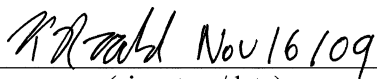


## RADARSAT-2 PRODUCT DESCRIPTION

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

Released by CADM: Bob Slade

  
\_\_\_\_\_  
(signature/date)

CADM signature indicates that all above approvals have been received and are on file.

### 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.

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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	

<b>ISSUE</b>	<b>DATE</b>	<b>PAGE(S)</b>	<b>DESCRIPTION</b>	<b>RELEASE</b>
1/6	Nov. 2, 2009	All	<p>First Issue, Sixth Revision</p> <p>Detailed product characteristics updated as a result the following changes to the RSAT-2 Operating License:</p> <ul style="list-style-type: none"><li>• Amendment #11 – Revision 3: Addition of Multi-Look Fine SLC Product Type,</li><li>• Amendment #11 – Revision 5: Extension of Ultra-Fine Incidence Angle Range,</li><li>• Amendment #11 – Revision 6: Relaxation of Resolution Restrictions (updates to Spotlight, Ultra-Fine, Fine Quad-Pole, Standard Quad-Pole product characteristics),</li><li>• Amendment #11 – Revision 7: Extension of Standard Quad-Pole and Fine Quad-Pole Incidence Angle Ranges.</li></ul> <p>Corrected terminology for Extended High and Extended Low beam modes.</p>	

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## ACRONYMS AND ABBREVIATIONS

BAQ	Block Adaptive Quantization
CD-ROM	Compact Disk – Read Only Memory
CEOS	Committee on Earth Observation Satellites
dB	decibel
EH	Extended coverage Extended High beam
EL	Extended coverage Extended Low beam
F	Fine resolution beam
FQ	Fine resolution Quad-polarization beam
FM	Frequency Modulation
H	Horizontal polarization
Hz	Hertz
HH	Horizontal polarization on transmit, Horizontal polarization on receive
HV	Horizontal polarization on transmit, Vertical polarization on receive
ISLR	Integrated Side Lobe Ratio
MBytes	Unit of data volume equal to $2^{20}$ bytes (= $2^{23}$ bits)
MDA	MacDonald, Dettwiler and Associates Ltd.
MDA GSI	MDA Geospatial Services Inc.
MF	Multi-Look Fine resolution beam
NESZ	Noise-Equivalent Sigma-Zero
NRT	Near Real Time
PRF	Pulse Repetition Frequency
PSLR	Peak Side Lobe Ratio
S	Standard beam
SAR	Synthetic Aperture Radar
SCN	ScanSAR Narrow mode/product
SCW	ScanSAR Wide mode/product
SGF	SAR Georeferenced Fine product (also known as Path Image)

SGX	SAR Georeferenced Extra product (also known as Path Image Plus)
SL	Spotlight
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)
SSR	Solid State Recorder
SQ	Standard Quad-polarization beam
TBC	To Be Confirmed
TBD	To Be Determined
U	Ultra-Fine resolution beam
USGS	United States Geological Service
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

# 1 RADARSAT-2 PRODUCTS

This document introduces the RADARSAT-2 products. It provides an overview of the products followed by detailed descriptions. The overview classifies the products and describes sensor-related information. RADARSAT-2 products include products compatible with the RADARSAT-1 mission as well as new products having enhanced resolution and/or polarization options.

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

Web: [www.radarsat2.info](http://www.radarsat2.info)

Email: [clientservices@mdacorporation.com](mailto:clientservices@mdacorporation.com)

## 1.1 Overview

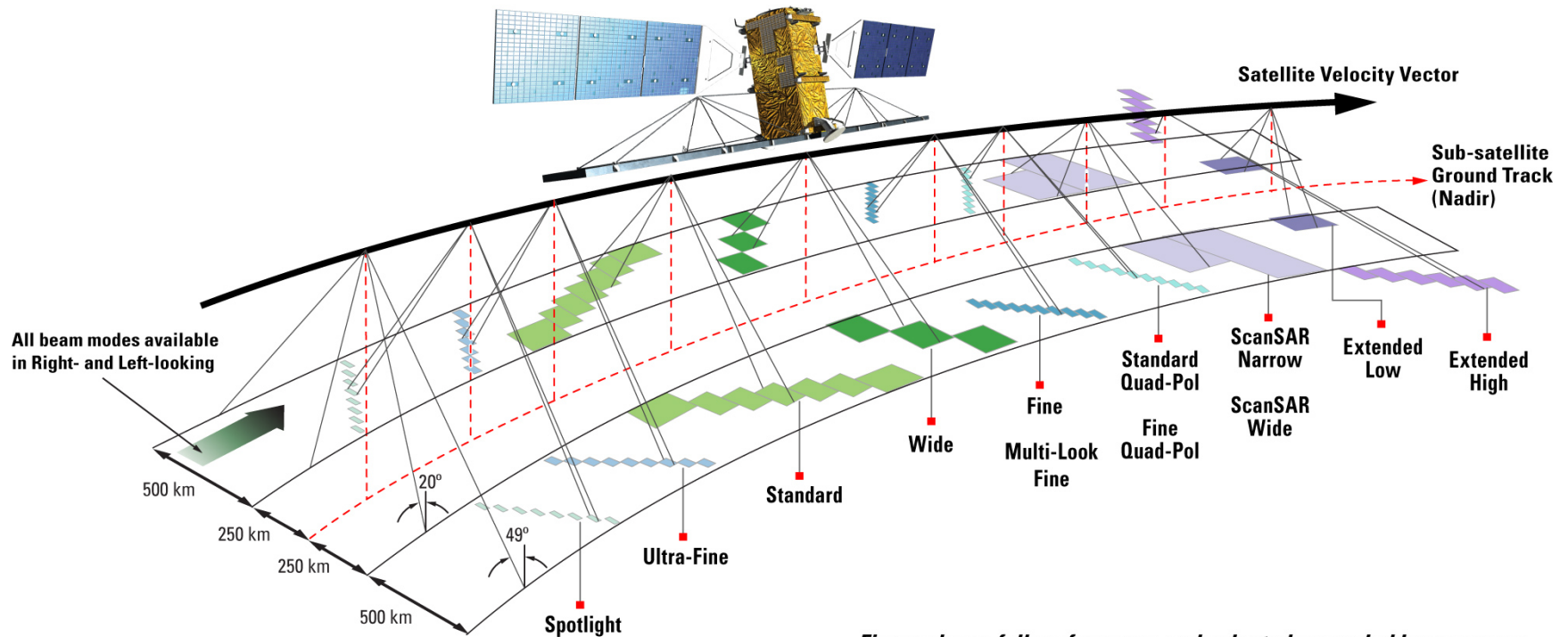
A RADARSAT-2 product consists of Synthetic Aperture Radar (SAR) image or signal data, and accompanying meta data, stored on a computer medium.

RADARSAT-2 products are characterized by the beam mode used by the satellite and the level of processing that has been applied to the data. This section contains a description of the beam modes, followed by a summary of the products. Detailed descriptions of the individual products are provided in Section 2. Information on detailed product fields and content is provided in the RADARSAT-2 Product Format Definition (Document RN-RP-51-2713), which is available from MDA.

Products using some modes or covering certain areas may not be available to all customers. Details of any such restrictions are not included in this document.

