RADARSAT-2 PRODUCT FORMAT DEFINITION

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

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CHANGE RECORD

ISSUE	DATE	PAGE(S)	DESCRIPTION	RELEASE
0/1	May 14, 2001	All	Draft – First Revision	
1/0	Nov. 19, 2001	All	First Issue	
1/1	March 15, 2002	See change bars	Updated for RIDs received at PDS PDR: RSI-RSI-8 CCRS-TIL-11 CCRS-TIL-12 CIS-CIS-6 RSI-RSI-9 RSI-RSI-10	
1/2	June 19, 2002	See change bars	First Issue – Second Revision Updated for corrections discovered during detailed design of product formatting software, and to add specification of units.	
1/3	Feb. 13, 2003	See change bars	First Issue – Third Revision Updated for corrections discovered during implementation of product formatting software.	
1/4	July 28, 2003	Section 5, Pages 18, 19, 24, 25, 34, 37 and 42	First Issue – Fourth Revision Added new fields to handle product flipping to nominally north-up and east-right. Clarified LUTs do not apply to SSG and SPG products.	
1/5	Nov. 24, 2003		First Issue – Fifth Revision	
		5-8	Changed pulsesTransmittedPerDwell to pulsesReceivedPerDwell	
		5-29 to 5-31	Added description of Rational Function	

ISSUE	DATE	PAGE(S)	DESCRIPTION	RELEASE
1/6	June 20, 2007	(viii)	First Issue, Sixth Revision	
		(ix) 1-1	Corrected beamModeMnemonicType to beamList in 9 places	
		2-1	Added chirpPower description	
		5-2, 5-7, 5-8, 5-9,	Added new field, crossCorrelationPeakLoc, to Chirp Quality (ref. Bugzilla 2331)	
		5-16, 5-18, 5-19, 5-20,	Spotlight mode addition	
		5-21, 5-22, 5-24, 5-25	Other updates pertaining to Bugzilla Issues 1580, 2265, and 2594.	
1/7	Mar. 14, 2008		First Issue, Seventh Revision	
			Pre-Launch and Commissioning Phase Updates.	
		5-5, 5-40	Corrected copyright string.	
		5-8	Clarified settableGain	
		5-13	Clarified yaw, roll, pitch.	
		5-14	Corrected payload characteristics ParameterFile min/max values	
		5-15	Added spotlightRadiometricCorrection	
		5-16	Corrected roll angle units attribute. Clarified zeroDopplerTimeFirstLine and zeroDopplerTimeLastLine	
		5-18	Corrected dopplerCentroidCoefficients	
		5-19	Corrected dopplerRateValuesCoefficient, and phaseCoefficients.	
		5-21	Corrected groundToSlantRangeCoefficients.	
		5-33	Corrected ellipsoid parameters.	
		5-36	Corrected acquisitionIdentifiers	
		6-3	Corrected Geotiff fields	
		7-1 – 7-3	Updated Labelling content, updated File Organization and Naming content	

ISSUE	DATE	PAGE(S)	DESCRIPTION	RELEASE
1/8	Aug. 23, 2010		First Issue, Eight Revision	
			Miscellaneous updates from Operations Phase.	
		5-17	Updated azimuthLookBandwidth description.	
		1-1	Updated Scope section.	
		2-1	Updated Documents A-1, R-10.	
		5-40	Added a reference to Document R-11.	
		7-3	Added local disk product naming convention.	
		5-24	Removed erroneous entry in Table 5-23 cell corresponding to first row, column “Attributes”.	
		5-31	Corrected description for zone.	
		Table 6-1	Corrected descriptions of PlanarConfiguration and SampleFormat	
		Table 5-14	Corrected the description for “lutApplied” field: “Constant-Beta” => “Constant-beta”	
		Table 5-14	Corrected description for field “interPolarizationMatricesCorrection”	
		Table 5-3	Corrected description of “pulseLength” and “pulseBandwidth”	
		5-36	Added “NITF 2.1” to “productFormatIdentifiers”	
1/9	Jan. 18, 2011	5-7, 5-39	Adding wide versions of Standard Quad-Pol, Fine Quad-Pol, Fine, Ultra-Fine and Multi-look Fine in the description of “beamModeMnemonic” and “beamModeMnemonicType”	

ISSUE	DATE	PAGE(S)	DESCRIPTION	RELEASE
1/10	Aug. 17, 2011		First Issue, Tenth Revision	
			Added 2 new ScanSAR product types (SCF and SCS) and new metadata associated with single azimuth look ScanSAR beam modes, and updated descriptions of metadata related to noise subtraction for the ScanSAR beam modes. Also, addressed various issues identified by the calibration team.	
1/11	Mar. 15, 2013		First Issue, Eleventh Revision	
		Section 1.3, A	Add new appendix describing image coordinate systems.	
		Section 5.5.4	Added description of Spotlight Synthetic Aperture Time	
		Section 6	Update to addition of BigTIFF and explanation regarding endianness	
		Section 7	Restructured and added more content describing Look-Up Table Files	
		Table 6-3	Add field ProjNatOriginLongGeoKey	
		Table 5-3	Update referenceNoiseLevel description	
		Table 5-43	Update beamModeMnemonicType	
		Table 5-2	Update beamModeMnemonic	
		Table 5-40	Update acquisitionIdentifiers	
		Table 5-42All	Update beamListVarious minor updates and corrections.	
1/12	July 15, 2014		First Issue, Twelfth Revision	
			ECN C23499	
		Table 5-3	Clarify description of adcSamplingRate	
		Table 5-30	Clarify description of resamplingKernel	
		Section 4.3, Table 8-1	Update description of Readme.txt Add description of KML file	

ISSUE	DATE	PAGE(S)	DESCRIPTION	RELEASE
1/13	Jan. 13, 2016		First Issue, Thirteenth Revision	
			ECN C27038	
		Tables 5-13, 4-17, 5-18	Clarified descriptions of Doppler centroid Doppler rate, and ground to slant range coefficients	
		Tables 5-15, 5-28, 5-35, 5-38	Clarified descriptions of reported geodetic coordinates and heights (all are with respect to the reference ellipsoid).	
		Table 6-1	Clarified descriptions of BitsPerSample	
		Table 5-1	Increased ProductId length restriction	
1/14	May 16, 2016		First Issue, Fourteenth Revision	
			ECN C27917	
		Table 5-12	Clarified attitude angles descriptions	
		Table 5-21	Corrected clarification of ground to slant range coefficients made in previous version	
1/15	Oct. 26, 2016		First Issue, Fifteenth Revision	
			ECN C28334	
		Section 5.4.2.1	Corrected range ambiguity length equation	
		Section 7.2	Clarified descriptions of calibrated backscatter values	
		Section 7.4	Added clarification notes, corrected radiometric scaling values for 8-bit geocoded products	
		Section 8.3	Updated to reflect the content and naming of current products	

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ACRONYMS AND ABBREVIATIONS

ARC	Albers Conical Equal Area
ASCII	American Standard Code for Information Interchange (text)
BAQ	Block Adaptive Quantization
bit	binary digit
BSQ	Band Sequential
BIP	Band Interleaved by Pixel
CC	Cubic Convolution
CD	Compact Disk
CD-ROM	Compact Disk - Read Only Memory
cm	centimeter
CSA	Canadian Space Agency
dB	decibel
deg	degrees
DEM	Digital Elevation Model
DV	Detection of Vessels
EH	Extended coverage High incidence beam
EL	Extended coverage Low incidence beam
F	Fine resolution beam
FQ	Fine resolution Quad-polarization beam
FRED	Framed Raw Expanded Data
GATN	Gatineau satellite station
GByte	gigabyte
GeoTIFF	Geographic extensions to the Tagged Image File Format
GHz	Gigahertz
GSI	Geospatial Services, International (a division of MDA)
HH	Horizontal polarization on transmit, Horizontal polarization on receive
HV	Horizontal polarization on transmit, Vertical polarization on receive
Hz	Hertz
HTML	Hypertext Markup Language
I/Q	In phase/Quadrature
ID	Identifier
kHz	kilohertz

km	kilometer
KML	Keyhole Markup Language
LCC	Lambert Conformal Conic
LUT	Look-Up Table
m	meter
MDA	MDA Systems Ltd.
MF	Multi-Fine resolution beam
MHz	megahertz
mm	millimeter
MODEX	Moving Object Detection Experiment
ms	millisecond
MX	MODEX
N	North
NITF	National Imagery Transmission Format
NN	Nearest Neighbor
ns	nanosecond
NSP	National Systems Projection
OS	Ocean Surveillance
PASS	Prince Albert Satellite Station
PDS	Processing and Delivery Subsystem
PRI	Pulse Repetition Interval
PS	Progressive ScanSAR
rad	radians
RADAR	Radio Detection and Ranging
RADARSAT	Radar Satellite
RAW	Raw signal data product
RMS	Root mean square
s	second
S	South
S	Standard beam
SAR	Synthetic Aperture Radar
SCF	ScanSAR Fine product type
SCN	ScanSAR Narrow product type
SCNA	ScanSAR Narrow “A” beam mode mnemonic

SCNB	ScanSAR Narrow “B” beam mode mnemonic
SCS	ScanSAR Sampled product type
SCW	ScanSAR Wide product type
SCWA	ScanSAR Wide “A” beam mode mnemonic
SCWB	ScanSAR Wide “B” beam mode mnemonic
SGC	SAR Georeferenced Coarse product
SGF	SAR Georeferenced Fine product
SGX	SAR Georeferenced Extra-Fine product
SL	Spotlight
SLC	Single Look Complex
SPG	SAR Precision Geocorrected product
SQ	Standard Quad-polarization beam
SSG	SAR Systematic Geocorrected product
STPL	State Plane
TIFF	Tagged Image File Format
TOPS	Terrain Observation by Progressive Scans
U	Ultra-Fine resolution beam
μs	microsecond
UPS	Universal Polar Stereographic
UTC	Universal Time Coordinated
UTM	Universal Transverse Mercator
VH	Vertical polarization on transmit, Horizontal polarization on receive
VV	Vertical polarization on transmit, Vertical polarization on receive
W	Watts
W	Wide swath beam
W3C	World Wide Web Consortium
XML	Extensible Markup Language
XF	Extra-Fine resolution beam
XSL	Extensible Stylesheet Language
XSLT	XSL for Transformations

1 INTRODUCTION

1.1 Purpose

This document defines the RADARSAT-2 product format for georeferenced and geocorrected (geocoded) products.

