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RADARSAT CONSTELLATION MISSION
PRODUCT SPECIFICATION

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ACRONYMS AND ABBREVIATIONS

AIS	Automatic Identification System
BAQ	Block Adaptive Quantization
GB	Giga Byte
GCC	GeoCoded Complex
GCD	GeoCoded Detected
GeoTIFF	Geographic Tagged Image File Format
GRC	GRound range georeferenced Complex
GRD	GRound range georeferenced Detected
H	Horizontal
HH	Horizontal on transmit and Horizontal on receive
HV	Horizontal on transmit and Vertical on receive
ISLR	Integrated Side Lobe Ratio
LUT	Look Up Table
MDA	MDA Systems Ltd.
MLC	Multi-Look Complex
NESZ	Noise Equivalent Sigma Zero
NITF	National Imagery Transmission Format
PBW	Pulse BandWidth
PRF	Pulse Repetition Frequency
RCM	RADARSAT Constellation Mission
RF	Radio Frequency
SAR	Synthetic Aperture Radar
SC	SCanSAR
SCN	SCanSAR Narrow
SCW	SCanSAR Wide
SGX	SAR Georeferenced Extra
SLC	SLant range georeferenced Complex
SPG	SAR Precision Geocorrected

SSG	SAR Systematic Geocorrected
V	Vertical
VH	Vertical on transmit and Horizontal on receive
VV	Vertical on transmit and Vertical on receive
XML	eXtensible Markup Language

1 INTRODUCTION

This document defines the Image Products for the RADARSAT Constellation Mission (RCM).

1.1 Scope

This document is an interface control document which provides a high-level description of the Image Products for all RCM SAR imaging modes.

2 DOCUMENTS

2.1 Reference Documents

The following documents provide background information for this document.

R-1	RCM-SP-53-0419 (/P)	MDA, RCM Image Product Format Definition (public).
R-2	IEEE Std 149-1979	IEEE Standard Test Procedures for Antennas.

3 Image Products Summary

The abbreviations used for the various Image Product types are formed from two letters indicating the geographic coordinate system:

- SL - SLant range georeferenced
- GR - GRound range georeferenced
- GC - GeoCoded

Followed by a single letter indicating the data type:

- C - Complex
- D - Detected

There are a total of six different combinations covered in this document:

- **SLC** represents a SLant range georeferenced Complex product (i.e. equivalent to a Single-Look Complex product for RADARSAT-1 or RADARSAT-2).
- **GRD** or **GRC** represent GRound range georeferenced Detected and Complex products (GRD is equivalent to an SGX, SCN or SCW product for RADARSAT-1 or RADARSAT-2).
- **GCD** or **GCC** represent GeoCoded Detected and Complex products (GCD is equivalent to an SSG or SPG product for RADARSAT-1 or RADARSAT-2).
- **MLC** represent a Multi-Look slant range georeferenced Complex product for dual Co-/Cross-Polarization[1] or Compact Polarization which is a spatially averaged version of the **SLC** product condensed to a single multi-burst image of the covariance matrix elements. The covariance matrix elements consist of two real diagonal elements $|xH|^2$ and $|xV|^2$, and a complex off-diagonal element xH*conj(xV) where x is either Circular, H or V depending on the SLC product polarization setting and conj denotes the complex conjugate.

The RCM System will provide the Image Product types indicated by an "X" in Table 3-1, subject to the following notes:

- Descriptions in parentheses are provided to aid in understanding the mode, and contain nominal values as the actual values may vary with imaging altitude or with imaging incidence. Each description consists of the following items: mode type, swath width or spot size (ground range and azimuth dimensions), number of swath

[1] Although the MLC format supports both dual Co-/Cross-Polarization and Compact Polarization, its usefulness is mainly for Compact Polarization since the polarimetric phase of the dual Co-/Cross-Polarization products is not calibrated.

positions within the accessible swath, ground range and azimuth resolutions, range looks x azimuth looks. It should be noted that complex products (SLC, GRC and GCC) of modes designed for multi-looking will be produced with a single look in each dimension using the full bandwidth.

- All modes with the exception of the Quad-Polarization Mode include Single Polarization options (transmitting H or V and receiving either H or V polarization simultaneously) and Dual Co-/Cross-Polarization options (transmitting H or V polarization, and receiving both H and V polarization simultaneously). Additionally, these modes support a Compact Polarimetry option with circular polarization (right-handed defined according to the IEEE Standard convention [R-2]) on transmit and H and V polarization simultaneously on receive. Some modes (Medium Resolution 50m, Low Resolution 100m, High Resolution 5m and Very High Resolution 3m, Medium Resolution 16m, Medium Resolution 30m) also include a Dual HH-VV polarization option (HH polarization is collected from one set of bursts and VV polarization is collected from a second set of bursts time inter-leaved with the first set of bursts), but the performance numbers will be degraded for any Dual HH-VV polarization option of a mode relative to other polarization options. The Dual HH-VV polarization option has reduced swath width, degraded azimuth resolution or a reduced number of azimuth looks as indicated in Table 3-1. If a Dual HH-VV polarization option is provided, GRD and GCD product types will be supported, but no SLC, MLC, GRC or GCC products will be available. The Quad-Polarization Mode transmits H and V polarization alternately from pulse to pulse, and receiving both H and V polarization simultaneously.
- The Medium Resolution 50m High PRF mode provides improved azimuth ambiguity performance over the Medium Resolution 50m mode at the expense of higher downlink data rates and higher Raw Product data volumes. It does not support the Dual HH-VV polarization option.
- The Medium Resolution 50m High Incidence mode provides extended imaging access to the North Pole. This high incidence swath position has degraded range ambiguity performance and a reduced swath width relative to other swath positions of the Medium Resolution 50m Beam Mode Type. It does not support the Dual HH-VV polarization option.
- The Medium Resolution 50m mode, the Medium Resolution 50m High PRF mode and the Medium Resolution 50m High Incidence mode are different Beam Modes of the Medium Resolution 50m Beam Mode Type.