### 1.1.1 Beam Modes

The space segment of the RADARSAT-2 SAR system consists of a radar transmitter, a radar receiver and a data downlink transmitter. The radar transmitter and receiver operate through an electrically steerable antenna that directs the transmitted energy in a narrow beam normal to the satellite track. The elevation angle and the elevation profile of the beam can be adjusted so that the beam intercepts the earth's surface over the desired range of incidence angles. The beam modes are each characterized by a specific beam elevation angle and width, as shown in Figure 1-1.



*Figure shows full performance and selected expanded beam ranges*

AI-8760-91CR13

**Figure 1-1 RADARSAT-2 SAR Modes of Operation**

For any given beam mode, the same beam elevation angle and width is used for both transmit and receive. The receiver detects the echo resulting from reflection or scattering of the transmitted signal from the earth's surface. The detected signal is then digitized, recorded and encoded prior to transmission to the on-ground data reception facility. Data transmission may occur in near-real time (NRT) while the data are being collected, or the data may be stored in the on-board solid-state recorders (SSR) 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, will 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.

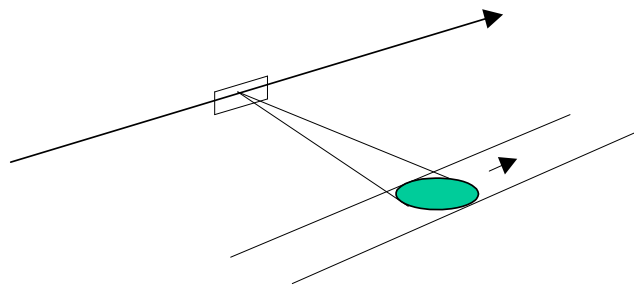
The SAR instrument may be operated in one of three modes:

- Single Beam;
- ScanSAR;
- Spotlight.

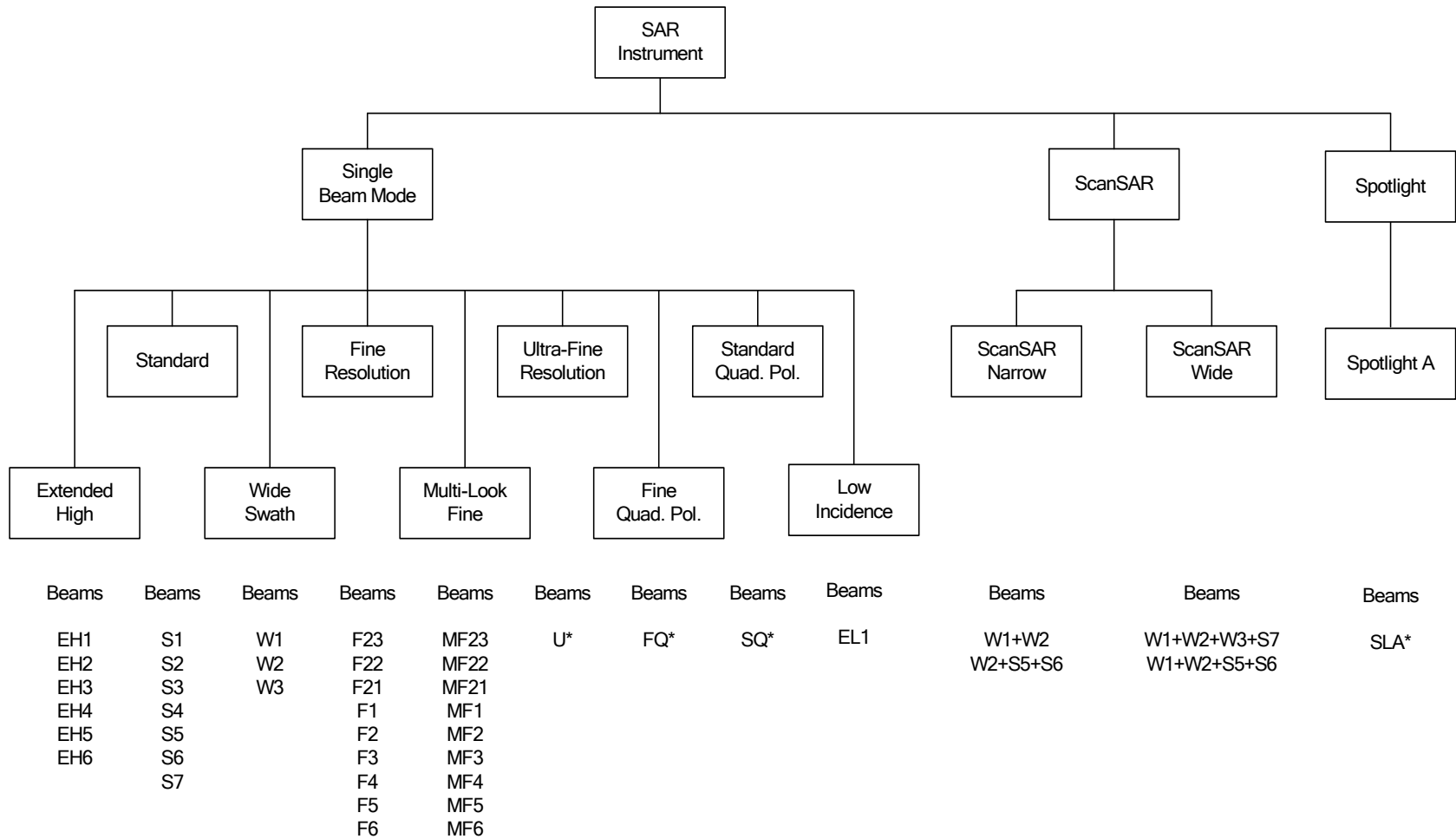
Figure 1-3 shows the relationships between the beam modes and the individual beams used within each mode. The following sections describe the various beam modes.

### 1.1.1.1 Single Beam Mode

Single beam mode is a stripmap SAR mode. In Single Beam operation, the beam elevation and profile are maintained constant throughout the data collection period.



**Figure 1-2 Single Beam Mode**



An asterisk "\*" indicates that a large number of beams are available for that mode.

**Figure 1-3 RADARSAT-2 SAR Instrument Modes**

The following Single Beam operational modes are available:

a) Standard

Standard Beams allow 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 seven beams, referred to as S1 to S7. The nominal incidence angle range covered by the full set of beams is 20 degrees (at the inner edge of S1) to 49 degrees (at the outer edge of S7). 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 images 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 Beams allow imaging of wider swaths than the Standard Beams, but at the expense of a slightly coarser spatial resolution. The three Wide Swath Beams, W1, W2 and W3, provide coverage of swaths of approximately 170 km, 150 km and 120 km widths spanning a total incidence angle range from 20 degrees to 45 degrees. (Images obtained with Beam W3 contain a nadir ambiguity within the swath, which may be visible as a narrow bright line parallel to the flight direction.) Wide Swath Beam images 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 Beams are intended for applications which require finer spatial resolution. Images from this mode have a nominal ground swath of 50 km. Nine Fine Resolution Beams, F23 to F21, and F1 to F6 are available to cover the incidence angle range from 30 to 50 degrees. Imaging options are available to provide a choice of swath positions with overlaps of more than 50% between successive swaths. Fine Resolution Beam images 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) Multi-Look Fine