Georeferenced products include slant range (SLC) and ground range (SGF, SGX, SGC, SCN, SCW, SCF, SCS) products. Geocorrected products include systematic (SSG) and precision (SPG) geocoded products.

The format of RAW data products is specified in the FRED Product Specification (Document R-2).

1.2 Scope

This document specifies the content, format and organization of RADARSAT-2 products as generated by the RADARSAT-2 processor. Detailed information on the classification of RADARSAT-2 products and sensor characteristics are provided in the RADARSAT-2 Product Description (Document A-1).

The primary format for the imagery data follows the GeoTIFF specification (Document R-4). Alternatively, "RADARSAT-2 NITF 2.1 Product Format Definition" (Document R-12) specifies the format for the imagery data following the NITF specification (Document R-9).

Based on this document, a set of XML schema files have been derived which provide the definitive definition of the XML metadata. The schemas are included with every RADARSAT-2 product. In the case where the contents of this document differ from the schemas, the schemas shall be taken as the definitive definition.

This document is intended for use by MDA, GSI, CSA and end users of RADARSAT-2 products.

1.3 Document Structure

- **Section 1** identifies the purpose and scope of this document.
- **Section 2** lists applicable and reference documents.
- **Section 3** provides a discussion of the concept of RADARSAT-2 products.
- **Section 4** provides a description of the types of files that make up a RADARSAT-2 product.

- **Section 5** presents the definition of the content and format of the metadata in the product information file, and provides examples of using it to support post-processing calculations.
- **Section 6** presents the definition of the GeoTIFF image pixel data format.
- **Section 7** presents the definition of the output scaling look-up table file format.
- **Section 8** describes the organization of the product files.
- **Appendix A** presents the RADARSAT-2 image coordinate reference systems.

2 DOCUMENTS

2.1 Applicable Documents

The following documents of the date/revision indicated form part of this document to the extent referenced herein. Any conflict between this document and any of the applicable documents should be brought to the attention of MacDonald Dettwiler for resolution.

A-1	RN-SP-52-1238	RADARSAT-2 Product Description, Issue/Revision 1/9, MacDonald Dettwiler.

2.2 Reference Documents

The following documents provide useful reference information associated with this document. These documents are to be used for information only. Changes to the date/revision number (if provided) do not make this document out of date.

R-1	RK-IC-51-2386	RADARSAT-2 Ground Segment Processing & Distribution Subsystem to Product Recipient Interface Control Document, MacDonald Dettwiler.
R-2	DG-MA-50-6897	Framed Raw Expanded Data Product Specification.
R-3		TIFF Revision 6.0, Aldus Corporation, June 3, 1992.
R-4		GeoTIFF Format Specification, GeoTIFF Revision 1.0, Version 1.8.2, November 10, 1995, Niles Ritter and Mike Ruth.
R-5		Extensible Markup Language (XML) 1.0 (Second Edition), W3C Recommendation, 6 October 2000.
R-6		XSL Transformations (XSLT) Version 1.0, W3C Recommendation, November 16, 1999.
R-7		XML Schema Part 1: Structures, W3C Recommendation, May 2, 2001.
R-8		XML Schema Part2: Datatypes, W3C Recommendation, May 2, 2001.

R-9	STDI-0002	Compendium of Controlled Extensions for the NITF, Version 2.1, November 16, 2000.
R-10	RN-TN-53-0076	Geolocation of RADARSAT-2 Georeferenced Products, MacDonald Dettwiler.
R-11	PG-TN-52-7196	RADARSAT-2 Application Look-Up Tables (LUT), MacDonald Dettwiler.
R-12	RN-SP-52-8207	RADARSAT-2 NITF 2.1 Product Format Definition, MacDonald Dettwiler.

3 CONCEPTS

The objective of this RADARSAT-2 product format definition is:

1. to define a product format that focuses on the knowledge and information that make up the product;
2. to take a dynamic view of products, allowing third-party image processing tools to iteratively enhance a product by adding new knowledge or information; and
3. to make it easy for the end user to use such products by ensuring that the format is both widely supported and based on current technologies.

In order to meet this objective, the RADARSAT-2 product format definition is based upon a number of key concepts:

1. A product is simply a collection of information, often loosely referred to as image data and accompanying metadata. Throughout the remainder of this document, the term product means simply a collection of information; image pixel data is regarded as just another type of information presented in a raster organization.
2. This information is layered. The base layer describes the source(s) of the raw information. Additional layers are then appended, incorporating information which describe various aspects of the product such as the location and format of the image pixel data, the geometric and radiometric aspects of the imagery, and the results of applying various processing steps. Within each layer, the information is arranged hierarchically.
3. The metadata is captured using Extensible Markup Language (XML). Such an approach is an industry accepted standard for the interchange of information, is easy to use and understand by both human and machine, and is recognized by many third-party tools such as translators, browsers, databases and image processors.
4. Any image format can potentially be used to store the pixel information. The product identifies the format and provides references to the file(s) which contain the image pixel information, and it is the responsibility of the end user to ensure that he/she has the necessary tools that can correctly interpret the specified format. The RADARSAT-2 processor generated products nominally follow the GeoTIFF format, which is the geographic extension of the TIFF format. Alternatively, products can be generated following the NITF format. Both of these are industry accepted standards and are already supported by most image processors.
5. This product specification deliberately does not support raw, unprocessed sensor data, preferring instead to use a single format, namely FRED, for the interchange of all such level 0 data.

The diagram in Figure 3-1 provides a pictorial view of a hypothetical RADARSAT-2 product. The top of the diagram shows the basic product as generated by the RADARSAT-2 processor and defined in this document. Subsequent image processing steps have been applied to this product, initially by a theoretical RADARSAT-2 value-added processing system, followed by the end user's own image processing tools. In this example, quick-look, map overlay, thematic and annotation information was added, and the results of applying a "detection" algorithm (which may, for example, identify oil spills, floods, ice, etc.) were then incorporated. The result is a complete, multi-layered set of information that constitutes a product.

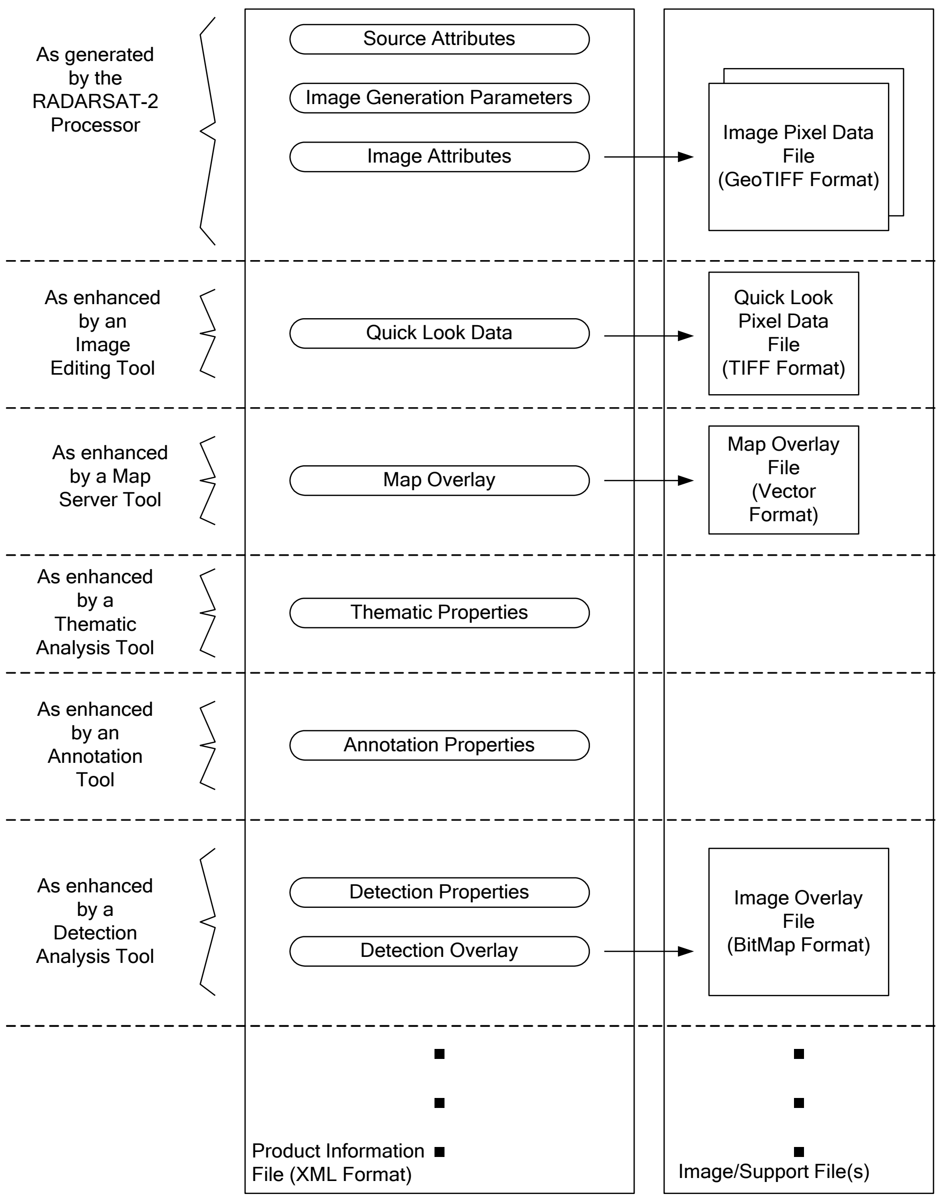

Figure 3-1 Product Format Concept

4 PRODUCT COMPOSITION

This section describes the different types of files included within RADARSAT-2 products. The basic product as generated by the RADARSAT-2 processor contains a Product Information File and one or more Image Pixel Data Files. The composition of RADARSAT-2 products is shown in Figure 4-1.