Table 3-1 RCM Modes and Image Product Types

	SLC	MLC	GRD	GRC	GCD	GCC
Ship Detection Mode Single, Dual Co-/Cross-Pol or Compact Pol (ScanSAR, 350km swath defined over a nominal incidence angle range of 40 to 58 degrees, variable resolution, 5x1 looks for detected and MLC products, 1 look for SLC products)	X	X except Single	X			
Low Noise Mode Single, Dual Co-/Cross-Pol or Compact Pol (ScanSAR, 350km swath, 4 overlapping swath positions evenly spaced within a 600km accessible swath defined by nominal incidence angle range of 19 to 58 degrees, 100m x 100m resolution,4x2 looks for detected products, 3x2 looks for MLC products, 1 look for SLC products)	X	X except Single	X		X	
Low Resolution 100m Mode Single, Dual Co-/Cross-Pol, Dual HH-VV Pol or Compact Pol (ScanSAR, 500km swath defined over a nominal incidence angle range of 19 to 54 degrees (250km swath with 4 evenly spaced swath positions within the same 500km accessible swath for Dual HH-VV), 100m x 100m resolution, 8x1 looks for detected products, 6x1 looks for MLC products, 1 look for SLC products)	X except Dual HH-VV	X except Single and Dual HH-VV	X		X	
Medium Resolution 50m Mode Single, Dual Co-/Cross-Pol, Dual HH-VV Pol or Compact Pol (ScanSAR, 350km (175km for Dual HH-VV) swath, 4 (6 for Dual HH-VV) overlapping swath positions evenly spaced within a 600km accessible swath defined by nominal incidence angle range of 19 to 58 degrees, 50m x 50m resolution, 4x1 looks for detected and MLC products, 1 look for SLC products)	X except Dual HH-VV	X except Single and Dual HH-VV	X		X	
Medium Resolution 50m High PRF Mode Single, Dual Co-/Cross-Pol or Compact Pol (ScanSAR, 350km swath, 4 overlapping swath positions evenly spaced within a 600km accessible swath defined by nominal incidence angle range of 19 to 58 degrees, 50m x 50m resolution, 4x1 looks for detected and MLC products, 1 look for SLC products)	X	X except Single	X		X	
Medium Resolution 50m High Incidence Mode Single, Dual Co-/Cross-Pol or Compact Pol (ScanSAR, 133km swath defined over a nominal incidence angle range of 55 to 60 degrees, 50m x 50m resolution, 4x1 looks for detected and MLC products, 1 look for SLC products)	X	X except Single	X		X	

	SLC	MLC	GRD	GRC	GCD	GCC
Medium Resolution 30m Mode Single, Dual Co-/Cross-Pol, Dual HH-VV Pol or Compact Pol (ScanSAR, 125km swath, 4 overlapping swath positions evenly spaced within a 350km accessible swath defined by nominal incidence angle range of 19 to 47 degrees, 30m x 30m resolution, 2x2 looks (2x1 looks in Dual HH-VV) for detected and MLC products, 1 look for SLC products)	X except Dual HH-VV	X except Single and Dual HH-VV	X		X	
Quad-Polarization Mode Quad Pol (Single beam, 20km swath, 21 overlapping swath positions evenly spaced within a 250km accessible swath defined by nominal incidence angle range of 24 to 44 degrees, nominally 9m x 9m resolution, 1 look)	X		X	X	X	X
Medium Resolution 16m Mode Single, Dual Co-/Cross-Pol, Dual HH-VV Pol or Compact Pol (Single Beam, 30km swath, 16 overlapping swath positions evenly spaced within a 350km accessible swath defined by nominal incidence angle range of 19 to 47 degrees, 16m x 16m resolution, 1x4 looks (1x2 looks in Dual HH-VV) for detected products, 1 look for complex products)	X except Dual HH-VV		X	X except Dual HH-VV	X	X except Dual HH-VV
High Resolution 5m Mode Single, Dual Co-/Cross-Pol, Dual HH-VV Pol or Compact Pol (Single Beam, 30km swath, 23 overlapping swath positions evenly spaced within a 500km accessible swath defined by nominal incidence angle range of 19 to 54 degrees, 5m x 5m (5m x 12m for Dual HH-VV) resolution, 1 look)	X except Dual HH-VV		X	X except Dual HH-VV	X	X except Dual HH-VV
Very High Resolution 3m Mode Single, Dual Co-/Cross-Pol, Dual HH-VV Pol or Compact Pol (Single Beam, 20km swath, 42 overlapping swath positions evenly spaced within a 500km accessible swath defined by nominal incidence angle range of 19 to 54 degrees, 3m x 3m (3m x 7.5m for Dual HH-VV) resolution at 35 degrees incidence, 1 look)	X except Dual HH-VV		X	X except Dual HH-VV	X	X except Dual HH-VV
Spotlight Mode Single, Dual Co-/Cross-Pol or Compact Pol (Single Beam, 20km x 5km spot size, 29 overlapping swath positions evenly spaced within a 350km accessible swath defined by nominal incidence angle range of 19 to 47 degrees, 3m x 1m resolution at 35 degrees incidence, 1 look)	X		X		X	

The RCM system will provide Image Products in a format that uses Geographic Tagged Image File Format (GeoTIFF) for imagery and Extensible Markup Language (XML) for metadata, or National Imagery Transmission Format (NITF) for imagery and metadata.