The Multi-Look Fine Resolution Beam modes cover the same swaths as the Fine Resolution modes. Products with multiple looks in range and azimuth are generated at approximately the same spatial resolution as Fine Resolution mode products, but with multiple looks and therefore improved radiometric resolution. Single look products are generated at finer spatial resolutions than Fine Resolution mode products. The higher data rate capacity of the recorders allows the multiple

looks to be obtained without a reduction in swath width. As with the Fine Resolution Beam modes, nine beams cover the incidence angle range from 30 to 50 degrees. Multi-Look Fine Resolution images 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).

e) Ultra-Fine

The Ultra-Fine Resolution Beams are intended for applications which require very high spatial resolution. In this mode the radar operates with the highest sampling rate, and so the ground swath coverage is limited to keep data rate within the recorder limits. The set of Ultra-Fine Resolution Beams cover any area within the incidence angle range from 20 to 49 degrees. Each beam within the set images a swath width of at least 20 km. Ultra-Fine Resolution images 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) Extended High (High Incidence)

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 minor degradation of image quality can be expected when compared with the Standard Beam Mode. 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 images can only be generated in HH polarization.

g) Extended Low (Low Incidence)

A single Extended Low Incidence Beam, EL1, is provided for imaging in the incidence angle range 10 to 23 degrees with a nominal ground swath coverage of 170 km. As for the Extended High Incidence Beams, 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 images can only be generated in HH polarization.

h) Standard Quad Polarization

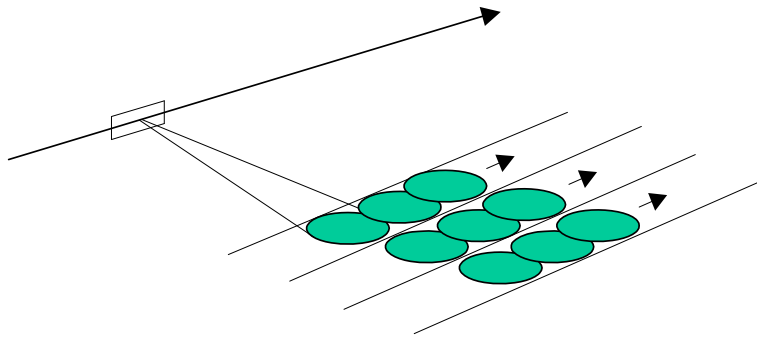
In RADARSAT-2 Quad Polarization modes, the radar transmits pulses alternately in horizontal (H) and vertical (V) polarizations, and receives the return signals from each pulse in both H and V polarizations separately. These modes therefore enable full polarimetric (HH+VV+HV+VH) image products to be generated. The Standard Quad Polarization mode operates with the same pulse bandwidths as the Standard Beam mode. Images 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.

i) Fine Quad Polarization

The Fine Quad Polarization mode provides full polarimetric imaging with the same spatial resolution as the Fine Resolution Beam modes. Fine Quad Polarization images 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.

### 1.1.1.2 ScanSAR Mode

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



**Figure 1-4 ScanSAR Mode**

In the various ScanSAR modes, two, three or four of the single 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. 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. For the standard RADARSAT-2 ScanSAR modes, the radar beam switching has been chosen to provide two azimuth looks per beam for all points.

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.

The following ScanSAR operational modes are available:

a) ScanSAR Narrow (SCN)

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

- SCNA: W1 + W2
- SCNB: W2 + S5 + 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.

b) ScanSAR Wide (SCW)

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

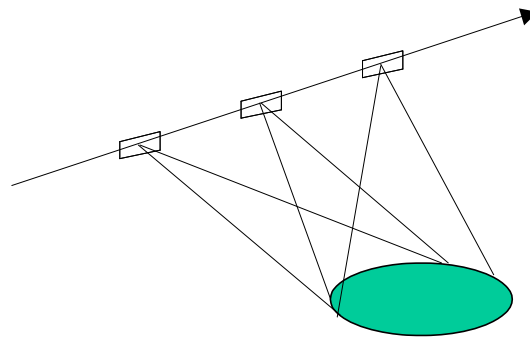
- SCWA: W1 + W2 + W3 + S7
- SCWB: W1 + W2 + S5 + S6

The SCWA combination allows imaging of a swath of more than 500 km covering the full incidence angle range of 20 to 49 degrees spanned by the Standard Beams. The SCWB combination allows imaging of a swath of more than 450 km covering the incidence angle range from 20 to 46 degrees. Images obtained with the first option include a nadir ambiguity within the Beam W3 swath, which may be visible as a narrow bright line parallel to the flight direction. The second is therefore offered for users who wish to avoid the appearance of a nadir ambiguity, and can accept the slightly narrower swath width.

### 1.1.1.3 Spotlight Mode

The Spotlight Beams are intended for applications which require the best spatial resolution available from the RADARSAT-2 SAR system. In this mode the radar operates with the highest sampling rate, and so the ground swath coverage is limited to keep data rate within the recorder limits. Unlike the other modes, Spotlight images are also of fixed size in the along track direction.

The set of Spotlight Beams cover any area within the incidence angle range from 20 to 49 degrees. Each beam within the set images a swath width of at least 18 km. Spotlight images 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).



**Figure 1-5 Spotlight Mode**

### 1.1.2 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 Pol.” and “Quad Pol” columns of Table 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	✓	✓	✓	✓			
Multi-Look Fine	✓	✓	✓	✓			
Fine	✓	✓	✓	✓	✓	✓	
Standard	✓	✓	✓	✓	✓	✓	
Wide	✓	✓	✓	✓	✓	✓	
ScanSAR Narrow	✓	✓	✓	✓	✓	✓	
ScanSAR Wide	✓	✓	✓	✓	✓	✓	
Extended High	✓						
Extended Low	✓						
Fine Quad-Pol							✓
Standard Quad-Pol							✓

Notes:

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

### 1.1.3 Products Summary

Three types of SAR products are produced. Table 1-2 provides a summary of these product types with a mapping to the processing levels adopted by the data distribution agency (MDA GSI). These are identical to the RADARSAT-1 processing levels for all modes supported by RADARSAT-1.

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 1-2 RADARSAT-2 Products Summary**

Products		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
Geocorrected	SAR Systematic Geocorrected	SSG	Systematic Geocoded	Map Image
	SAR Precision Geocorrected	SPG	Precision Geocoded	Precision Map Image

**Table 1-3 Summary of RADARSAT-2 Beam Modes and Products**

BEAM MODE	PRODUCT <sup>1,2</sup>	Pixel Spacing <sup>3,4</sup>	Resolution <sup>3,5</sup>	Scene Size <sup>6</sup>	Incidence Angle <sup>7</sup>	No. Looks	Polarizations Options <sup>8</sup>
		[Rng x Az] (m)	[Rng x Az] (m)	[Rng x Az] (km)	°	[Rng x Az]	
Spotlight	SLC	1.3 x 0.4	1.6 x 0.8	18 x 8	20 to 49	1 x 1	Single Co or Cross (HH or VV or HV or VH)
	SGX	1 x 1/3	4.6 - 2.1 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 49	1 x 1	Single Co or Cross (HH or VV or HV or VH)
	SGX	1 x 1	4.6 - 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)
	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					
Fine	SLC	4.7 x 5.1	5.2 x 7.7	50 x 50	30 to 50	1 x 1	Single Co, Cross or Dual (HH or VV or HV or VH or HH+HV or VV+VH)
	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					
Standard	SLC	8 or 11.8 x 5.1	9.0 or 13.5 x 7.7	100 x 100	20 to 49	1 x 1	Single Co, Cross or Dual (HH or VV or HV or VH or HH+HV or VV+VH)
	SGX	8 x 8	26.8 - 18.0 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, Cross or Dual (HH or VV or HV or VH or HH+HV or VV+VH)
	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					
ScanSAR Narrow	SCN	25 x 25	79.9 - 37.7 x 60	300 x 300	20 to 46	2 x 2	Single Co, Cross or Dual (HH or VV or HV or VH or HH+HV or VV+VH)
ScanSAR Wide	SCW	50 x 50	160 - 72.1 x 100	500 x 500	20 to 49	4 x 2	Single Co, Cross or Dual (HH or VV or HV or VH or HH+HV or VV+VH)
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)
	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)
	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)
	SGX	3.13 x 3.13	16.5 - 6.8 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)
	SGX	8 x 3.13	28.6 - 17.7 x 7.6				
	SSG, SPG	8 x 3.13					

