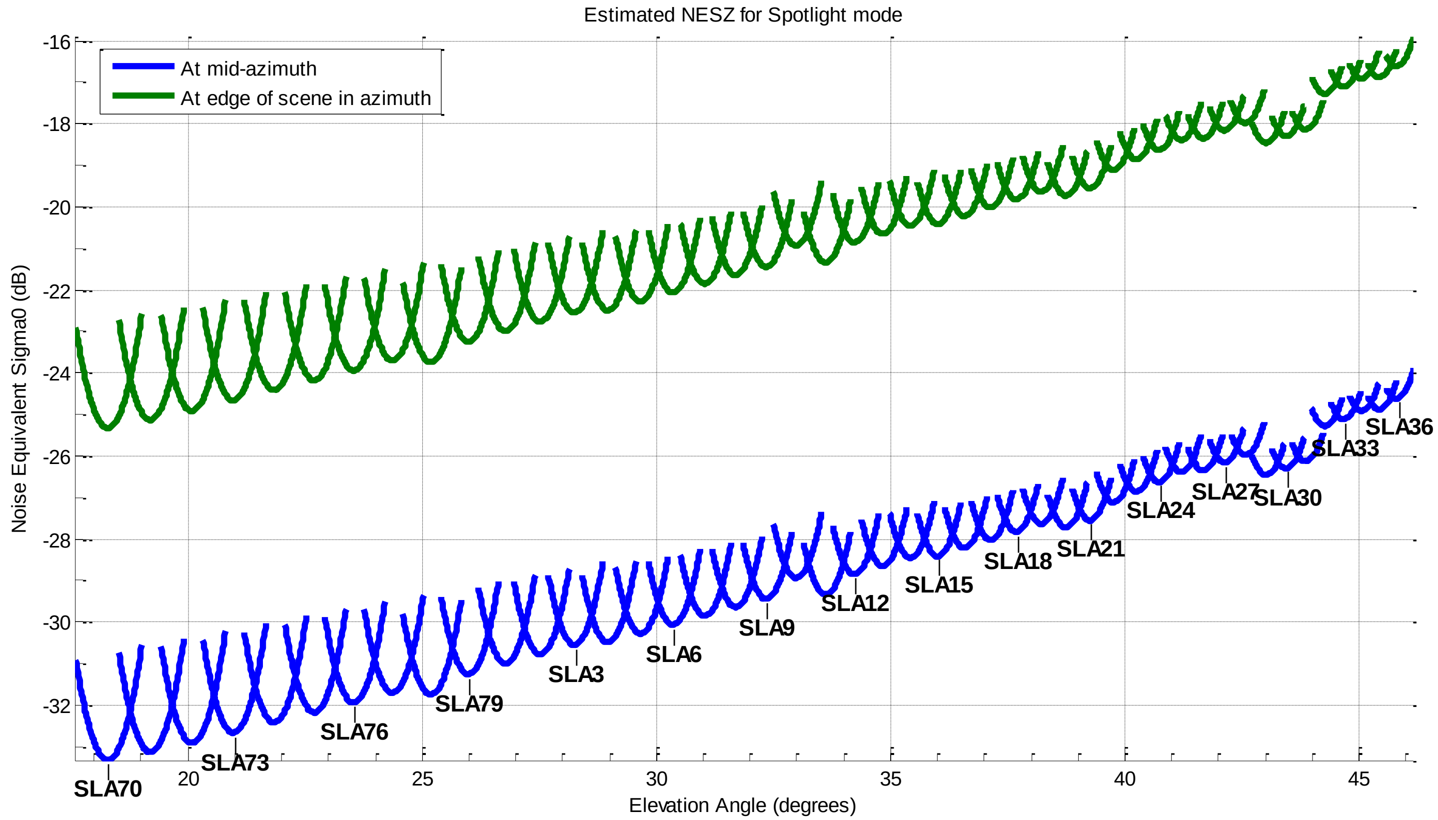


C.3 Spotlight Mode

In Spotlight mode, the NESZ varies as a function of azimuth angle as well as elevation angle. It is lowest at the centre of a Spotlight image and highest near the image corners. The first plot below shows how the NESZ is estimated to vary over the azimuth extent of a Spotlight image (normalized to the middle of the scene, which corresponds to zero azimuth angle).

The second plot below provides the estimated NESZ values as a function of elevation angle for both the middle (mid-azimuth) line, and the first or last (azimuth edge) line, of a product.




Estimated NESZ for Spotlight mode
At mid-azimuth
At edge of scene in azimuth
Noise Equivalent Sigma0 (dB)
Elevation Angle (degrees)
-16
-18
-20
-22
-24
-26
-28
-30
-32
20
25
30
35
40
45
SLA70
SLA73
SLA76
SLA79
SLA3
SLA6
SLA9
SLA12
SLA15
SLA18
SLA21
SLA24
SLA27
SLA30
SLA33
SLA36