Since standard GeoTIFF format has a maximum file size of 4 GB, for GeoTIFF products the BigTIFF file format variant may be used where data volumes warrant.

The RCM metadata format is specified in [R-1].

4 IMAGE PRODUCT DESCRIPTIONS

4.1 Image Product Description Notes

Sampling

In Table 4-1 and Table 4-2, the Raw or complex image product sampling or pixel spacing in each dimension have been set so as to meet the Nyquist criterion: i.e. the sampling rate must exceed the bandwidth of the local signal content. For detected products, the range pixel spacing are set to either meet the Nyquist criterion or slightly under-sampled relative to Nyquist in order to obtain square pixel spacing for all imaging modes except Ship Detection while limiting the oversampling in azimuth for optimal product volume. The extent of the range under-sampling is beam swath dependent. The worst case range under-sampling relative to Nyquist among all imaging modes and all beam swaths is 17% and 6% respectively for GRD and GCD products, and 50% for MLC products (see Appendix A). The range under-sampling has only a minor impact on the detected products image quality while remaining compliant to mission level ISLR and resolution requirements. For complex products, the Nyquist criterion is equivalent to a requirement that the sampling rate exceeds the coherent processing signal bandwidth for each point. For detected and MLC products, it is equivalent to a requirement that the sampling rate to exceed the coherent signal processing bandwidth by at least a factor of 2. The sampling values for detected products in the Product Description Table are set to be round numbers or submultiples of 100m.

The ScanSAR SLC Image Products comprise a set of processed bursts spanning multiple beams. Within this set, each burst is processed into an image such that it comprises slant-range and azimuth image pixels which are coincident with a common output pixel grid for a swath position. Constant slant-range and azimuth pixel spacing are employed over the entire set of processed bursts spanning all beams in a swath position. Pixel spacings are defined in terms of the range and azimuth sampling rates which are chosen based on the highest pulse bandwidth multiplied by a range oversampling factor of 1.05 and the highest Doppler bandwidth per burst multiplied by an azimuth oversampling factor of 1.1 among all beams in a swath position (note: pixel spacing in time-based units can be obtained from the inverse of the sampling rates). The pulse bandwidth per beam per swath position for all ScanSAR modes are listed in Table 4-5. The Doppler bandwidth per burst is derived from the beam dwell time and for ScanSAR modes with more than one swath position, the beam dwell times have been chosen to produce approximately the same azimuth resolution for all beams in a mode resulting in one azimuth sampling rate for all swath positions in a mode.

The ScanSAR MLC Image Products employ a similar common output pixel grid as the corresponding ScanSAR SLC Image Products with the same azimuth pixel spacing and a slant range pixel spacing selected to achieve 50% under-sampling relative to Nyquist for a swath position. Exception is the Medium Resolution 50m High Incidence mode with half the azimuth pixel spacing of the SLC Image Products and a slant range pixel spacing selected to satisfy the Nyquist criterion. The processed bursts of the ScanSAR MLC Image Product are combined to form a single image.

The "Slant Range Sampling (m)" as given in the following Table 4-1 for ScanSAR SLC and MLC products is valid for the entire scene and is dependent on the range sampling rate chosen for a swath position. The "Azimuth Sampling (m)" as given in Table 4-1 for ScanSAR SLC products is only valid for the nominal spacecraft altitude of 605.7 km. It is dependent on the azimuth sampling rate chosen for a swath position as well as the spacecraft ground speed which is dependent on incidence angle and spacecraft altitude. The mid-incidence angle is 50 degrees for Ship Detection mode, 58 degrees for the Medium Resolution 50m High Incidence mode and 35 degrees for all other ScanSAR modes.

For single beam (Quad-Pol, Stripmap and Spotlight) SLC products, the Slant Range Sampling Rate as given in Table 4-1 is a function of pulse bandwidth and the pulse bandwidth can vary among beams in a mode. The Slant Range Sampling Rate is valid for the beam covering the 35 degrees mid-incidence angle. The Azimuth Sampling Rate is a function of the pulse repetition frequency (multiplied by one half for Quad-Pol, one for Stripmap and four for Spotlight) which is dependent on beam rank and spacecraft altitude. The Azimuth Sampling Rate as given in Table 4-1 is valid for the beam covering the 35 degrees mid-incidence angle and nominal spacecraft altitude.

BAQ Encoding

Most of the imaging modes in Table 4-1 and Table 4-2 can operate with 4-bit BAQ in single received polarization[2]. The Ship Detection Mode operates at 2-bit BAQ in single received polarization in order to support real-time downlink. Note that the Ship Detection Mode was designed as a single-polarization mode, with ship detection performance optimized for single co-pol operation. While it can in theory be operated in Compact Pol or dual co and cross Pol modes, this is not recommended as it would necessitate operation with 1-bit BAQ in order to satisfy the on-board storage maximum input data rate constraint. In practice, some modes may be operated with 3-bit or 2-bit BAQ at imaging incidence angles other than the mid-coverage swath incidence angle of 35 degrees due to the on-board storage data rate constraint. For Dual Co-/Cross-Polarization and Compact Pol operations with High Resolution 5m Mode, 2-bit BAQ or 3-bit BAQ is used to remain within the on-board storage data rate constraint depending

[2] Even if 4-bit BAQ is possible in single-polarization for most modes, a default value of 3-bit BAQ is often used in practice.

on swath position. For Dual Co-/Cross-Polarization and Compact Pol operations with Very High Resolution 3m Mode and Spotlight mode, 1-bit BAQ, 2-bit BAQ or 3-bit BAQ are used depending on swath position.