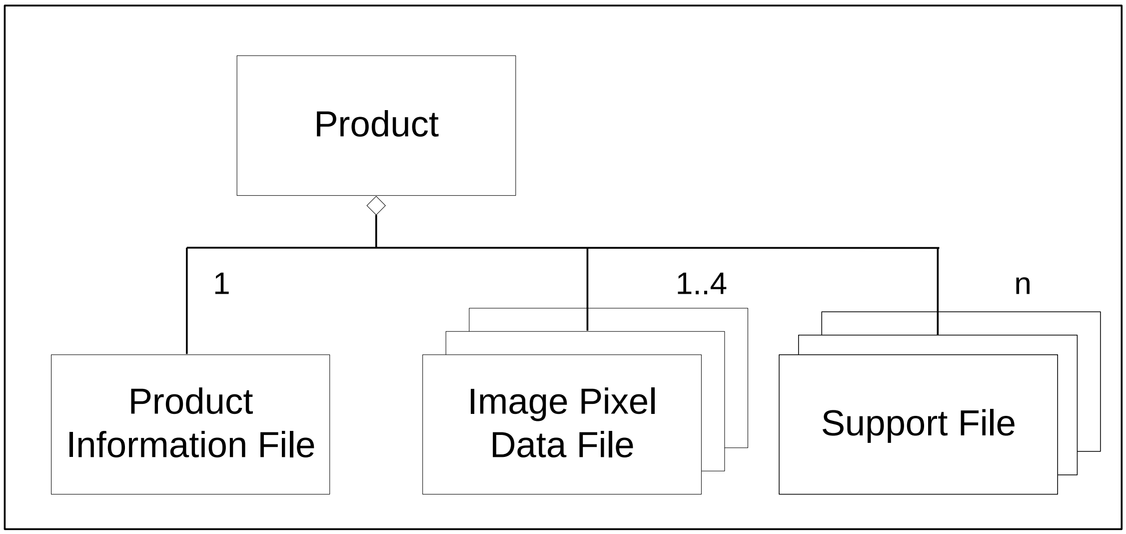

Figure 4-1 Product Composition

4.1 Product Information File

The Product Information File is an ASCII file that logically groups known information on the product. For example, groupings are provided for source, image generation and imagery information related to the product. The content of the Product Information File for the various product types is described in Section 5. The Product Information File is encoded in Extensible Markup Language (XML) format. XML has the following features:

- Based on Unicode (superset of ASCII)
- Human readable
- Machine readable
- Not position dependent
- Open standard with industry acceptance and support
- Provides hierarchy of information
- Platform independent

- Easily usable as exchange format for distributed environments
- Free parsers available
- Separation of content and presentation

XML 1.0 Specification is described in the W3C Recommendation (Document R-5). XML syntax and features that have been used in the Product Information File are demonstrated in the annotated example below:

Sample XML File	Description
<?xml **version="1.0"**?>	XML file header
<employeeDatabase>	Start of an employee database record
<employee reference=”**1234**”>	Start of an employee record with a reference attribute of **1234**. While the reference attribute in this example may be unique, attributes do not have to be unique
<lastName>**Smith**</lastName>	lastName item with value ”**Smith**”
<firstName>**John**</firstName>	firstName item with value ”**John**”
<jobTitle>**Engineer**</jobTitle>	jobTitle item with value ”**Engineer**”
<dependents>**2**</dependents>	dependents item with value **2**
<promotionDates>	Start list of promotionDates
1982 1984 1990	Individual date entries of list separated by spaces
</promotionDates>	End list of promotionDates
</employee>	End of employee record
<employee reference=”**1500**”>	Start of next employee record with a reference attribute of **1500** to distinguish from previous employee record
<lastName>**Hunter**</lastName>	lastName item with value ” **Hunter**”
<firstName>**Kim**</firstName>	firstName item with value ” **Kim**”
<jobTitle>**Manager**</jobTitle>	jobTitle item with value ” **Manager**”
<dependents>**0**</dependents>	dependents item with value **0**
<promotionDates>	Start list of promotionDates
1991	Individual date entries of list separated by spaces
</promotionDates>	End list of promotionDates
</employee>	End of employee record
</employeeDatabase>	End of employee database record

4.2 Image Pixel Data File

All RADARSAT-2 products include one or more Image Pixel Data Files. One, two, or four Image Pixel Data Files may be included, corresponding to single, dual, or quad polarization modes, respectively. Each file contains the raster SAR image for a given polarization.

4.3 Support Files

Support files for RADARSAT-2 products include:

- A “Readme” file to provide information for a RADARSAT-2 product viewer.
- A License file to describe the licensing of the product.
- XML Schema files that impose constraints on the Product Information File.

In addition, other support files may be included, such as.

- A reduced-resolution browse image in TIFF format.
- Output scaling Look-Up Table Files (LUTs) in XML format are included with georeferenced products (not with geocorrected products). These LUTs allow the conversion of image pixel values from the digital numbers provided in the image pixel data files to physical units of sigma-nought, beta-nought, or gamma values (depending on which LUT is used). This conversion is done by applying a constant offset and range dependent gain to the SAR image pixel values.
- A KML file for displaying a bounding box of the product coverage in Google Earth. It is not intended to provide accurate geolocation information of the product.

5 FORMAT OF THE PRODUCT INFORMATION FILE

This section describes the format of the Product Information File. Section 5.1 describes the layout of the file and introduces the concept of a Data Store. Section 5.2 explains how the information is presented in the tables used to describe the Data Stores. A description of the tables used to group other information such as identifiers, units, and lists is also given in this section. Section 5.3 contains detailed information on the Data Stores. These Data Stores basically describe a schema that is used to control the contents and format of the Product Information File. Section 5.4 provides further understanding of the format by describing selected example uses of the metadata in post-processing calculations.

5.1 Layout of the Product Information File

As described in the Concepts section, the product is organized in hierarchical layers, with the basic product layers being supplied by the RADARSAT-2 processor. Related information within the product is grouped into Data Stores. Figure 5-1 shows how the Data Stores fit within the product hierarchy.

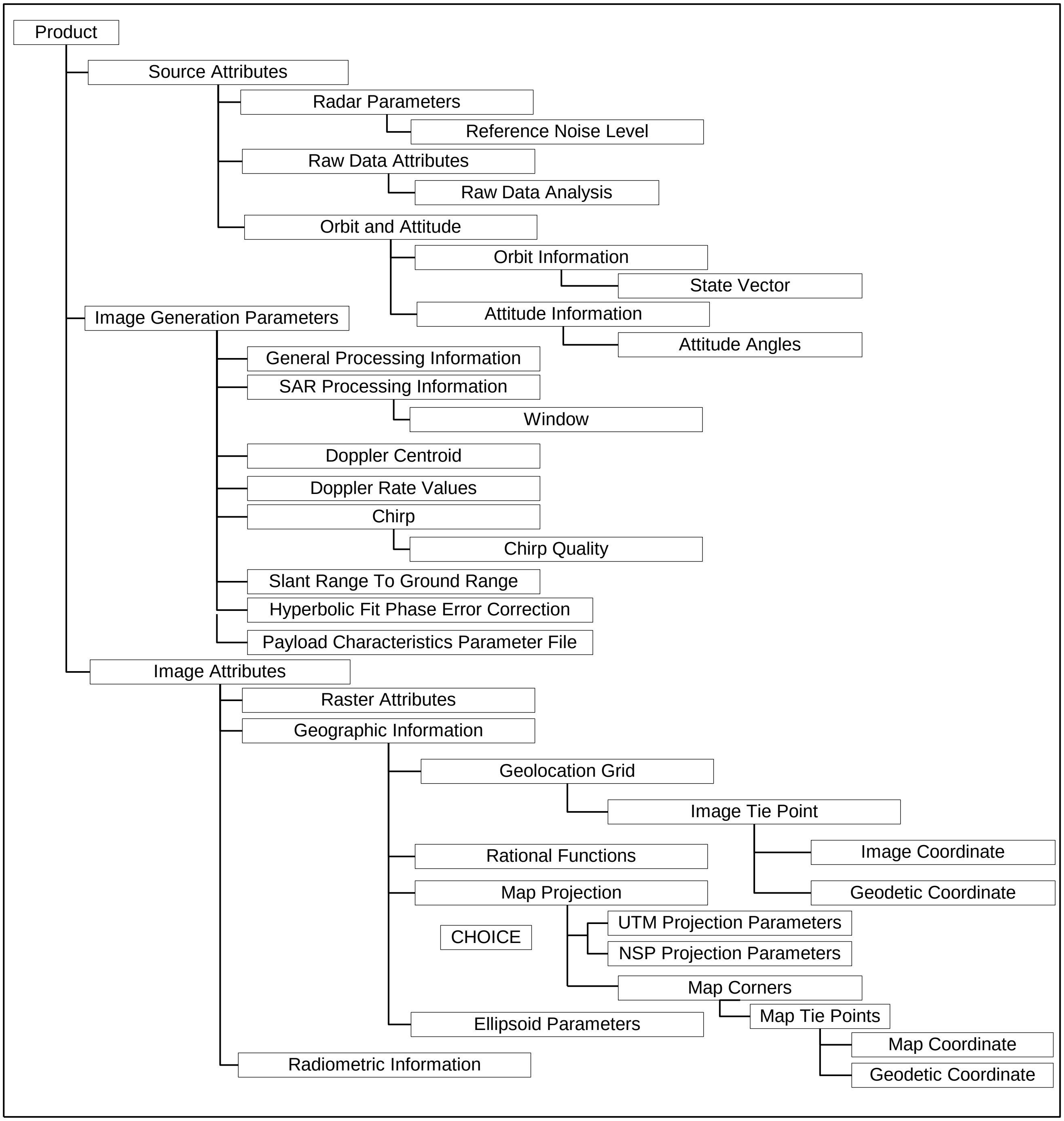

Figure 5-1 Product Data Stores Hierarchy

5.2 Table Descriptions

The tables in the following section describe the contents of the product information file and its Data Stores. Three additional tables in Section 5.3.5 are provided to group identifiers, units, and lists. Each Data Store table is preceded by an arrow diagram:

```
product→...→<name-of-Data-Store>
```

to indicate the location of the Data Store relative to the product "root". The tables describing the product parameters (root of the product) and common parameters omit this arrow diagram. The columns of the tables are:

- **Name:** A unique XML *tag* name for an *element*. For the Data Store tables the first row is shaded to indicate that the name of the Data Store does not constitute a valid tag name, but is provided to provide context for any attributes or description that may be applicable to the Data Store.
- **Min,max:** The minimum and maximum number of times an element can occur in the product. "0,1" implies that the element is optional. The "∞" symbol implies no upper bound. This column is omitted for the Identifiers, Units, and Lists tables.
- **Type:** The contents of an element may be one of the following types:

  complex: a user-defined type that is not part of the XML specification (Data Store),

  simple: derived from restrictions on a list or atomic type,

  list: finite-length sequence of atomic values,

  atomic: an indivisible type within the context of XML Schema, i.e., primitive or built-in derived type (xsd:string, xsd:integer, etc.)

  Complex types are expanded in their own table. A shaded **choice** block implies that only one of the types enclosed within the block can occur in the product. Simple types are grouped into tables provided for identifiers, units and lists. Both complex and simple types are prefixed with "rs2prod:"; atomic types are prefixed with "xsd:".
- **Attributes:** A modifier on the element. In most cases these are units. However, attributes also exist for polarization (pole), beam types (beam), data representation for real, imaginary, or magnitude (dataStream), pulse identifiers (pulse), fore and aft or combined wing identifiers (wing), incidence angle correction identifiers (incidenceAngleCorrection), and copyright information for the product (copyright).

  All attributes are required when specified. An example of the use of attributes is the settableGain element:

  ```
  <settableGain beam="U1" pole="HH" wing="Fore" units="dB">0.5
  </settableGain>
  ```

The attributes column is omitted for Identifiers, Units and Lists tables.

- **From/To:** Exists only for the Lists table to indicate the minimum/maximum size of a list. The "∞" symbol implies no upper bound, implying that the length of the list will ultimately be determined by the number of entries within the list.
- **Description:** Further details on the element.
  Note that the Identifiers table (Table 5-40) describes the possible values for identifiers referenced in the Type or Attributes columns of the Data Store tables. Each identifier appearing in these columns is specified with the naming convention:

  ```
  rs2prod:<name-of-Identifier>Identifers
  ```

  where name-of-Identifier is uniquely represented in the Identifiers table. Similarly, the Units table (Table 5-40) describes the possible values for units that are referenced in the Attributes column. Each unit appearing in the Attributes column is specified with the naming convention:

  ```
  rs2prod:<name-of-Unit>Units
  ```

  where name-of-Unit is uniquely represented in the Units table.

  Finally, the Lists table (Table 5-41) describes the possible types of lists used within the product. A list specification of the form:

  ```
  rs2prod:<name-of-List>List
  ```

  in the Type column of a Data Store table implies that there is a unique definition for the name-of-List in the List table.

5.3 Schema Details for the Product Information File

5.3.1 Product Parameters

Table 5-1 Products

Name	Min,Max	Type	Attributes	Description
Product	1,1		copyright=xsd:string,	RADARSAT-2 Data and Products (c) MacDonald, Dettwiler and Associates Ltd., <year of acquisition> - All Rights Reserved.
ProductId	1,1	xsd:string		Unique identifier from 1 to 128 characters. (Possible characters: 0-9A-Za-z._-)
documentIdentifier	1,1	xsd:string		Identifies the document and version number which describes this product format.
sourceAttributes	1,1	rs2prod:sourceAttributesDataStore		Source (instrument) attributes. Information describing the sensor characteristics, raw data and satellite orbit and attitude.
imageGenerationParameters	1,1	rs2prod:imageGenerationParameters DataStore		Image generation parameters. Information related to SAR processing, Doppler Centroid, Doppler rates, chirp, chirp quality, and conversion from slant range to ground range.
imageAttributes	1,1	rs2prod:imageAttributesDataStore		Image attributes. Image-related information such as line/pixel information, geographical location, map projection, if applicable, and image pixel data file location.

5.3.2 Source Attributes

Source (instrument) attributes provide information on the sensor characteristics, raw data and satellite orbit and attitude.

product→sourceAttributes

Table 5-2 Source Attributes

Name	Min,Max	Type	Attributes	Description
sourceAttributesDataStore				Source Attributes Data Store
satellite	1,1	rs2prod:satelliteIdentifiers		
sensor	1,1	rs2prod:sensorIdentifiers		
inputDatasetId	1,1	rs2prod:inputDatasetIdType		Archive segment ID in archive
imageId	1,1	rs2prod:imageIdType		Image segment ID
inputDatasetFacilityId	1,1	rs2prod:inputDatasetFacilityNameType		Name of the facility from which the raw data was received. Examples of defined entries include “Gatineau”, “Prince Albert” and “Not Specified”.
beamModeId	1,1	rs2prod:beamModeIdType		Beam mode ID (an integer which uniquely identifies the satellite imaging configuration)
beamModeMnemonic	1,1	rs2prod:beamModeMnemonicType		Beam mode mnemonic (a string of up to 6 alphanumeric characters which uniquely identifies the satellite imaging configuration). May be one of the following quoted string patterns, where ‘n’ represents one or more numeric characters, ‘?’ represents one or more alphabet or numeric characters, ‘{?}’ indicates optionally one or more alphabet or numeric characters. For some non-operational modes, additional characters may follow: Standard: "Sn" Wide: "Wn" Extended High: “EHn” Extended Low: "ELn" Fine: "Fn{?}" Wide Fine: "F0Wn" Std Quad-Pol: "SQn"

Name	Min,Max	Type	Attributes	Description
				Wide Std Quad-Pol: "SQnW" Fine Quad-Pol: "FQn" Wide Fine Quad-Pol: "FQnW" Multi-Look Fine: "MFn{?}" Wide Multi-Look Fine: "MFnW" Ultra-Fine: "Un" Wide Ultra-Fine: "UnWn" ScanSAR Narrow: "SCNA", "SCNB" ScanSAR Wide: "SCWA", "SCWB" Spotlight: "SLAn", "SLBn" Ocean Surveillance: "OS?" Detection of Vessels: "DV?” Extra Fine: "XF0?" MODEX: “MX?” TOPS: “PS?”
rawDataStartTime	1,1	rs2prod:utcTimeType		Date/time stamp of first raw data line used during the processing
radarParameters	1,1	rs2prod:radarParametersDataStore		Information describing the characteristics of the sensor used to acquire the data
rawDataAttributes	1,1	rs2prod:rawDataAttributesDataStore		Statistics and other analysis on the raw data.
orbitAndAttitude	1,1	rs2prod:orbitAndAttitudeDataStore		Information on the satellite orbit and attitude

product→sourceAttributes→radarParameters

Table 5-3 Radar Parameters

Name	Min,Max	Type	Attributes	Description
radarParametersDataStore				Radar Parameters Data Store. Information describing the characteristics of the sensor used to acquire the data
acquisitionType	1,1	rs2prod:acquisitionIdentifiers		Type of data acquisition
beams	1,1	rs2prod:beamList		Radar beams used to produce this product. There are multiple beams in ScanSAR modes and only one beam in other modes. Examples of defined beams include: "S1", … ,"S8", "W1", … ,"W3", "F1", … ,"F6", "F21", … , "F23", "MF1", … ,"MF6", "MF21", … ,"MF23", "U1", … , "U48", "U70", … "U79", "EL1", "EH1", … ,"EH6", "Q1", … , "Q31", "SL1", …, "SL48", "SL70", …,"SL79", "XF0W1", … , "XF0W3", "XF0S7"
polarizations	1,1	rs2prod:polarizationList		Polarizations used to produce this product
pulses	1,1	rs2prod:pulseList		Pulses used to produce this product. Typically only one entry in list, but two entries ("Lower_50" and "Upper_50") for Ultrafine and Spotlight
pulsesReceivedPerDwell	0,∞	rs2prod:receivedPulsesPerDwellType	beam=rs2prod:beamList	ScanSAR burst parameter for ScanSAR only. Number of pulses received and recorded per dwell for each beam. Beam attribute values are same as those used in the beams list.
numberOfPulseIntervalsPerDwell	0,∞	rs2prod:priPerDwellType	beam=rs2prod:beamList	ScanSAR burst parameter for ScanSAR only. Number of pulse transmission intervals per dwell for each beam. Beam attribute values are same as those used in the beams list.
rank	1, ∞	rs2prod:rankType	beam=rs2prod:beamList	Rank, one entry per beam. The number of transmitted pulse repetition intervals between transmission and reception for each beam. Beam attribute values are same as those used in the beams list.