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NOTES:

1. Products available: Single Look Complex (SLC); Path Image Plus (SGX); Path Image (SGF); Map Image (SSG); Precision Map Image (SPG).
2. All products are georeferenced. SLC, SGX and SGF are aligned with the satellite track. SSG and SPG are on a map projection (SPG requires ground control points).
3. For SLC products the range coordinate is in radar slant range. All other products are in ground range.
4. For SLC products the azimuth pixel spacing is nominal and depends on the PRF.
5. Resolution is nominal. Ground range resolution varies with incidence angle.
6. Scene size is nominal and may vary with incidence angle. All products except Spotlight products are available in longer strips in the azimuth direction.
7. Incidence angles are nominal values. They may be extended to lower and higher values in the future.
8. Polarizations Options: Single Co Pol [HH or VV]; Single Cross Pol [HV or VH]; Dual Pol [HH+HV or VV+VH]; Quad Pol [HH+VV+HV+VH]
9. All modes and product characteristics are subject to change. Some restrictions apply.

## **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 subsatellite track. Georeferenced products can be in either one of two coordinate systems: slant range or ground range. Products in ground range coordinates use a 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 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 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, some

beams give wider coverage than others, and an average value is given in the table. With the exception of Spotlight products, the nominal length for each product has been defined to be equal to the width in ground range. In general, however, a longer image can be generated if specified by the user. The maximum azimuth length for each beam and product type is listed in the table.

### **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. 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. To meet this criterion, 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.

### **Pixel Data Representation**

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

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

### **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:

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

Similarly the number of lines in an image is given by:

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

The image size stated in the tables is approximate, and corresponds 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 by the user.

Where products may contain data for more than one polarization, the image size information in the Product Description table is given per polarization channel.

### **Nominal Product Volume**

The nominal product volume is calculated as follows:

$$Volume = PixelsPerLine * Lines * BytesPerPixel$$

This volume corresponds to the Nominal Image Size except in Spotlight mode where it corresponds to a typical range. The auxiliary data attached to the image is not included in this volume.

Where products may contain data for more than one polarization, the product volume information in the Product Description table is given per polarization channel.

## **2.1.2 Processing Terms**

### **Number of Range Looks**

The number of range looks is the number of distinct or 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.

### **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.

### **Number of Samples in ScanSAR Matched Filter**

The number of samples in the matched filter is the number of azimuth samples (pulse returns) processed coherently in each ScanSAR look. This value is the same for all beams used in any one ScanSAR mode.

### **ScanSAR Azimuth Look Bandwidth**

This parameter is the Doppler bandwidth of the signal from any given target within the set of samples used for each ScanSAR look. For any ScanSAR mode, this bandwidth varies from beam to beam, and decreases from near edge to far edge within any one beam. The values given in the tables are for a point near the middle of the beam.

### **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 Range Resolution**

The nominal range resolution is specified in terms of the 3 dB Impulse Response Width (3 dB-IRW) in the range direction where:

The Impulse Response Function is the two-dimensional function appearing in a processed image as a result of the compression of returned energy from a point target.

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 can be stated either in ground range or slant range coordinates, depending on the product type. For ground range products, nominal range resolution values are stated for the near and far edges of each beam.

### **Nominal Azimuth Resolution**

Nominal azimuth resolution is specified in terms of the 3 dB Impulse Response Width in the azimuth direction. The nominal azimuth resolution is constant within each product.

### **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 ( $\sigma_0$ ) of an area which contributes a mean level in the image equal to the additive noise level. Any features which have backscatter lower than this level may be difficult to discern in the image. The NESZ level varies across the swath for any beam, and is generally lower (i.e. better) near the middle. 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 relative mean energies measured from the image product for two areas of uniform distributed target within a region equal in size to the nominal image coverage area for the given product.

### **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, 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 value is non-integer. 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.

### **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 tiepoint metadata). The values in the tables assume that the Earth's surface follows the shape of the geoid at a local elevation height as selected in

the Production Order. The typical performance figures in the table are based on use of the orbit data included in the X-band downlinked data. The use of ground truth data is not included.

### **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 (I and 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. 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 using the full available signal bandwidths. For dual or quad polarization SLC products, the images for different polarization channels are co-registered.

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

**Table 2-1 SLC Product Description**

	Standard	Fine Resolution	Multi-Look Fine Resolution	Ultra-Fine Resolution	Wide Swath	Extended High	Extended Low	Standard Quad Pol.	Fine Quad Pol.	Spotlight
Format	TIFF/GeoTIFF with ASCII metadata									
Output Media	Magnetic tape, local disk, CD-ROM									
Coordinate System	Slant Range									
Pixel Data Representation	16-bit I and 16-bit Q									
<b>Product Characteristics</b>										
Nominal Image Coverage (ground range x azimuth)	100 km x 100 km	50 km x 50 km	50 km x 50 km	20 km x 20 km	150 km x 150 km	75 km x 75 km	170 km x 170 km	25 km x 25 km	25 km x 25 km	18 km x 8 km
Maximum Image Azimuth Dimension	400 km (TBC)	200 km (TBC)	200 km (TBC)	100 km (TBC)	500 km (TBC)	400 km (TBC)	400 km (TBC)	100 km (TBC)	100 km (TBC)	8 - 11 km
Approximate Pixel Spacing (slant range x azimuth)	8.0m x 5.1m (S1-2) 11.8m x 5.1m (S3-7)	4.7 m x 5.1 m	2.7 m x 2.9 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	8.0m x 5.1m (near) 11.8m x 5.1m (far)	4.7 m x 5.1 m	1.3 m x 0.4 m
Approximate Image Size (pixels x lines)	6000 x 20000	8000 x 10000	14000 x 17000	9500 x 9500	7000 x 30000	5600 x 15000	6200 x 33000	1500 x 5000	3300 x 5000	8000 x 20000
Nominal Product Volume	~460 MBytes per polarization	~305 MBytes per polarization	~910 MBytes	~350 MBytes	~800 MBytes per polarization	~320 MBytes	~780 MBytes	~29 MBytes per polarization	~63 MBytes per polarization	400 - 1200 Mbytes
<b>Processing Parameters</b>										
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 (S3-7)	30 MHz	50 MHz	100MHz	11.6 MHz	11.6 MHz	17.3 MHz	17.3 MHz (near) 11.6 MHz (far)	30 MHz	100MHz
Azimuth Look Bandwidth	900 Hz	900 Hz	1500 Hz	2430 Hz	900 Hz	900 Hz	900 Hz	900 Hz	900 Hz	9400 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 (3.5)
<b>Typical Image Quality Characteristics</b>										
Nominal Slant Range Resolution	9.0 m (S1-2) 13.5 m (S3-7)	5.2 m	3.1 m	1.6 m	13.5 m	13.5 m	9.0 m	9.0m (SQ1-SQ11) 13.5m (SQ12-SQ31)	5.2 m	1.6 m
Nominal Azimuth Resn.	7.7 m	7.7 m	4.6 m	2.8 m	7.7 m	7.7 m	7.7 m	7.6 m	7.6 m	0.8 m
Equiv. No. of Indept. Looks	1	1	1	1	1	1	1	1	1	1
Noise-Equiv. Sigma-Zero	-29±2 dB	-26±3 dB	-21±3 dB	-24±3 dB	-28±2 dB	-28±4 dB	-29±2 dB	-40±3 dB	-36.5±3 dB	Centre: -24 - -31dB Corners: -15.5dB - -21dB
Radiometric Error	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB
Absolute Location Error	< 20 m	< 15 m	< 15 m	< 15 m	< 25 m	< 20 m	< 30 m	< 20 m	< 15 m	< 15 m
Relative Phase Error	<3°	<3°	<3°	<3°	<3°	<3°	<3°	<3°, <5° inter-pol	<3°, <5° inter-pol	<3°