ScanSAR Single-Look Complex Products

In Table 4-1 and Table 4-2, ScanSAR SLC products have been included to allow interferometric information to be obtained when the data are used in combination with one or more other complex products from the same area. In order for the interferometric operations to be valid, the data that are combined from the two data sets must be obtained with equivalent ScanSAR bursts with the same beam. To enable this to be performed optimally, each block of complex image pixels formed from a single ScanSAR burst will be provided separately in the product, and not merged into a single image. In order to accommodate some azimuth pointing differences between different data collections used for interferometry, the successive blocks generated from bursts with the same beam will include more azimuth overlap than is required to form a continuous image.

Complex Image Products for Modes Designed for Multi-Looking

In Table 4-3 and Table 4-4, complex (SLC, GRC and/or GCC) products are provided for some modes that are defined so as to provide multi-look images at a specified resolution. These products will be produced with a single look in each dimension using the full pulse bandwidth in range and the processed bandwidth in azimuth. This allows users to perform multi-looking either by spatial averaging or by applying multiple spectral filters. This applies to complex products for Ship Detection, Medium Resolution 50m, Low Resolution 100m, Medium Resolution 16m, Medium Resolution 30m and Low Noise modes. (Note: For ScanSAR modes with two azimuth looks, i.e. the Medium Resolution 30m mode and the Low Noise mode, data for the two azimuth looks are in separate image blocks.)

Polarization Channels

Dual Polarization mode Image Products will be provided in the form of two layers of image pixels corresponding to the two polarization channels. The pixels for the two polarization channels are spatially registered.

The Quad-Polarization mode Image Products will be provided in the form of four layers of image pixels corresponding to the four polarization channels. The pixels for the four polarization channels are spatially registered.

MLC Image Products will be provided in the form of three layers of image pixels corresponding to the three covariance matrix elements. The pixels for the three covariance matrix elements are spatially registered.

Product Volumes

Raw Product volumes in Table 4-1 and Table 4-2 are mostly based on 4-bit BAQ operation of the radar (note: exception is the Ship Detection mode which operates at 2-bit BAQ in order to support real-time downlink) and for a single polarization channel (note: exception to the single polarization channel Raw Product volumes is the Quad-Polarization mode where the Raw Product volume includes all 4 polarization channels of HH, VV, HV and VH, and the dual HH-VV polarization options where the Raw Product volumes include the HH and VV polarization channels). Raw Product volume for Compact Pol Ship Detection mode at 1-bit BAQ with dual received polarizations is slightly less than the single pol Ship Detection mode at 2-bit BAQ as the Compact pol transmit pulse length is reduced by a factor of 2 in order to remain under the maximum Payload operating temperature limit. For radar operations with 3-bit, 2-bit or 1-bit BAQ due to on-board storage data rate constraint, the Raw Product volumes will be reduced approximately in proportion to the word length. The Raw Product volumes for Ship Detection Mode, Medium Resolution 50m m**o**de, Medium Resolution 50m High PRF mode and the Medium Resolution 50m High Incidence mode also include AIS signal data.

Approximate product volumes of all Image Product types except MLC given in Table 4-1 and Table 4-2 are for a single polarization channel. Approximate product volumes of the MLC Image Product type are for two polarization channels (Dual Co-/Cross-Pol or Compact Pol). Approximate Volume per km Along-Track for Spotlight mode represents the data volume for the entire Spotlight image.

The volume of a geocoded Image Product depends on the rotation required to bring the swath into a standard map orientation. Volumes given in Table 4-1 and Table 4-2 are for square scenes resulting from 45 degree rotation of a square swath or Spotlight image and include the addition of black-fill.

Ground Azimuth Dimensions

Ground azimuth dimensions given in Table 4-1 and Table 4-2 are those for square scenes except for Spotlight mode but non-square scene ground azimuth dimensions are also supported. The current processor design has placed restrictions on the azimuth dimension to be no longer than 1.5 times the width.

Application Specific Amplitude Scaling

For fixed point products, floating point image amplitude samples are scaled before conversion to fixed point detected and complex products according to user selectable Look Up Tables (LUTs). The scaling is performed primarily in accordance with application specific needs to prevent saturation and to preserve numerical precision in the conversion from floating point to fixed point pixel representations. The application specific LUT contains a scaling factor or gain that can vary with imaging incidence

angle and is selected according to the type of terrain covered by the product area. Available application specific LUTs will include Unity, Constant-beta, Constant-gamma, Constant-sigma, Ice, Sea, Land, Mixed, Point Target, Point Target-1, Point Target-2, Calibration-1, Calibration-2, Ship-1, Ship-2 and Ship-3. With the exception of the Unity LUT, all LUTs will be provided with two user selectable options: one option employs the same scaling factor for all polarization channels while a second option uses a different scaling factor for each of the five possible polarization combinations, i.e., HH, VV, HV/VH, CircularH and CircularV. The scaling factor applied to the MLC off-diagonal element is the geometric mean of the scaling factors applied to the diagonal elements for the paired polarization combinations of HH and HV, VH and VV, or CircularH and CircularV.

For floating point products, the available scaling LUTs are Unity-beta, Unity-gamma and Unity-sigma which produce floating point image amplitude samples with square of the amplitude samples representing beta-naught, gamma and sigma-naught values respectively.