Name	Min,Max	Type	Attributes	Description
settableGain	1, ∞	xsd:double	beam=rs2prod:beamList, pole=rs2prod:polarizationIdentifiers, wing=rs2prod:wingIdentifiers, units=rs2prod:powerUnits	Gain values used on the instrument. Gain values will be specified either in terms of polarization or wing, not both. Beam attribute values are same as those used in the beams list. (units = dB). Wing can be either fore or aft.
radarCenterFrequency	1,1	xsd:double	units=rs2prod:frequencyUnits	Center frequency of the instrument. (units = Hz)
pulseRepetitionFrequency	1,∞	rs2prod:prfType	beam=rs2prod:beamList, units=rs2prod:frequencyUnits	Transmitted pulse repetition frequency for each beam. Beam attribute values are same as those used in the beams list. (units = Hz). For products with two wing identifiers (Fore and Aft), the received PRF is effectively double the transmitted PRF.
pulseLength	1,2	rs2prod:pulseDurationType	pulse=rs2prod:pulseIdentifers units=rs2prod:timeUnits	Time duration of each pulse. For Ultrafine and Spotlight, there are two pulses and this field is repeated for each pulse. (units = s)
pulseBandwidth	1,2	rs2prod:pulseBandwidthType	Pulse=rs2prod:pulseidentifiers Units=rs2prod:frequencyunits	Bandwidth of each pulse. For Ultrafine and Spotlight, there are two pulses and this field is repeated for each pulse. (units = Hz)
antennaPointing	1,1	rs2prod:antennaPointingIdentifiers		Antenna pointing direction
adcSamplingRate	1,2	rs2prod:rangeSamplingRateType	pulse=rs2prod:pulseIdentifiers units=rs2prod:frequencyUnits	Sampling rate of the radar analog to digital converter for each pulse (units = Hz). For dual-pulse stitched mode acquisition types (Ultrafine and Spotlight), the field is repeated for each pulse, and the effective range sampling rate for the products is double the rate for each pulse.
yawSteeringFlag	1,1	rs2prod:yawSteeringFlagIdentifiers		Indicates if yaw steering is used.
geodeticFlag	1,1	rs2prod:geodeticFlagIdentifiers		Indicates what satellite orientation reference frame is used.
rawBitsPerSample	1,1	rs2prod:rawBitsPerSampleIdentifiers		BAQ encoding level (bits per sample: 1,2,3,4 or 8)
samplesPerEchoLine	1,∞	xsd:unsignedLong	beam=rs2prod:beamList	Number of samples per echo line for each beam. Used to determine sample window length. Beam attribute values are same as those used in the beams list.

Name	Min,Max	Type	Attributes	Description
referenceNoiseLevel	3,6	rs2prod:referenceNoiseLevelDataStore		Estimated mean image noise levels as a function of georeferenced image pixel in range. Note that in the case of special reduced-bandwidth SLC products (SLC Fine, SLC Standard, and SLC Wide), the effect of the azimuth bandwidth reduction is not included in these estimates. For most products this consists of three data stores, one for noise equivalent beta nought, one for sigma nought, and one for gamma. Nominally, the referenceNoiseLevel is given for the first polarization channel in the imagery only. For dual-polarization ScanSAR SCS or SCF product types, the referenceNoiseLevel is given for both polarization channels in the imagery, for a total of six data stores. If noise subtraction was performed, these represent a first order approximation to the range dependent reference noise levels that were used in the noise subtraction.
azimuthNoiseLevelScaling	0,∞	rs2prod:azimuthNoiseLevelScalingDataStore	beam =rs2prod:beamList	For each ScanSAR image block, these scaling factors describe the estimated noise level variation as a function of image block line number in azimuth, at the mid-range point of the image block. Cross-multiplying this by the range dependent reference noise level provides a first order approximation of the 2D varying noise level within an image block. This is provided only for SCS or SCF product types for beam modes having a single azimuth look. Nominally, the azimuthNoiseLevelScaling is given for the first polarization channel in the imagery only. For dual-polarization ScanSAR SCF or SCF product types, the azimuthNoiseLevelScaling is given for both polarization channels in the imagery. If noise subtraction was performed, these represent a first order approximation to the azimuth dependent scaling factors that were applied (note that during the application of the noise subtraction, the processor actually uses azimuth dependent scaling factors that vary slowly with range).

Name	Min,Max	Type	Attributes	Description
numPRIsPerPointingStep	0,1	xsd:integer		Number of transmitted pulse repetition intervals per antenna azimuth pointing step during a Spotlight acquisition. Spotlight mode only. This value applies to all pointing steps except the last one, which may have fewer PRIs.
totalNumberOfPointingSteps	0,1	xsd:integer		Total number of antenna azimuth pointing steps during a Spotlight acquisition. Always an odd number. Spotlight mode only.
stepSizeInAntennaPointing	0,1	xsd:double		Step size in antenna azimuth pointing. Spotlight mode only. (units = degrees)

product→sourceAttributes→radarParameters→referenceNoiseLevel

Table 5-4 Reference Noise Level

Name	Min,Max	Type	Attributes	Description
referenceNoiseLevelDataStore			incidenceAngleCorrection= rs2prod:incidenceAngleCorrectionIndentifiers pole=rs2prod:polarizationIdentifiers (given only for SCS or SCF product types, otherwise assume the first polarization only)	Reference Noise Level Data Store
pixelFirstNoiseValue	1,1	xsd:integer		Pixel number corresponding to first noise value (the leftmost pixel in image is defined to be pixel 0). For SSG and SPG products, this applies to intermediate georeferenced image data prior to geocoding.
stepSize	1,1	xsd:integer		Number of image pixels between list entries. For SSG and SPG products, this applies to intermediate georeferenced image data prior to geocoding.
numberOfNoiseLevelValues	1,1	xsd:integer		Number of entries in list

Name	Min,Max	Type	Attributes	Description
noiseLevelValues	1,1	rs2prod:noiseLevelValuesList	units=rs2prod:powerUnits,	Estimated noise level values as a function of georeferenced image pixel position in range. For SSG and SPG products, these apply to intermediate georeferenced image data prior to geocoding. (units = dB)

product→sourceAttributes→radarParameters→ azimuthNoiseLevelScalingDataStore

Table 5-5 Azimuth Noise Level Scaling

Name	Min, Max	Type	Attributes	Description
azimuthNoiseLevelScalingDataStore			beam =rs2prod:beamList pole=rs2prod:polarizationIdentifiers (given only for SCS or SCF product types, otherwise assume the first polarization only)	Azimuth Noise Level Scaling Factors Data Store (NOTE: this is used only in the case of single azimuth look ScanSAR beam modes)
stepSize	1,1	xsd:double		Number of lines between each list entry
numberOfNoiseLevelScalingFactors	1,1	xsd:integer		Number of entries in the list
noiseLevelScalingFactors	1,1	rs2prod:noiseLevelValuesList	units = rs2prod:powerUnits	Scaling factors representing the azimuth dependence of the noise level at the mid-range point of a single-azimuth-look ScanSAR image block. These scaling factors are not necessarily symmetric and are approximately centered about the middle of each image block in azimuth. Samples increase with azimuth time order. Refer also to Section 5.4.3 below. (units = dB)

product→sourceAttributes→rawDataAttributes

Table 5-6 Raw Data Attributes

Name	Min,Max	Type	Attributes	Description
rawDataAttributesDataStore				Describes characteristics of the raw SAR data
numberOfInputDataGaps	1,1	xsd:unsignedLong		Number of gaps detected in the raw data used to produce this product. A gap is defined as a predetermined number of range lines
gapSize	1,1	xsd:unsignedLong		Predefined size of a gap in lines
numberOfMissingLines	1,4	xsd:unsignedLong	pole=rs2prod:polarizationIdentifiers	Number of missing lines (not including gaps) detected in the raw data used to produce this product.
rawDataAnalysis	1,4	rs2prod:rawDataAnalysisDataStore		Results from raw data analysis. Possible attributes are polarization, wing and pulse.

product→sourceAttributes→rawDataAttributes→rawDataAnalysis

Table 5-7 Raw Data Analysis

Name	Min,Max	Type	Attributes	Description
rawDataAnalysisDataStore			pole=rs2prod:polarizationIdentifiers, wing=rs2prod:wingIdentifiers, pulse=rs2prod:pulseIdentifiers	Raw Data Analysis Data Store
bias	2,2	xsd:double	dataStream=rs2prod:dataStreamIdentifiers	Measured mean of the raw data after BAQ decoding
standardDeviation	2,2	xsd:double	dataStream=rs2prod:dataStreamIdentifiers	Standard deviation of the raw data after BAQ decoding
gainImbalance	1,1	xsd:double		Ratio of variances of real and imaginary channels
phaseOrthogonality	1,1	xsd:double	units=rs2prod:angularUnits	Phase Orthogonality (quadrature departure) (units = deg) A positive value represents +ve I and Q axes less than 90 degs apart.