## **2.3 Ground Range Products**

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. The products for Standard and Fine Quad-Polarization beams (SQ\* and FQ\*) contain detected data and are available in SGX form only.

For each ScanSAR mode, the ground range products are available in only one form, which is equivalent to SGF for single-beam products. The division of the ScanSAR products into SCN and SCW is according to the image width (Narrow or Wide). SCN products contain combinations of either beams W1+W2, or W2+S5+S6. SCW products contain combinations of either beams W1+W2+W3+S7 or W1+W2+W5+W6.

Spotlight mode products are available in SGF and SGX forms.

### **2.3.1 SGX Product (Path Image Plus)**

SGX products have a 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 2-2.

**Table 2-2 SGX Product Description**

	Standard	Fine (F) and Multi-Look Fine (MF) Res	Ultra-Fine Resolution	Wide Swath	Extended High	Extended Low	Standard Quad-Pol	Fine Quad-Pol	Spotlight
Format	TIFF/GeoTIFF with ASCII metadata								
Output Media	Magnetic tape, local disk, CD-ROM								
Coordinate System	Ground Range								
Pixel Data Representation	16-bit unsigned integer (magnitude detected)								
<b>Product Characteristics</b>									
Nominal Image Coverage (range x azimuth)	100 km x 100 km	50 km x 50 km	20 km x 20 km	150 km x 150 km	75 km x 75 km	170 km x 170 km	25 km x 25 km	25 km x 25 km	18 km x 8 km
Maximum Image Azimuth Dimension	400 km (TBC)	200 km (TBC)	100 km (TBC)	500 km (TBC)	400 km (TBC)	400 km (TBC)	100 km (TBC)	100 km (TBC)	8 - 11 km
Pixel Spacing (range x azimuth) a	8 m x 8 m	3.125 m x 3.125 m	1.0 m x 1.0 m	10 m x 10 m	8 m x 8 m	10 m x 10 m	8 m x 3.125 m	3.125 m x 3.125 m	1.0 m x 1/3 m
Nominal Image Size (pixels x lines)	12500 x 12500	16000 x 16000	20000 x 20000	15000 x 15000	9375 x 9375	17000 x 17000	3125 x 8000	8000 x 8000	18000 x 25000
Nominal Product Volume	298 MBytes per polarization	488 Mbytes per polarization	763 Mbytes	429 Mbytes per polarization	167 MBytes	550 MBytes	48 MBytes per polarization	122 MBytes per polarization	900 - 1300Mbytes
<b>Processing Parameters</b>									
Number of Range Looks	1	1 (F), 2 @ 33% overlap (MF)	1	1	1	1	1	1	1
Number of Azimuth Looks	4 with 39% overlap	1 (F), 2 @ 33% overlap (MF)	1	4 with 39% overlap	4 with 39% overlap	4 with 39% overlap	1	1	1
Range Look Bandwidth	17.3 MHz (S1-2) 11.6 MHz (S3-7)	30 MHz	100 MHz	11.6 MHz	11.6 MHz	17.3 MHz	17.3MHz (near) 11.6 MHz (far)	30 MHz	100 MHz
Azimuth Look Bandwidth	293 Hz	900 Hz	2430 Hz	293 Hz	293 Hz	293 Hz	900 Hz	900 Hz	9400 Hz
Range Spectral Weighting	Kaiser (2.8)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.8)	Kaiser (2.8)	Kaiser (2.8)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.4)
Azimuth Spectral Weighting	Kaiser (2.9)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.9)	Kaiser (2.9)	Kaiser (2.9)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (3.5)
<b>Typical Image Quality Characteristics</b>									
Nominal Range Resolution	See Table 2-3 to Table 2-7								
Nominal Azimuth Resolution	24.7 m	7.7 m (F) 7.6 m (MF)	2.8 m	24.7 m	24.7 m	24.7 m	7.6 m	7.6 m	0.8 m
Noise-Equivalent Sigma-Zero	-29±2 dB	-26±3 dB (F) -21±3 dB (MF)	-24±3 dB	-28±2 dB	-28±4 dB	-29±2 dB	-40±3 dB	-36.5±3 dB	Centre: -24 - -31dB Corners: -15.5dB - -21dB
Radiometric Error	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB
Equiv. No. of Independent Looks	3.4	1 (F), >3 (MF)	1	3.4	3.4	3.4	1	1	1
Absolute Location Error	< 20 m	< 15 m	< 15 m	< 25 m	< 20 m	< 30 m	< 20 m	< 15 m	< 15 m
Relative Phase Error	N/A								

**Table 2-3 Standard Beam Applicable Characteristics**

Beams	S1	S2	S3	S4	S5	S6	S7
Nominal Incidence Angles ( $^{\circ}$ )	20-27	24-31	30-37	34-40	36-42	41-46	45-49
Nominal Range Resolution (m)	26.8 – 20.0	22.6 – 17.6	27.0 – 22.7	24.8 – 21.4	23.1 – 20.3	20.7 – 18.8	19.5 – 18.0

**Table 2-4 Wide Swath Beam Applicable Characteristics**

Beams	W1	W2	W3
Nominal Incidence Angles ( $^{\circ}$ )	20-31	31-39	39-45
Nominal Range Resolution (m)	40.0 – 26.1	26.9 – 21.5	21.9 – 19.2

**Table 2-5 Fine and Multi-Look Fine Resolution Beam Applicable Characteristics**

Beams	F23	F22	F21	F1	F2	F3	F4	F5	F6
Nominal Incidence Angles ( $^{\circ}$ )	30-34	31-36	34-39	36-40	39-43	41-45	43-47	45-48	46-50
Nominal Range Resolution (m)	10.4-9.3	9.9-8.8	9.3-8.3	8.7-8.0	8.4-7.7	8.0-7.4	7.7-7.2	7.4-7.0	7.2-6.8