4.2 Product Description Tables

The RCM System will provide products with the form and sampling stated in the "Form of data", "Range sampling" and "Azimuth sampling" rows of Table 4-1 and Table 4-2. It should be noted that the swath widths of the Medium Resolution 50m mode and the Low Resolution 100m mode Dual HH-VV Polarization option have been degraded to half of the other polarization options. The azimuth resolutions of the High Resolution 5m mode and the Very High Resolution 3m mode Dual HH-VV Polarization option have been degraded to 10m and 6m to 8m (increasing with incidence) respectively even though their azimuth sample spacing remain the same as the other polarization options.

The RCM System will provide products that have been processed with the numbers of looks and weighting function parameters stated in Table 4-3 and Table 4-4. It should be noted that for the Dual HH-VV Polarization option of the Medium Resolution 16m mode and the Medium Resolution 30m mode, the number of azimuth looks has been reduced by a factor of 2 relative to the other polarization options.

Table 4-1 Raw and Image Product Description Table - Contents and Volumes

	Ship Detection	Low Noise	Low Resolution 100m	Medium Resolution 50m	Medium Resolution 50m High PRF	Medium Resolution 50m High Incidence	Medium Resolution 30m	Quad-Polarization	Medium Resolution 16m	High Resolution 5m	Very High Resolution 3m	Spotlight
RAW												
Form of Data	continuous series of pulse returns											
Sample Representation	2-bit BAQ	BAQ blocks of 4-bit (I,Q) samples										
Average Pulse Return Line Length (µs)	226	205	198	205	205	162	154	101	149	151	107	107
Approx. Range Sampling (MHz)	54	16	21	21	21	16	20	48	24	72	108	108
Approx. Azimuth Sampling (Hz)	2700	2700	2800	2700	2900	2500	3300	4800	3100	3100	3600	3600
Approx. Volume per km Along-Track (Mbits)[1]	21	11	14	14	15	8	12	54	13	39	47	1010
SLC Fixed Point												
Form of Data	image blocks							continuous image swath				
Pixel Representation	16-bit I + 16-bit Q (2's complement signed integers)											
Average Slant Range Dimension (km)	27	26	24	26	26	19	18	12	18	18	12	12
Slant Range Sampling Rate (MHz)	105	17	34	34	34	15	34	48	24	72	108	108
Azimuth Sampling Rate (Hz)	218	95	95	188	188	181	306	2400	3100	3100	3600	14400
Slant Range Sampling (m)	1.4	8.9	4.5	4.5	4.5	10.2	4.5	3.1	6.3	2.1	1.4	1.4
Azimuth Sampling (m)	31.8	73.3	73.3	37.0	37.0	38.2	22.7	2.9	2.2	2.2	1.9	0.5
Approx. Volume per km Along-Track (Mbits)[1]	322	37	84	89	98	28	78	43	41	122	144	2870
Approx. Volume per Square Scene (Mbits)[1]	112409	12802	41795	30811	34144	3616	9684	851	1215	3645	2870	n/a
MLC Fixed Point												
Form of Data	continuous image swath							n/a	n/a	n/a	n/a	n/a
Pixel Representation	16-bit unsigned integer (magnitude detected) diagonal elements 16-bit 2's complement signed integer I + 16-bit 2's complement signed integer Q off-diagonal element							n/a	n/a	n/a	n/a	n/a
Average Slant Range Dimension (km)	27	26	24	26	26	19	18	n/a	n/a	n/a	n/a	n/a
Slant Range Sampling Rate (MHz)	26	7	7	11	11	9	19	n/a	n/a	n/a	n/a	n/a
Azimuth Sampling Rate (Hz)	218	95	95	188	188	362	306	n/a	n/a	n/a	n/a	n/a
Slant Range Sampling (m)	5.7	22.3	21.0	14.3	14.3	16.3	7.9	n/a	n/a	n/a	n/a	n/a
Azimuth Sampling (m)	31.8	73.3	73.3	37.0	37.0	38.2	22.7	n/a	n/a	n/a	n/a	n/a
Approx. Volume per km Along-Track (Mbits)[1]	97	9	13	25	25	24	27	n/a	n/a	n/a	n/a	n/a
Approx. Volume per Square Scene (Mbits)[1]	33827	2821	6131	8722	8722	3183	3324	n/a	n/a	n/a	n/a	n/a
GRD Fixed Point												
Form of Data	continuous image swath											
Pixel Representation	16-bit unsigned integer (magnitude detected)											
Ground Range Dimension (km)	350	350	500	350	350	133	125	20	30	30	20	20
Ground Azimuth Dimension (km)	350	350	500	350	350	133	125	20	30	30	20	5
Range Sampling (m)	4	40	40	20	20	20	12.5	2.5	6.25	2	1.25	0.33
Azimuth Sampling (m)	16	40	40	20	20	20	12.5	2.5	6.25	2	1.25	0.33
Approx. Volume per km Along-Track (Mbits)[1]	88	4	6	15	15	6	13	52	13	121	206	14420
Approx. Volume per Square Scene (Mbits)[1]	30667	1227	2504	4907	4907	709	1603	1026	370	3605	4102	n/a
GCD Fixed Point												
Form of Data	n/a	image area in standard map orientation										
Pixel Representation	n/a	16-bit unsigned integer (magnitude detected)										
Ground Range Dimension (km)	n/a	350	500	350	350	133	125	20	30	30	20	20
Ground Azimuth Dimension (km)	n/a	350	500	350	350	133	125	20	30	30	20	5
East-West Sampling (m)	n/a	25	25	12.5	12.5	12.5	8.33	1.67	4	1.25	0.8	0.25
North-South Sampling (m)	n/a	25	25	12.5	12.5	12.5	8.33	1.67	4	1.25	0.8	0.25
Approx. Volume per Square Scene (Mbits)[1]	n/a	6281	12818	25123	25123	3628	7210	4615	1803	18458	20028	80109
GRC Fixed Point												
Form of Data	n/a	n/a	n/a	n/a	n/a	n/a	n/a	continuous image swath				n/a
Pixel Representation	n/a	n/a	n/a	n/a	n/a	n/a	n/a	16-bit I + 16-bit Q				n/a
Ground Range Dimension (km)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	20	30	30	20	n/a
Ground Azimuth Dimension (km)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	20	30	30	20	n/a
Range Sampling (m)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	5	4	4	2.5	n/a
Azimuth Sampling (m)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	5	4	4	2.5	n/a
Approx. Volume per km Along-Track (Mbits)[1]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	26	61	61	103	n/a
Approx. Volume per Square Scene (Mbits)[1]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	513	1803	1803	2051	n/a