Name	Min,Max	Type	Attributes	Description
rawDataHistogram	2,2	rs2prod:histogramList	dataStream=rs2prod:dataStreamIdentifiers	Histogram of the raw data after BAQ decoding

product→sourceAttributes→orbitAndAttitude

Table 5-8 Orbit and Attitude

Name	Min,Max	Type	Attributes	Description
orbitAndAttitudeDataStore				Orbit and Attitude Data Store
orbitInformation	1,1	rs2prod:orbitInformationDataStore		Spacecraft orbit information used for processing
attitudeInformation	1,1	rs2prod:attitudeInformationDataStore		Spacecraft attitude data used for processing

product→sourceAttributes→orbitAndAttitude→orbitInformation

Table 5-9 Orbit Information

Name	Min,Max	Type	Attributes	Description
orbitInformationDataStore				Orbit Information Data Store
passDirection	1,1	rs2prod:passDirectionIdentifiers		Direction of satellite pass defined at the start of the archive segment
orbitDataSource	1,1	rs2prod:orbitDataSourceIdentifiers		Source of orbit data
orbitDataFile	1,1	xsd:anyURI		Name of orbit data file used during processing. If orbitDataSource=Downlinked this file was only used for initial framing of the data.
stateVector	1,∞	rs2prod:stateVectorDataStore		State vector entries

product→sourceAttributes→orbitAndAttitude→orbitInformation→stateVector

Table 5-10 State Vector

Name	Min,Max	Type	Attributes	Description
stateVectorDataStore				State Vector Data Store. Earth Centered Rotating (ECR) coordinates
timestamp	1,1	rs2prod:utcTimeType		Date/time stamp of current state vector
xPosition	1,1	xsd:double	units=rs2prod:distanceUnits	(units = m)
yPosition	1,1	xsd:double	units=rs2prod:distanceUnits	(units = m)
zPosition	1,1	xsd:double	units=rs2prod:distanceUnits	(units = m)
xVelocity	1,1	xsd:double	units=rs2prod:velocityUnits	(units = m/s)
yVelocity	1,1	xsd:double	units=rs2prod:velocityUnits	(units = m/s)
zVelocity	1,1	xsd:double	units=rs2prod:velocityUnits	(units = m/s)

product→sourceAttributes→orbitAndAttitude→attitudeInformation

Table 5-11 Attitude Information

Name	Min,Max	Type	Attributes	Description
attitudeInformationDataStore				Attitude Information Data Store
attitudeDataSource	1,1	rs2prod:attitudeSourceIdentifiers		Source of attitude data used for processing
attitudeOffsetsApplied	1,1	xsd:boolean		True if attitude offsets from the Payload Characterization Parameters file were applied prior to use of attitude data.
attitudeAngles	1,∞	rs2prod:attitudeAnglesDataStore		Attitude angles used during processing. Maybe from downlink or user specified.

product→sourceAttributes→orbitAndAttitude→attitudeInformation→AttitudeAngles

Table 5-12 Attitude Angles

Name	Min,Max	Type	Attributes	Description
attitudeAnglesDataStore				Attitude Angles Data Store. Represents the (intrinsic) rotation sequence about mechanical build axes required to transition from flight axes to build axes in the following order: yaw, then roll, then pitch. The mechanical build axes are defined as follows: - the z (yaw) axis is perpendicular to the SAR Antenna radiating/observing face and positive in the direction of radiation/observation; - the x (roll) axis is parallel to the long axis of the SAR antenna and positive in the direction of the spacecraft velocity vector when the spacecraft is in its nominal attitude; - the y (pitch) axis completes the right-hand triad. If the geodeticFlag is "Off-Geocentric" (currently expected to be true for the duration of the RADARSAT-2 mission), then the flight axes are defined as follows: - the origin is at the centre of mass of the spacecraft; - the z (yaw) axis points towards the centre of the earth; - the y (pitch) axis points along the anti-orbit normal, that is along the direction of the cross-product (z × v) of the z axis with the spacecraft velocity vector (v); - the x (roll) axis completes the right-hand triad and is roughly in the direction of the spacecraft velocity.
Timestamp	1,1	rs2prod:utcTimeType		Date/time stamp of current attitude information
Yaw	1,1	xsd:double	units=rs2prod:angularUnits	Spacecraft yaw angle (units = deg). Positive for nose right rotation about the z axis (i.e. clockwise when looking along the z axis). When Right-Looking, a small positive yaw generally means that the SAR antenna is pointing slightly backwards. When Left-Looking, a small positive yaw generally means it is pointing slightly forwards.
Roll	1,1	xsd:double	units=rs2prod:angularUnits	Spacecraft roll angle (units = deg). Positive for left side up rotation about the x axis (i.e. clockwise when looking along the x axis). Roll is negative for Right-Looking and positive for Left-Looking.
Pitch	1,1	xsd:double	units=rs2prod:angularUnits	Spacecraft pitch angle (units = deg). Positive for nose up rotation about the y axis (i.e. clockwise when looking along the y axis).

5.3.3 Image Generation Parameters

Image generation parameters describe the processing applied to the source data to produce the output product. These include general and SAR processing information, Doppler Centroid, Doppler rates, chirp, chirp quality, and conversion from slant range to ground range.

product→imageGenerationParameters

Table 5-13 Image Generation Parameters

Name	Min,Max	Type	Attributes	Description
imageGenerationParametersDataStore				Image Generation Parameters Data Store
generalProcessingInformation	1,1	rs2prod:generalProcessingInformationDataStore		General information relating to processing location, date and software version
sarProcessingInformation	1,1	rs2prod:sarProcessingInformationDataStore		Detailed information describing the SAR processing parameters
dopplerCentroid	1,∞	rs2prod:dopplerCentroidDataStore		Describes the Doppler Centroid at the time indicated in the record. Refer to dopplerCentroidDataStore. Note: Collectively, the instances of this field describe the Doppler centroid frequency used during processing as a function of range and (if applicable) azimuth. For Spotlight products, the Doppler centroid frequency of the product image data additionally varies with zero Doppler time at a rate equal to the absolute value of the Doppler rate, where the Doppler rate is given below.
dopplerRateValues	1,1	rs2prod:dopplerRateValuesDataStore		Describes the Doppler rate values at the time indicated in the record.
chirp	1,4	rs2prod:chirpDataStore		Describes the chirp parameters derived from the calibration pulses. Depends on attribute: pulse. Refer to chirpDataStore
slantRangeToGroundRange	1,∞	rs2prod:slantRangeToGroundRangeDataStore		Slant Range to Ground Range conversion information
hyperFitPhaseErrorCorr	0,1	rs2prod: hyperFitPhaseErrorCorrDataStore		Describes the Hyperbolic Fit Phase Error Correction at the time indicated in the record. Refer to hyperFitPhaseErrorCorrDataStore. Spotlight Mode only.

Name	Min,Max	Type	Attributes	Description
payloadCharacteristicsParameterFile	5,6	xsd:anyURI		Names of Payload Characterization Parameter files.

product→imageGenerationParameters→generalProcessingInformation

Table 5-14 General Processing Information

Name	Min,Max	Type	Attributes	Description
generalProcessingInformationDataStore				General Processing Information Data Store
productType	1,1	rs2prod:productTypeIdentifiers		
processingFacility	1,1	rs2prod:processingFacilityNameType		Name of facility processing the data
processingTime	1,1	rs2prod:utcTimeType		Date/time at which processing was performed
softwareVersion	1,1	xsd:string		Version of software used to process the data

product→imageGenerationParameters→sarProcessingInformation

Table 5-15 SAR Processing Information

Name	Min,Max	Type	Attributes	Description
sarProcessingInformationDataStore				SAR Processing Information Data Store
lutApplied	1,1	xsd:string		Output scaling LUT applied.
elevationPatternCorrection	1,1	xsd:boolean		If true, antenna elevation pattern correction applied.
rangeSpreadingLossCorrection	1,1	xsd:boolean		If true, range spreading loss correction applied.
pulseDependantGainCorrection	1,1	xsd:boolean		If true, pulse dependent gain correction applied.
spotlightRadiometricCorrection	0,1	xsd:boolean		If true, spotlight radiometric correction has been applied. Spotlight mode only. Default = false

Name	Min,Max	Type	Attributes	Description
noiseSubtractionPerformed	0,1	xsd:boolean		If true, indicates that the approximate expected mean instrument noise level has been subtracted from the imagery. See Appendix B of the Product Description Document [A-1] for further explanation of the noise subtracted product. Applicable only for ScanSAR SCS and SCF products.
receiverSettableGain	1,1	xsd:boolean		If true, receiver settable gain applied during processing.
rawDataCorrection	1,1	xsd:boolean		If true, raw data correction applied.
rangeReferenceFunctionSource	1,1	rs2prod:rangeReferenceFunctionSourceIdentifiers		Source of range reference function for this product.
interPolarizationMatricesCorrection	1,1	xsd:boolean		If true, inter-polarization correction matrices applied. Only applicable for quad-polarization SLC products.
dopplerSource	1,1	rs2prod:dopplerSourceIdentifiers		The source of the Doppler centroid coefficients used to process this product.
dopplerAmbiguityComputed	1,1	xsd:boolean		If true, Doppler Ambiguity computed
dopplerAmbiguityUsed	1,1	xsd:boolean		True if the computed Doppler ambiguity was used during processing. Only has meaning if dopplerAmbiguityComputed = true
estimatedRollAngleUsed	1,1	xsd:boolean		If true, estimated roll angle used. Always false for single beam and Spotlight products.
estimatedRollAngle	0,1	xsd:double	units=rs2prod:angularUnits	Roll angle estimated by processor. Only included if "estimatedRollAngleUsed" is set to true. (units = deg)
radiometricSmoothingPerformed	1,1	xsd:boolean		If true, radiometric smoothing performed. Only applies to ScanSAR, set to FALSE for Single Beam and Spotlight products.
zeroDopplerTimeFirstLine	1,1	rs2prod:utcTimeType		Zero Doppler date/time of the first (top) line of the image data. For SSG and SPG products, this applies to intermediate ground range image data prior to geocoding. If north-south flipping has occurred, this value refers to the first line after the flip.