**Table 2-6 Extended Low and Extended High Beam Applicable Characteristics**

Beams	EL1	EH1	EH2	EH3	EH4	EH5	EH6
Nominal Incidence Angles ( $^{\circ}$ )	10-23	49-52	50-53	51-55	54-57	56-58	57-60
Nominal Range Resolution (m)	52.7-23.3	18.2-17.3	17.8-17.0	17.5-16.7	16.9-16.3	16.6-16.1	16.3-15.9

**Table 2-7 Ultra-Fine, Spotlight, Standard and Fine Quad Pol. Beam Applicable Characteristics**

Beams	U*	SLA*	SQ*	FQ*
Nominal Incidence Angles ( $^{\circ}$ )	20-49	20-49	18-49	18-49
Nominal Range Resolution (m)	4.6-2.1	4.6-2.1	28.6-17.7	16.5-6.8

### **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 ground range SGF products is provided in Table 2-8.

**Table 2-8 SGF Product Description**

	Standard	Fine (F) and Multi-Look Fine (MF) Res	Ultra-Fine Resolution	Wide Swath	Extended High	Extended Low	Spotlight
Format	TIFF/GeoTIFF with ASCII metadata						
Output Media	Magnetic tape, local disk, CD-ROM						
Coordinate System	Ground Range						
Pixel Data Representation	16-bit unsigned integer (magnitude detected)						
<b>Product Characteristics</b>							
Nominal Image Coverage (range x az)	100 km x 100 km	50 km x 50 km	20 km x 20 km	150 km x 150 km	75 km x 75 km	170 km x 170 km	18 km x 8 km
Maximum Image Azimuth Dimension	400 km (TBC)	200 km (TBC)	100 km (TBC)	500 km (TBC)	400 km (TBC)	400 km (TBC)	8 – 11 km
Pixel Spacing (range x azimuth)	12.5 m x 12.5 m	6.25 m x 6.25 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	13000 x 13000	12000 x 12000	6000 x 6000	13600 x 13600	36000 x 16000
Nominal Product Vol.	122 MBytes per polarization	122 MBytes per polarization	340 MBytes	274 MBytes per poln	69 MBytes	352 MBytes	1200 - 1800 Mbytes
<b>Processing Parameters</b>							
Number of Range Looks	1	1 (F), 2 @ 33% overlap (MF)	1	1	1	1	1
Number of Azimuth Looks	4 with 39% overlap	1 (F), 2 @ 33% overlap (MF)	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 (S3-7)	30 MHz	100 MHz	11.6 MHz	11.6 MHz	17.3 MHz	100 MHz
Az. Look Bandwidth	293 Hz	900 Hz	2430 Hz	293 Hz	293 Hz	293 Hz	9400 Hz
Range Spectral Weighting	Kaiser (2.8)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.8)	Kaiser (2.8)	Kaiser (2.8)	Kaiser (2.4)
Azimuth Spectral Weighting	Kaiser (2.9)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.9)	Kaiser (2.9)	Kaiser (2.9)	Kaiser (3.5)
<b>Typical Image Quality Characteristics</b>							
Nom. Range Resn <sup>a</sup>	See Table 2-3 to Table 2-7						
Nom. Az. Resn <sup>a</sup>	24.7 m	7.7 m (F) 7.6 m (MF)	2.8 m	24.7 m	24.7 m	24.7 m	0.8 m
Noise-Equivalent Sigma-Zero	-29±2 dB	-26±3 dB (F) -21±3 dB (MF)	-24±3 dB	-28±2 dB	-28±4 dB	-29±2 dB	Centre: -24 - -31dB Corners: -15.5dB - -21dB
Radiometric Error	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB
Equiv. No. of Independent Looks	3.4	1 (F), >3 (MF)	1	3.4	3.4	3.4	1
Absolute Location Error	< 20 m	< 15 m	< 15 m	< 25 m	< 20 m	< 30 m	< 15 m
Relative Phase Error	N/A						

<sup>a</sup> Information on resolution does not include the effects of undersampling in the SGF product.

### **2.3.3 SCN Product (ScanSAR Narrow)**

The SCN product is a ground coordinate multi-look image produced from data obtained in ScanSAR modes using either two or three single beams. Image pixels are 25 m square and scenes are nominally 300 km in each dimension. Longer scenes than nominal, up to a maximum length, can be generated if specified by the user. In general, the pixel spacing does not meet the Nyquist sampling criterion, and so the SCN product is the ScanSAR equivalent of an SGF product for a single beam mode. SCN products are generated using two looks in range and two looks in azimuth for a nominal total of four looks.

A description of SCN products is provided in Table 2-9. Beam mode applicable characteristics are included in Table 2-10.

### **2.3.4 SCW Product (ScanSAR Wide)**

The SCW product is a ground coordinate multi-look image produced from data obtained in ScanSAR modes using four single beams. Image pixels are 50 m square and scenes are nominally 500 km in each dimension. Longer scenes than nominal, up to a maximum length, can be generated if specified by the user. In general, the pixel spacing does not meet the Nyquist sampling criterion, and so the SCW product is the ScanSAR equivalent of an SGF product for a single beam mode. SCW products are generated using four looks in range and two looks in azimuth for a nominal total of eight looks.

A description of SCW products is provided in Table 2-9. Beam mode applicable characteristics are included in Table 2-11.

**Table 2-9 ScanSAR Product Description**

	SCN	SCW
Format	TIFF/GeoTIFF with ASCII metadata	
Output Media	Magnetic tape, local disk, CD-ROM	
Coordinate System	Ground Range	
Pixel Data Representation	selectable 8-bit or 16-bit unsigned integer (magnitude detected)	
<b>Product Characteristics</b>		
Nominal Image Coverage	300 km range x 300 km	500 km range x 500 km
Maximum Image Azimuth Dimension	1200 km (TBC)	3000 km (TBC)
Pixel Spacing (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)	273 MBytes per polarization	190 MBytes per polarization
<b>Processing Parameters</b>		
Number of Range Looks	2	4
Number of Azimuth Looks	2	2
Range Look Bandwidth	5.8 MHz	2.9 MHz
Number of Samples in Azimuth Matched Filter	See Table 2-10	See Table 2-11
Azimuth Look Bandwidth (Hz)	See Table 2-10	See Table 2-11
Range Spectral Weighting	Kaiser (2.8)	Kaiser (2.8)
Azimuth Spectral Weighting	Kaiser (2.9)	Kaiser (2.9)
<b>Typical Image Quality Characteristics</b>		
Nominal Range Resolution	See Table 2-10	See Table 2-11
Nominal Azimuth Resolution	See Table 2-10	See Table 2-11
Noise-Equiv. Sigma-Zero	-28.5±2.5 dB	28.5±2.5 dB
Radiometric Error	<1 dB	<1 dB
Equiv. No. of Indept. Looks	> 3	> 6
Absolute Location Error	< 50 m	< 100 m
Relative Phase Error	N/A	

**Table 2-10 ScanSAR Narrow Mode Applicable Characteristics**

	SCN				
	SCNA		SCNB		
Beam Combinations	W1	W2	W2	S5	S6
Nominal Incidence Angles (°)	20-31	31-39	31-39	36-42	41-46
Approx. Range Resolution (m)	91-60	61-49	61-49	52-46	47-43
Approx. Azimuth Resolution	46	52	68	69	77
Number of Samples in Matched Filter	112		85		
Azimuth Look Bandwidth (Hz)	174	155	117	116	104

**Table 2-11 ScanSAR Wide Mode Applicable Characteristics**

	SCW							
	SCWA				SCWB			
Beam Combinations	W1	W2	W3	S7	W1	W2	S5	S6
Nominal Incidence Angles <sup>(o)</sup>	20-31	31-39	39-45	45-49	20-31	31-39	36-42	41-46
Approx. Range Resolution (m)	183-120	122-98	99-88	89-82	183-120	122-98	105-93	94-86
Approx. Azimuth Resolution	90	101	100	113	90	101	103	113
Number of Samples in Matched Filter	58				58			
Azimuth Look bandwidth (Hz)	89	79	80	71	89	79	78	71

## **2.4 Geocorrected Products**

### **2.4.1 SSG Product (Map Image)**

An SSG product is generated by geocorrection of a Single Beam 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. 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 2-12.