	Ship Detection	Low Noise	Low Resolution 100m	Medium Resolution 50m	Medium Resolution 50m High PRF	Medium Resolution 50m High Incidence	Medium Resolution 30m	Quad-Polarization	Medium Resolution 16m	High Resolution 5m	Very High Resolution 3m	Spotlight
GCC Fixed Point												
Form of Data	n/a	n/a	n/a	n/a	n/a	n/a	n/a	std. map orientation				n/a
Pixel Representation	n/a	n/a	n/a	n/a	n/a	n/a	n/a	16-bit I + 16-bit Q				n/a
Ground Range Dimension (km)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	20	30	30	20	n/a
Ground Azimuth Dimension (km)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	20	30	30	20	n/a
East-West Sampling (m)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	3.33	2.5	2.5	1.67	n/a
North-South Sampling (m)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	3.33	2.5	2.5	1.67	n/a
Approx. Volume per Square Scene (Mbits)[1]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	2308	9229	9229	9229	n/a
SLC Floating Point												
Form of Data	image blocks							continuous image swath				
Pixel Representation	32-bit I + 32-bit Q (IEEE 754-2008 binary32 floating point numbers)											
Average Slant Range Dimension (km)	27	26	24	26	26	19	18	12	18	18	12	12
Range Sampling (MHz)	105	17	34	34	34	15	34	48	24	72	108	108
Azimuth Sampling (Hz)	218	95	95	188	188	181	306	2400	3100	3100	3600	14400
Slant Range Sampling (m)	1.4	8.9	4.5	4.5	4.5	10.2	4.5	3.1	6.3	2.1	1.4	1.4
Azimuth Sampling (m)	31.8	73.3	73.3	37.0	37.0	38.2	22.7	2.9	2.2	2.2	1.9	0.5
Approx. Volume per km Along-Track (Mbits)[1]	643	74	168	177	196	55	155	86	324	243	287	5740
Approx. Volume per Square Scene (Mbits)[1]	224818	25603	83589	61622	68288	7232	19367	1701	9720	7290	5740	n/a
MLC Floating Point												
Form of Data	continuous image swath							n/a	n/a	n/a	n/a	n/a
Pixel Representation	IEEE 754-2008 binary32 floating point numbers (magnitude detected) diagonal elements 32-bit I + 32-bit Q (IEEE 754-2008 binary32 floating point numbers) off-diagonal element							n/a	n/a	n/a	n/a	n/a
Average Slant Range Dimension (km)	27	26	24	26	26	19	18	n/a	n/a	n/a	n/a	n/a
Range Sampling (MHz)	26	7	7	11	11	9	19	n/a	n/a	n/a	n/a	n/a
Azimuth Sampling (Hz)	218	95	95	188	188	362	306	n/a	n/a	n/a	n/a	n/a
Slant Range Sampling (m)	5.7	22.3	21.0	14.3	14.3	16.3	7.9	n/a	n/a	n/a	n/a	n/a
Azimuth Sampling (m)	31.8	73.3	73.3	37.0	37.0	38.2	22.7	n/a	n/a	n/a	n/a	n/a
Approx. Volume per km Along-Track (Mbits)[1]	194	17	25	50	50	48	54	n/a	n/a	n/a	n/a	n/a
Approx. Volume per Square Scene (Mbits)[1]	67653	5642	12262	17443	17443	6365	6647	n/a	n/a	n/a	n/a	n/a
GRD Floating Point												
Form of Data	continuous image swath											
Pixel Representation	IEEE 754-2008 binary32 floating point number (magnitude detected)											
Ground Range Dimension (km)	350	350	500	350	350	133	125	20	30	30	20	20
Ground Azimuth Dimension (km)	350	350	500	350	350	133	125	20	30	30	20	5
Range Sampling (m)	4	40	40	20	20	20	12.5	2.5	6.25	2	1.25	0.33
Azimuth Sampling (m)	16	40	40	20	20	20	12.5	2.5	6.25	2	1.25	0.33
Approx. Volume per km Along-Track (Mbits)[1]	176	8	11	29	29	11	26	103	25	241	411	28840
Approx. Volume per Square Scene (Mbits)[1]	61334	2454	5007	9814	9814	1418	3205	2051	739	7210	8204	n/a
GRC Floating Point												
Form of Data	n/a	n/a	n/a	n/a	n/a	n/a	n/a	continuous image swath				n/a
Pixel Representation	n/a	n/a	n/a	n/a	n/a	n/a	n/a	32-bit I + 32-bit Q				n/a
Ground Range Dimension (km)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	20	30	30	20	n/a
Ground Azimuth Dimension (km)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	20	30	30	20	n/a
Range Sampling (m)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	5	4	4	2.5	n/a
Azimuth Sampling (m)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	5	4	4	2.5	n/a
Approx. Volume per km Along-Track (Mbits)[1]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	52	121	121	206	n/a
Approx. Volume per Square Scene (Mbits)[1]	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1026	3605	3605	4102	n/a