Name	Min,Max	Type	Attributes	Description
zeroDopplerTimeLastLine	1,1	rs2prod:utcTimeType		Zero Doppler date/time of last (bottom) line of the image data. For SSG and SPG products, this applies to intermediate ground range image data prior to geocoding. If north-south flipping has occurred, this value refers to the last line after the flip.
numberOfLinesProcessed	1,4	xsd:integer	pole=rs2prod:polarizationIdentifiers	Number of input raw data echo lines processed for each polarization. Echo lines are acquired at the rate of one per transmitted pulse, per receive polarization, per antenna wing.
samplingWindowStartTimeFirstRawLine	1,8	xsd:double	beam=rs2prod:beamList, units=rs2prod:timeUnits	Sampling window start time for the first line of the raw data ingested. Multiple entries for ScanSAR. Beam attribute values are same as those used in the beams list. Time between start of transmission of pulse and opening of receive window. (units = s)
samplingWindowStartTimeLastRawLine	1,8	xsd:double	beam=rs2prod:beamList, units=rs2prod:timeUnits	Sampling window start time of the last line of the raw data ingested. Multiple entries for ScanSAR. Beam attribute values are same as those used in the beams list. Time between start of transmission of pulse and opening of receive window. (units = s)
numberOfSwstChanges	1,∞	xsd:integer	beam=rs2prod:beamList	Number of sampling window start time changes in the raw data used to process this scene. Multiple entries for ScanSAR. Beam attribute values are same as those used in the beams list.
numberOfRangeLooks	1,1	xsd:integer		Number of looks used in range processing. For ScanSAR beam mode products where the number of range looks varies by beam (i.e. perBeamNumberOfRangeLooksUsed is true), this is the maximum value across all beams.
rangeLookBandwidth	1,1	xsd:double	units=rs2prod:frequencyUnits	Full bandwidth processed per range look. (units = Hz) For ScanSAR beam mode products where the number of range looks varies by beam (i.e. perBeamNumberOfRangeLooksUsed is true), this is the maximum value across all beams.

Name	Min,Max	Type	Attributes	Description
totalProcessedRangeBandwidth	1,1	xsd:double	units=rs2prod:frequencyUnits	Total bandwidth used during range processing. (units = Hz) For ScanSAR beam mode products where the number of range looks varies by beam (i.e. perBeamNumberOfRangeLooksUsed is true), this is the maximum value across all beams.
perBeamNumberOfRangeLooksUsed	0,1	xsd:boolean		If true, indicates that the number of range looks applied to each of the ScanSAR beams in the beam list varies by beam. Applicable only for ScanSAR product types processed with a different number of range looks for each ScanSAR beam.
perBeamNumberOfRangeLooks	0,∞	xsd:integer	beam=rs2prod:beamList	Number of range looks used in range processing for each of the ScanSAR beams in the beam list. Provided only if perBeamNumberOfRangeLooksUsed is true.
perBeamRangeLookBandwidths	0,∞	xsd:double	beam=rs2prod:beamList units=rs2prod:frequencyUnits	Full bandwidth processed per range look for each of the ScanSAR beams in the beam list. (units = Hz) Provided only if perBeamNumberOfRangeLooksUsed is true.
perBeamTotalProcessedRangeBandwidths	0,∞	xsd:double	beam=rs2prod:beamList units=rs2prod:frequencyUnits	Total bandwidth used during range processing for each of the ScanSAR beams in the beam list. (units = Hz) Provided only if perBeamNumberOfRangeLooksUsed is true.
numberOfAzimuthLooks	1,1	xsd:integer		Number of azimuth looks
scalarLookWeights	1,1	rs2prod:lookWeightList		Scalar weightings used in look summation, one value per look
azimuthLookBandwidth	1,1	xsd:double	units=rs2prod:frequencyUnits	Total bandwidth processed per azimuth look. For Spotlight products, azimuth look bandwidth represents the total Doppler bandwidth of each target in the scene. (units = Hz)
totalProcessedAzimuthBandwidth	1,1	xsd:double	units=rs2prod:frequencyUnits	Total bandwidth used during azimuth processing. (units = Hz)
azimuthWindow	1,1	rs2prod:windowDataStore		Windowing parameters used for azimuth processing

Name	Min,Max	Type	Attributes	Description
rangeWindow	1,1	rs2prod:windowDataStore		Windowing parameters used for range processing
incidenceAngleNearRange	1,1	xsd:double	units=rs2prod:angularUnits	Incidence angle at near range at mid-azimuth position of the image. (units =deg). For SSG and SPG products, this applies to intermediate ground range image data prior to geocoding.
incidenceAngleFarRange	1,1	xsd:double	units=rs2prod:angularUnits	Incidence angle at far range at mid-azimuth position of the image. (units = deg). For SSG and SPG products, this applies to intermediate ground range image data prior to geocoding.
slantRangeNearEdge	1,1	xsd:double	units=rs2prod:distanceUnits	Slant range to near edge of image data at mid-azimuth. (units = m). For SSG and SPG products, this applies to intermediate ground range image data prior to geocoding.
satelliteHeight	1,1	xsd:double	units=rs2prod:distanceUnits	Satellite height above reference ellipsoid computed by processor at scene center. (units = m)
slantRangeCentre	0,1	xsd:double	units=rs2prod:distanceUnits	Mid slant range of range compressed data at mid-acquisition time (units = m). Spotlight mode only.

product→imageGenerationParameters→sarProcessingInformation→window

Table 5-16 Window

Name	Min,Max	Type	Attributes	Description
windowDataStore				Window Data Store
windowName	1,1	rs2prod:windowNameIdentifiers		Name of window
windowCoefficient	1,1	xsd:double		Window coefficient

product→imageGenerationParameters→dopplerCentroid

Table 5-17 Doppler Centroid

Name	Min,Max	Type	Attributes	Description
dopplerCentroidDataStore				Doppler Centroid Data Store
timeOfDopplerCentroidEstimate	1,1	rs2prod:utcTimeType		Date/time for Doppler Centroid estimate
dopplerAmbiguity	1,1	xsd:integer		Doppler ambiguity number used during processing
dopplerAmbiguityConfidence	1,1	xsd:double		Doppler ambiguity confidence estimate. Range from 0.0 (no confidence) to 1.0 (highest confidence)
dopplerCentroidReferenceTime	1,1	xsd:double	units=rs2prod:timeUnits	2-way slant range time used as reference in Doppler Centroid polynomial calculation (t0). (units = s)
dopplerCentroidPolynomialPeriod	1,1	xsd:double		Approximate 2-way slant range time period in seconds corresponding to the slant range swath width. This is the period over which the Doppler centroid polynomial is valid, measured from Doppler centroid reference time (t0). For ScanSAR, this is the time corresponding to the full combined swath width. (units = s).
dopplerCentroidCoefficients	1,1	rs2prod:coefficientsList		List of up to 5 Doppler Centroid coefficients d0, d1, d2, d3, and d4 as a function of slant range time tSR where the Doppler Centroid frequency used in processing in Hz = d0 + d1(tSR - t0) + d2(tSR-t0)^2 + d3(tSR-t0)^3 + d4(tSR-t0)^4
dopplerCentroidConfidence	1,1	xsd:double		Doppler Centroid confidence estimate. Range from 0.0 (no confidence) to 1.0 (highest confidence)

product→imageGenerationParameters→dopplerRateValues

Table 5-18 Doppler Rate Values

Name	Min,Max	Type	Attributes	Description
dopplerRateValuesDataStore				Doppler Rate Values Data Store.
dopplerRateReferenceTime	1,1	xsd:double	units=rs2prod:timeUnits	2-way slant range time used as reference in Doppler rate polynomial calculation (t0). (units = s)
dopplerRateValuesCoefficients	1,1	rs2prod:coefficientsList		List of up to 5 Doppler rate values coefficients r0, r1, r2, r3, and r4 as a function of slant range time tSR where the Doppler frequency rate (in Hz per second of zero Doppler time) = r0 + r1(tSR - t0) + r2(tSR-t0)^2 + r3(tSR-t0)^3 + r4(tSR-t0)^4

product→imageGenerationParameters→chirp

Table 5-19 Chirp

Name	Min,Max	Type	Attributes	Description
chirpDataStore			pole=rs2prod:polarizationIdentifiers, wing=rs2prod:wingIdentifiers, pulse=rs2prod:pulseIdentifiers	Chirp Data Store
chirpQuality	1,1	rs2prod:chirpQualityDataStore		
chirpPower	1,1	xsd:double	units=rs2prod:powerUnits	Replica energy value calculated during processing (units = dB)
amplitudeCoefficients	1,1	rs2prod:coefficientsList		List of range chirp amplitude coefficients (-, s^-1, s^-2, s^-3, ...)
phaseCoefficients	1,1	rs2prod:coefficientsList		List of range chirp phase coefficients (cycles, Hz, Hz/s, Hz/s^2, ...)

product→imageGenerationParameters→chirp→chirpQuality

Table 5-20 Chirp Quality

Name	Min,Max	Type	Attributes	Description
ChirpQualityDataStore				Chirp Quality Data Store
replicaQualityValid	1,1	xsd:boolean		false = unable to reconstruct chirp during processing and chirp reconstruction was requested or the quality is below acceptable levels. true = able to reconstruct all chirps or chirp reconstruction not requested (nominal chirp used) and all quality measures were acceptable
crossCorrelationWidth	1,1	xsd:double		3-dB pulse width of chirp replica cross-correlation function between reconstructed chirp and nominal chirp (units = samples)
sideLobeLevel	1,1	xsd:double	units=rs2prod:powerUnits	First side lobe level of chirp replica cross-correlation function between reconstructed chirp and nominal chirp. (units = dB)
integratedSideLobeRatio	1,1	xsd:double	units=rs2prod:powerUnits	Integrated Side-Lobe Ratio of chirp replica cross-correlation function between reconstructed chirp and nominal chirp. (units = dB)
crossCorrelationPeakLoc	1,1	xsd:double		Cross correlation peak location (units = samples)

product→imageGenerationParameters→slantRangeToGroundRange

Table 5-21 Slant Range to Ground Range

Name	Min,Max	Type	Attributes	Description
slantRangeToGroundRangeDataStore				Slant Range to Ground Range Conversion Data Store. For SSG and SPG products, these fields apply to intermediate ground range samples prior to geocoding.
zeroDopplerAzimuthTime	1,1	rs2prod:utcTimeType		Zero Doppler date/time at which this entry applies
slantRangeTimeToFirstRangeSample	1,1	xsd:double	units=rs2prod:timeUnits	2-way slant range time to first range sample (the first pixel of a range line) for this entry. (units = s)