### **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 2-13.

**Table 2-12 SSG Product Description**

	Standard	Fine (F) and Multi-Look Fine (MF) Res	Ultra-Fine Resolution	Wide Swath	Extended High	Extended Low	Standard Quad-Pol	Fine Quad-Pol	Spotlight
Format	TIFF/GeoTIFF with ASCII metadata								
Output Media	Magnetic tape, local disk, CD-ROM								
Coordinate System	USGS Supported Map Projections (see Table 2-13)								
Pixel Data Representation	8 or 16-bit unsigned integer (magnitude detected)								
<b>Product Characteristics</b>									
Nominal Image Coverage (range x azimuth)	100 km x 100 km	50 km x 50 km	20 km x 20 km	150 km x 150 km	75 km x 75 km	170 km x 170 km	25 km x 25 km	25 km x 25 km	18 km x 8 km
Pixel Spacing (range x azimuth) <sup>a</sup>	12.5 m x 12.5 m	6.25 m x 6.25 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	8 m x 3.125 m	3.125 m x 3.125 m	0.5 m x 0.5 m
Nominal Image Size (pixels x lines)	9268 x 9268	9268 x 9268	15000 x 15000	13902 x 13902	6951 x 6951	15755 x 15755	3620 x 9268	9268 x 9268	40000 x 20000
Nominal Product Volume <sup>b</sup>	82 MBytes per polarization	82 MBytes per polarization	225 MBytes	184 MBytes per polarization	46 MBytes	236 MBytes	32 MB per polarization	82 MB per polarization	700 - 1100 Mbytes
<b>Processing Parameters</b>									
Number of Range Looks	1	1 (F), 2 @33% overlap (MF)	1	1	1	1	1	1	1
Number of Azimuth Looks	4 with 39% overlap	1 (F), 2@ 33% overlap (MF)	1	4 with 39% overlap	4 with 39% overlap	4 with 39% overlap	1	1	1
Range Look Bandwidth	17.3 MHz (S1-2) 11.6 MHz (S3-7)	30 MHz	100 MHz	11.6 MHz	11.6 MHz	17.3 MHz	17.3 MHz (near) 11.6 MHz (far)	30 MHz	100 MHz
Azimuth Look Bandwidth	293 Hz	900 Hz	2430 Hz	293 Hz	293 Hz	293 Hz	900 Hz	900 Hz	9400 Hz
Range Spectral Weighting	Kaiser (2.8)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.8)	Kaiser (2.8)	Kaiser (2.8)	Kaiser (2.8)	Kaiser (2.4)	Kaiser (2.4)
Azimuth Spectral Weighting	Kaiser (2.9)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.9)	Kaiser (2.9)	Kaiser (2.9)	Kaiser (2.9)	Kaiser (2.4)	Kaiser (3.5)
<b>Typical Image Quality Characteristics</b>									
Nominal Range Resolution	See Table 2-3 to Table 2-7								
Nominal Azimuth Resolution	24.7 m	7.7 m (F) 7.6 (MF)	2.8 m	24.7 m	24.7 m	24.7 m	7.6 m	7.6 m	0.8 m
Noise-Equivalent Sigma-Zero	-29±2 dB	-26±3 dB (F) -21±3 dB (MF)	-24±3 dB	-28±2 dB	-28±4 dB	-29±2 dB	-40±3 dB	-36.5±3 dB	Centre: -24 - -31dB Corners: -15.5dB - -21dB
Radiometric Error	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB



	Standard	Fine (F) and Multi-Look Fine (MF) Res	Ultra-Fine Resolution	Wide Swath	Extended High	Extended Low	Standard Quad-Pol	Fine Quad-Pol	Spotlight
Equiv. No. of Independent Looks	3.4	1 (F), >3 (MF)	1	3.4	3.4	3.4	1	1	1
Absolute Location Error <sup>1</sup>	< 20 m	< 15 m	< 15 m	< 25 m	< 20 m	< 30 m	< 20 m	< 15 m	< 15 m
Relative Phase Error	N/A								

<sup>a</sup> Image sizes and product volumes given for a nominal 10-degree rotation.

<sup>b</sup> Product volume is shown for 8-bit detected pixel data representation. Volumes are double for 16-bit detected pixels.

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<sup>1</sup> Achieved geolocation accuracy is dependent on the quality of DEM used.

**Table 2-13 Map Projections Supported for Geocorrected Products**

<b>Standard Map Projections</b>	
Universal Transverse Mercator	Miller Cylindrical
Polar Stereographic	Modified Stereographic Conformal (Alaska)
Space Oblique Mercator (A and B)	Mollweide
<b>Additional Map Projections</b>	Oblated Equal Area
Albers Conical Equal-Artea	Oblique Mercator (A and B)
Azimuthal Equidistant	Orthographic
Equidistant Conic (A and B)	Polyconic
General Vertical Near-Side Perspective	Robinson
Gnomonic	Sinusoidal
Hammer	State Plane Coordinate Systems
Interrupted Goode	Stereographic
Interrupt Mollweide	Transverse Mercator
Lambert Azimuthal Equal-Area	Van der Grinten
Lambert Conformal Conic	Wagner IV
Mercator	Wagner VII

Further projections are available.