[1]Approx. SLC product volume estimates have been computed for an imaging incidence angle of 35 degrees (50 degrees for Ship Detection Mode and 58 degrees for Medium Resolution 50m High Incidence Mode) using nominal pulse bandwidth and PRF values at nominal altitude. ScanSAR SLC products have included the highest combined burst image overlap and geoTIFF/NITF formatting overhead factors among swath positions of each imaging mode. Aprox. volumes of all other products except Raw products have included a geoTIFF/NITF formatting overhead factor of 1.05. Raw product volumes are maximum values computed among swath positions at either maximum or minimum orbit altitude and includes FRED Signal Data formatting overhead. 1 Mbit = 2^{20} bits.

Table 4-2 Raw and Image Product Description Table – Dual HH-VV Polarization Option Contents and Volumes

Dual HH-VV Polarization Option	Low Resolution 100m	Medium Resolution 50m	Medium Resolution 30m	Medium Resolution 16m	High Resolution 5m	Very High Resolution 3m
RAW						
Form of Data	continuous series of pulse returns					
Sample Representation	BAQ blocks of 4-bit (I,Q) samples					
Average Pulse Return Line Length (μs)	198	205	154	149	151	107
Approx. Range Sampling (MHz)	21	21	20	21	72	108
Approx. Azimuth Sampling (Hz)	2800	2800	3300	3100	3500	3500
Approx. Volume per km Along-Track (Mbits)[1]	13	14	12	13	45	50
GRD Fixed Point						
Form of data	continuous image swath					
Pixel Representation	16-bit unsigned integer (magnitude detected)					
Ground Range Dimension (km)	250	175	125	30	30	20
Ground Azimuth Dimension (km)	250	175	125	30	30	20
Range Sampling (m)	40	20	12.5	6.25	2	1.25
Azimuth Sampling (m)	40	20	12.5	6.25	2	1.25
Approx. Volume per km Along-Track (Mbits)[1]	3	8	13	13	121	206
Approx. Volume per Square Scene (Mbits)[1]	626	1227	1603	370	3605	4102
GCD Fixed Point						
Form of data	image area in standard map orientation					
Pixel Representation	16-bit unsigned integer (magnitude detected)					
Ground Range Dimension (km)	250	175	125	30	30	20
Ground Azimuth Dimension (km)	250	175	125	30	30	20
East-West Sampling (m)	25	12.5	8.33	4	1.25	0.8
North-South Sampling (m)	25	12.5	8.33	4	1.25	0.8
Approx. Volume per Square Scene (Mbits)[1]	3205	6281	7210	1803	18458	20028
GRD Floating Point						
Form of data	continuous image swath					
Pixel Representation	IEEE 754-2008 binary32 floating point number (magnitude detected)					
Ground Range Dimension (km)	250	175	125	30	30	20
Ground Azimuth Dimension (km)	250	175	125	30	30	20
Range Sampling (m)	40	20	12.5	6.25	2	1.25
Azimuth Sampling (m)	40	20	12.5	6.25	2	1.25
Approx. Volume per km Along-Track (Mbits)[1]	6	15	26	25	241	411
Approx. Volume per Square Scene (Mbits)[1]	1252	2454	3205	739	7210	8204

[1]Approx. product volumes have included a geoTIFF/NITF formatting overhead factor of 1.05 for all products except Raw products. Raw product volumes are maximum values computed among all swath positions at either maximum or minimum orbit altitude and includes FRED Signal Data formatting overhead. 1 Mbit = 2^{20} bits.

Table 4-3 Product Description Table - Processing Parameters

	Ship Detection	Low Noise	Low Resolution 100m	Medium Resolution 50m	Medium Resolution 50m High PRF	Medium Resolution 50m High Incidence	Medium Resolution 30m	Quad-Polarization	Medium Resolution 16m	High Resolution 5m	Very High Resolution 3m	Spotlight
Detected Products												
Number of Range Looks	5	4	8	4	4	4	2	1	1	1	1	1
Range Look Overlap (%)	30	30	30	30	30	30	30	n/a	n/a	n/a	n/a	n/a
Number of Azimuth Looks	1	2	1	1	1	1	2	1	4	1	1	1
Azimuth Look Overlap (%)	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a	30	n/a	n/a	n/a
Approx. Mid Range Look Bandwidth (MHz)	13	3	3	6	6	4	10	34	19	62	100	100
Approx. Azimuth Look Bandwidth (Hz)	198	86	86	171	171	165	279	882	489	1590	2671	8012
Range Look Weighting (Kaiser Parameter)	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Azimuth Look Weighting (Kaiser Parameter)	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Complex Products												
Number of Range Looks	1	1	1	1	1	1	1	1	1	1	1	1
Number of Azimuth Looks	1	1	1	1	1	1	1	1	1	1	1	1
Approx. Mid Range Look Bandwidth (MHz)	50	10	18	19	19	13	17	34	19	62	100	100
Approx. Azimuth Look Bandwidth (Hz)	198	86	86	171	171	165	279	882	1516	1590	2671	8012
Range Look Weighting (Kaiser Parameter)	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Azimuth Look Weighting (Kaiser Parameter)	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Multi-Look Complex Products												
Number of Range Looks	5	3	6	4	4	4	2	n/a	n/a	n/a	n/a	n/a
Range Look Overlap (%)	30	30	30	30	30	30	30	n/a	n/a	n/a	n/a	n/a
Number of Azimuth Looks	1	2	1	1	1	1	2	n/a	n/a	n/a	n/a	n/a
Approx. Mid Range Look Bandwidth (MHz)	13	4	4	6	6	4	10	n/a	n/a	n/a	n/a	n/a
Approx. Azimuth Look Bandwidth (Hz)	198	86	86	171	171	165	279	n/a	n/a	n/a	n/a	n/a
Range Look Weighting (Kaiser Parameter)	2.9	2.9	2.9	2.9	2.9	2.9	2.9	n/a	n/a	n/a	n/a	n/a
Azimuth Look Weighting (Kaiser Parameter)	2.9	2.9	2.9	2.9	2.9	2.9	2.9	n/a	n/a	n/a	n/a	n/a