**Table 2-14 SPG Product Description**

	Standard	Fine (F) and Multi-Look Fine (MF) Res	Ultra-Fine Resolution	Wide Swath	Extended High	Extended Low	Standard Quad-Pol	Fine Quad-Pol	Spotlight
Format	TIFF/GeoTIFF with ASCII metadata								
Output Media	Magnetic tape, local disk, CD-ROM								
Coordinate System	USGS Supported Map Projections (see Table 2-13)								
Pixel Data Representation	8 or 16-bit unsigned integer (magnitude detected)								
<b>Product Characteristics</b>									
Nominal Image Coverage (range x azimuth)	100 km x 100 km	50 km x 50 km	20 km x 20 km	150 km x 150 km	75 km x 75 km	170 km x 170 km	25 km x 25 km	25 km x 25 km	18 km x 8 km
Pixel Spacing (range x azimuth) <sup>a</sup>	12.5 m x 12.5 m	6.25 m x 6.25 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	8 m x 3.125 m	3.125 m x 3.125 m	0.5 m x 0.5 m
Nominal Image Size (pixels x lines)	9268 x 9268	9268 x 9268	15000 x 15000	13902 x 13902	6951 x 6951	15755 x 15755	3620 x 9268	9268 x 9268	40000 x 20000
Nominal Product Volume <sup>b</sup>	82 MBytes per polarization	82 MBytes per polarization	327 MBytes	184 MBytes per polarization	46 MBytes	236 MBytes	32 MB per polarization	82 MB per polarization	700 - 1100 MB
<b>Processing Parameters</b>									
Number of Range Looks	1	1 (F), 2 @33% overlap (MF)	1	1	1	1	1	1	1
Number of Azimuth Looks	4 with 39% overlap	1 (F), 2@ 33% overlap (MF)	1	4 with 39% overlap	4 with 39% overlap	4 with 39% overlap	1	1	1
Range Look Bandwidth	17.3 MHz (S1-2) 11.6 MHz (S3-7)	30 MHz	100 MHz	11.6 MHz	11.6 MHz	17.3 MHz	17.3 MHz (near) 11.6 MHz (far)	30 MHz	100 MHz
Azimuth Look Bandwidth	293 Hz	900 Hz	2308 Hz	293 Hz	293 Hz	293 Hz	855 Hz	855 Hz	9400 Hz
Range Spectral Weighting	Kaiser (2.8)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.8)	Kaiser (2.8)	Kaiser (2.8)	Kaiser (2.8)	Kaiser (2.4)	Kaiser (2.4)
Azimuth Spectral Weighting	Kaiser (2.9)	Kaiser (2.4)	Kaiser (2.4)	Kaiser (2.9)	Kaiser (2.9)	Kaiser (2.9)	Kaiser (2.9)	Kaiser (2.4)	Kaiser (3.5)
<b>Typical Image Quality Characteristics</b>									
Nominal Range Resolution	See Table 2-3 to Table 2-7								
Nominal Azimuth Resolution	24.7 m	7.7 m (F) 7.6 (MF)	2.8 m	24.7 m	24.7 m	24.7 m	7.6 m	7.6 m	0.8 m
Noise-Equivalent Sigma-Zero	-29±2 dB	-26±3 dB (F) -21±3 dB (MF)	-24±3 dB	-28±2 dB	-28±4 dB	-29±2 dB	-40±3 dB	-36.5±3 dB	Centre: -24 - -31dB Corners: -15.5dB - -21dB
Radiometric Error	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB	<1 dB
Equiv. No. of Independent Looks	3.4	1 (F), >3 (MF)	1	3.4	3.4	3.4	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.								
Relative Phase Error	N/A								

<sup>a</sup> Image sizes and product volumes given for a nominal 10-degree rotation.

<sup>b</sup> Product volume is shown for 8-bit detected pixel data representation. Volumes are double for 16-bit detected pixels.

## A INCIDENCE ANGLES AND NOMINAL RESOLUTIONS PER BEAM

**Table A-1 Standard, Wide, Extended Low, Extended High, ScanSAR Narrow, ScanSAR Wide, Fine**

Beams	Near Incidence Angle (degs)	Far Incidence Angle (degs)	Nominal near resolution (m)	Nominal far resolution (m)	Beams	Near Incidence Angle (degs)	Far Incidence Angle (degs)	Nominal near resolution (m)	Nominal far 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
					F21F	35.4	38.5	9.0	8.3
W1	20.0	31.5	40.0	26.1	F1N	36.1	39.2	8.8	8.2
W2	30.6	39.5	26.9	21.5	F1	36.9	39.9	8.7	8.1
W3	38.7	45.3	21.9	19.2	F1F	37.7	40.6	8.5	8.0
					F2N	38.5	41.4	8.4	7.9
EL1	10.0	23.1	52.7	23.3	F2	39.3	42.1	8.2	7.8
					F2F	40.0	42.8	8.1	7.7
EH1	48.5	52.1	18.2	17.3	F3N	40.7	43.5	8.0	7.6
EH2	50.0	53.4	17.8	17.0	F3	41.4	44.1	7.9	7.5
EH3	51.6	54.9	17.4	16.7	F3F	42.0	44.7	7.8	7.4
EH4	54.4	57.0	16.8	16.3	F4N	42.7	45.3	7.7	7.3
EH5	55.5	58.1	16.6	16.1	F4	43.3	45.9	7.6	7.2
EH6	56.8	59.3	16.3	15.9	F4F	43.9	46.5	7.5	7.2
					F5N	44.5	47.1	7.4	7.1
SCNA	20.0	39.5	79.9	43.0	F5	45.2	47.7	7.3	7.0
SCNB	30.6	46.5	53.7	37.7	F5F	45.7	48.2	7.3	7.0
					F6N	46.3	48.7	7.2	6.9
SCWA	20.0	49.3	159.8	72.1	F6	46.9	49.3	7.1	6.9
SCWB	20.0	46.5	159.8	75.3	F6F	47.5	49.9	7.1	6.8

**Table A-2 Multi-Look Fine**

<b>Beams</b>	<b>Near Incidence Angle (degs)</b>	<b>Far Incidence Angle (degs)</b>	<b>Nominal near resolution (m)</b>	<b>Nominal far resolution (m)</b>
MF23	30.0	33.4	10.4	9.4
MF23F	30.8	34.2	10.2	9.3
MF22N	31.6	34.9	9.9	9.1
MF22	32.4	35.7	9.7	8.9
MF22F	33.1	36.4	9.5	8.8
MF21N	33.9	37.1	9.3	8.6
MF21	34.7	37.8	9.1	8.5
MF21F	35.4	38.5	9.0	8.3
MF1N	36.1	39.2	8.8	8.2
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	44.5	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 Ultra-Fine**

Beams	Near Incidence Angle (degs)	Far Incidence Angle (degs)	Nominal near resolution (m)	Nominal far 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
U2	30.6	32.0	3.1	3.0
U3	31.5	32.9	3.0	2.9
U4	32.3	33.7	2.9	2.8
U5	33.2	34.5	2.9	2.8
U6	34.0	35.3	2.8	2.7
U7	34.8	36.1	2.8	2.7
U8	35.6	36.9	2.7	2.6
U9	36.4	37.6	2.7	2.6
U10	37.2	38.4	2.6	2.5
U11	37.9	39.1	2.6	2.5
U12	38.7	39.9	2.5	2.5
U13	39.4	40.6	2.5	2.4
U14	40.1	41.3	2.4	2.4
U15	40.8	42.0	2.4	2.4
U16	41.5	42.7	2.4	2.3
U17	42.2	43.3	2.3	2.3
U18	42.9	44.0	2.3	2.3
U19	43.6	44.6	2.3	2.2
U20	44.2	45.3	2.3	2.2
U21	44.9	45.9	2.2	2.2
U22	45.5	46.5	2.2	2.2
U23	46.1	47.1	2.2	2.2
U24	46.8	47.7	2.2	2.1
U25	47.4	48.3	2.1	2.1
U26	47.9	48.9	2.1	2.1
U27	48.5	49.5	2.1	2.1

**Table A-4 Spotlight**

<b>Beams</b>	<b>Near Incidence Angle (degs)</b>	<b>Far Incidence Angle (degs)</b>	<b>Nominal near resolution (m)</b>	<b>Nominal far resolution (m)</b>
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
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

**Table A-5 Standard Quad, Fine Quad**

Beams	Near Incidence Angle (degs)	Far Incidence Angle (degs)	Nominal near resolution (m)	Nominal far resolution (m)	Beams	Near Incidence Angle (degs)	Far Incidence Angle (degs)	Nominal near resolution (m)	Nominal far resolution (m)
SQ1	18.4	20.4	28.6	25.9	FQ1	18.4	20.4	16.5	14.9
SQ2	20.0	21.8	26.4	24.3	FQ2	20.0	21.8	15.2	14.0
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