Table 4-4 Product Description Table – Dual HH-VV Polarization Option Processing Parameters

Dual HH-VV Polarization Option	Low Resolution 100m	Medium Resolution 50m	Medium Resolution 30m	Medium Resolution 16m	High Resolution 5m	Very High Resolution 3m
Detected Products						
Number of Range Looks	8	4	2	1	1	1
Range Look Overlap (%)	30	30	30	n/a	n/a	n/a
Number of Azimuth Looks	1	1	1	2	1	1
Approx. Mid Range Look Bandwidth (MHz)	3	6	10	19	62	100
Approx. Azimuth Look Bandwidth (Hz)	80	159	265	489	663	1002
Range Look Weighting (Kaiser Parameter)	2.9	2.9	2.9	2.9	2.9	2.9
Azimuth Look Weighting (Kaiser Parameter)	2.9	2.9	2.9	2.9	2.9	2.9

Table 4-5 ScanSAR Beam Pulse Bandwidths

Ship Detection			Low Noise						Low Resolution 100m			Medium Resolution 50m and Medium Resolution 50m High PRF						Medium Resolution 50m High Incidence			Medium Resolution 30m					
Beam	Swath	PBW	Beam	Swath				PBW	Beam	Swath	PBW	Beam	Swath				PBW	Beam	Swath	PBW	Beam	Swath				PBW
SC	1	(MHz)	SC	1	2	3	4	(MHz)	SC	1	(MHz)	SC	1	2	3	4	(MHz)	SC	5	(MHz)	SC	1	2	3	4	(MHz)
28	x	100	1	x				16	1	x	32	1	x				32	38	x	14	15	x				32
29	x	76	2	x				14.5	2	x	29	2	x				29	39	x	14	16	x				29
30	x	65	3	x	x			12.5	3	x	25	3	x	x			25	40	x	14	17	x				25
31	x	57	4	x	x			11	4	x	22	4	x	x			22	41	x	14	18	x	x			22
32	x	50	5	x	x	x		9.5	5	x	19	5	x	x	x		19	42	x	14	19		x			22
33	x	44	6	x	x	x		8.75	6	x	17.5	6	x	x	x		17.5	43	x	14	20		x			19
34	x	44	7	x	x	x	x	8.75	7	x	17.5	7	x	x	x	x	17.5				21		x	x		17.5
35	x	32	8	x	x	x	x	8	8	x	16	8	x	x	x	x	16				22			x		17.5
36	x	25	9		x	x	x	7.5	9	x	15	9		x	x	x	15				23			x		16
37	x	25	10		x	x	x	7.5	10	x	15	10		x	x	x	15				24			x	x	15
			11			x	x	7	11	x	14	11			x	x	14				25				x	15
			12			x	x	7	12	x	14	12			x	x	14				26				x	14
			13				x	7				13				x	14				27				x	14
			14				x	7				14				x	14									

A DETECTED PRODUCTS RANGE UNDER-SAMPLING

Table A-1 Detected and MLC Products Range Under-Sampling

	Ship Detection	Low Noise	Low Resolution 100m	Medium Resolution 50m	Medium Resolution 50m High PRF	Medium Resolution 50m High Incidence	Medium Resolution 30m	Quad-Polarization	Medium Resolution 16m	High Resolution 5m	Very High Resolution 3m	Spotlight
GRD												
Range Sampling (m)	4	40	40	20	20	20	12.5	2.5	6.25	2	1.25	0.33
Range Sampling Relative To Nyquist	1.06	0.88	0.83	0.88	0.88	0.95	0.89	1.14	0.91	0.87	0.87	3.33
GCD												
Range Sampling (m)	n/a	25	25	12.5	12.5	12.5	8.33	1.67	4	1.25	0.8	0.25
Range Sampling Relative To Nyquist	n/a	0.99	0.94	0.99	0.99	1.08	0.94	1.21	1.01	0.98	0.96	3.12
MLC												
Slant Range Sampling (m)	5.7	22.3	21.0	14.3	14.3	16.3	7.9	n/a	n/a	n/a	n/a	n/a
Slant Range Sampling Relative To Nyquist	0.50	0.50	0.50	0.51	0.51	1.02	0.51	n/a	n/a	n/a	n/a	n/a

Dual HH-VV Polarization Option	Low Resolution 100m	Medium Resolution 50m	Medium Resolution 30m	Medium Resolution 16m	High Resolution 5m	Very High Resolution 3m
GRD						
Range Sampling (m)	40	20	12.5	6.25	2	1.25
Range Sampling Relative To Nyquist	0.83	0.88	0.89	0.91	0.87	0.89
GCD						
Range Sampling (m)	25	12.5	8.33	4	1.25	0.8
Range Sampling Relative To Nyquist	0.94	0.99	0.94	1.01	0.98	0.98