Name	Min,Max	Type	Attributes	Description
groundRangeOrigin	1,1	xsd:double	units=rs2prod:distanceUnits	Ground range reference position GR0 (see equation definition below). (units = m)
groundToSlantRangeCoefficients	1,1	rs2prod:coefficientsList		List of polynomial coefficients for converting ground range to slant range in a ground range product (or from relative image range to slant range in a SLC product). Provided as 6 coefficients, s0, s1, s2, s3, s4 and s5 where: Slant Range = s0 + s1(GR - GR0) + s2(GR-GR0)^2 + s3(GR-GR0)^3 + s4(GR-GR0)^4 +s5(GR-GR0)^5; GR is the ground range distance from the nearest-range image sample in a ground range product (or slant range distance from the nearest-range image sample in a SLC product); and GR0 is the groundRangeOrigin.

product→imageGenerationParameters→hyperFitPhaseErrorCorr

Table 5-22 Hyperbolic Fit Phase Error Correction

Name	Min,Max	Type	Attributes	Description
hyperFitPhaseErrorCorrDataStore				Hyperbolic Fit Phase Error Correction Data Store (Spotlight only).
midAcquisitionTime	1,1	rs2prod:utcTimeType		Date/Time of Mid-Acquisition.
hyperFitPhaseErrorCorrCoefficients	1,1	rs2prod:coefficientsList		List of coefficients of the hyperbolic fit phase error correction polynomial: h0, h1, h2, h3, ... where: Hyperbolic Fit Phase Error Correction = h0 + h1(AT) + h2(AT)^2 + h3(AT)^3 + ... and AT is the azimuth (slow) time in seconds with respect to the mid-acquisition time. (units of h0, h1, h2, h3, ... are radians*sec^{0}, radians*sec^{-1}, radians*sec^{-2}, radians*sec^{-3}, …).

5.3.4 Image Attributes

Image attributes describe image-related information such as raster attributes (line/pixel information), geographical location, map projection, if applicable, radiometric information and image pixel data file location.

product→imageAttributes

Table 5-23 Image Attributes

Name	Min,Max	Type	Attributes	Description
imageAttributesDataStore				Image Attributes Data Store
productFormat	1,1	rs2prod:productFormatIdentifiers		
outputMediaInterleaving	1,1	rs2prod:outputMediaInterleavingIdentifiers		Interleaving method used in image files
rasterAttributes	1,1	rs2prod:rasterAttributesDataStore		Raster attributes describing number of lines/pixels, and line/pixel spacing. Refer to imageInformationDataStore. Information applies to all polarizations.
geographicInformation	1,1	rs2prod:geographicInformationDataStore		Geographic information on the image, if applicable (tie points, map projection etc.)
radiometricInformation	1,2	rs2prod:radiometricInformationDataStore		Radiometric information. Depends on attribute: pole. Refer to radiometricInformationDataStore
lookupTable	0,3	xsd:anyURI	incidenceAngleCorrection=rs2prod:incidenceAngleCorrectionIdentifiers	File names of LUT files which can be used to derive Beta Nought, Sigma Nought or Gamma imagery from the product. The format of these files is described in Section 7. Not available for geocoded (SSG or SPG) products.
fullResolutionImageData	1,4	xsd:anyURI	pole=rs2prod:polarizationIdentifiers	File names for full resolution image data files in GeoTIFF or NITF 2.1 format

product→imageAttributes→rasterAttributes

Table 5-24 Raster Attributes

Name	Min,Max	Type	Attributes	Description
rasterAttributesDataStore				Raster Attributes Data Store
dataType	1,1	rs2prod:dataTypeIdentifiers		
bitsPerSample	1,2	xsd:unsignedLong	dataStream=rs2prod:dataStreamIdentifiers	2 entries for complex data 1 entry for magnitude detected data
numberOfSamplesPerLine	1,1	xsd:unsignedLong		Number of samples (pixels) per line of imagery including any zero-filled samples
numberOfLines	1,1	xsd:unsignedLong		Number of lines in the image
sampledPixelSpacing	1,1	xsd:double	units=rs2prod:distanceUnits	(units = m)
sampledLineSpacing	1,1	xsd:double	units=rs2prod:distanceUnits	(units = m)
lineTimeOrdering	1,1	rs2prod:timeOrderingIdentifiers		Indicates whether line numbers (i.e. azimuth) increase or decrease with time. For SSG and SPG products, this applies to intermediate ground range image data prior to geocoding.
pixelTimeOrdering	1,1	rs2prod:timeOrderingIdentifiers		Indicates whether pixel number (i.e. range) increases or decreases with time. For SSG and SPG products, this applies to intermediate ground range image data prior to geocoding.
numberOfBursts	0,1	xsd:integer		Total number of ScanSAR image blocks[1] per polarization over all beams (provided only for SCS or SCF product types).
numberOfCycles	0,1	xsd:integer		Number of ScanSAR cycles. This number is equal to the number of ScanSAR image blocks[1] divided by the number of beams in the beam list (provided only for SCS or SCF product types).

[1] In the case of single azimuth look ScanSAR data, a ScanSAR image block maps one-to-one with its corresponding imaging burst. In the case of multiple azimuth look ScanSAR data, a ScanSAR image block maps onto the common portions of 2 or more successive imaging bursts that were multi-looked together.

Name	Min,Max	Type	Attributes	Description
burstAttributes	0,∞	rs2prod::burstAttributesDataStore		A list of data stores providing the attributes for each ScanSAR image block[1] (provided only for SCS or SCF product types).

product→imageAttributes→burstAttributes

Table 5-25 ScanSAR Burst Attributes

Name	Min,Max	Type	Attributes	Description
burstAttributesDataStore			beam=rs2prod:beamList burst= xsd:integer	ScanSAR Burst Attributes Data Store (burst represents the ScanSAR image block number and ranges from 1 to numberOfBursts)
burstTopLeftLine	1,1	xsd:integer		Line number (starting at 1) of the image pixel having the nearest range and earliest zero-Doppler imaging time within the ScanSAR image block in the raster image. This corresponds to the top-left pixel in a coordinate system where the range increases to the right and the zero-Doppler time increases downward. Note that this is not necessarily the top-left pixel of the image block in the final product.
burstTopLeftPixel	1,1	xsd:integer		Pixel number (starting at 1) of the image pixel having the nearest range and earliest zero-Doppler imaging time within the ScanSAR image block in the raster image. This corresponds to the top-left pixel in a coordinate system where the range increases to the right and the zero-Doppler time increases downward. Note that this is not necessarily the top-left pixel of the image block in the final product.

Name	Min,Max	Type	Attributes	Description
burstBottomRightLine	1,1	xsd:integer		Line number (starting at 1) of the image pixel having the farthest range and latest zero-Doppler imaging time within the ScanSAR image block in the raster image. This corresponds to the bottom-right pixel in a coordinate system where the range increases to the right and the zero-Doppler time increases downward. Note that this is not necessarily the bottom-right pixel of the image block in the final product.
burstBottomRightPixel	1,1	xsd:integer		Pixel number (starting at 1) of the image pixel having the farthest range and latest zero-Doppler imaging time within the ScanSAR image block in Raster image. This corresponds to the bottom-right pixel in a coordinate system where the range increases to the right and the zero-Doppler time increases downward. Note that this is not necessarily the bottom-right pixel of the image block in the final product.

The purpose of the burst attributes metadata is to identify the individual image blocks in the processed ScanSAR image, which enables down-stream applications to identify potential range and azimuth ambiguities, and to locate areas of imagery having common processing operations applied and therefore having similar image quality characteristics such as noise levels.

The use of the term “burst” in this context is attributable to the fact that in a single azimuth look ScanSAR product, each output image block originates from a corresponding imaging burst (defined by a beam and ScanSAR cycle) in the raw data. However, in a multiple azimuth look ScanSAR product, each output image block is derived from combined portions of successive imaging bursts (having the same beam spanning a sequence of adjacent ScanSAR cycles) in the raw data.

The bursts attribute records are provided in increasing time order, starting with image block number 1. Refer to Figure 5-2 below for an explanation of the ScanSAR image blocks order in the raster image; in the example shown, the first image block is located at the lower left corner of the raster image.

Within a burst attributes record, the top-left pixel actually refers to the earliest imaged pixel of an image block (in terms of both range and zero-Doppler imaging time), and the bottom-right pixel refers to the latest imaged pixel of the image block. However, since the raster image may be flipped such that it is oriented nominally north-up and east-right, these are not necessarily the top-left and bottom-right pixels of the image block as it appears in the final product. This depends on the orbit pass direction (Ascending or Descending) and the antenna pointing direction (Left looking or Right looking). The *lineTimeOrdering* and *pixelTimeOrdering* fields in Table 5-23 indicate whether the line and pixel numbers increase or decrease with time in the raster image. As an example, Figure 5-2 below illustrates the right-looking Ascending case, where the *lineTimeOrdering* is decreasing from top to bottom and *pixelTimeOrdering* is increasing from left to right.

When a Sample Window Start Time (SWST) change occurs in the middle of an image block, there may be slight overlaps between the image block boundaries at the intersection points and possible blackfilled pixels on the leftmost and rightmost image blocks.

In addition, there will be small areas of orphaned imagery along the top and bottom of the image which are not allocated to a particular ScanSAR image block. This is due to the combination of overlap between adjacent beams and the illumination time offset between each beam within a ScanSAR cycle.

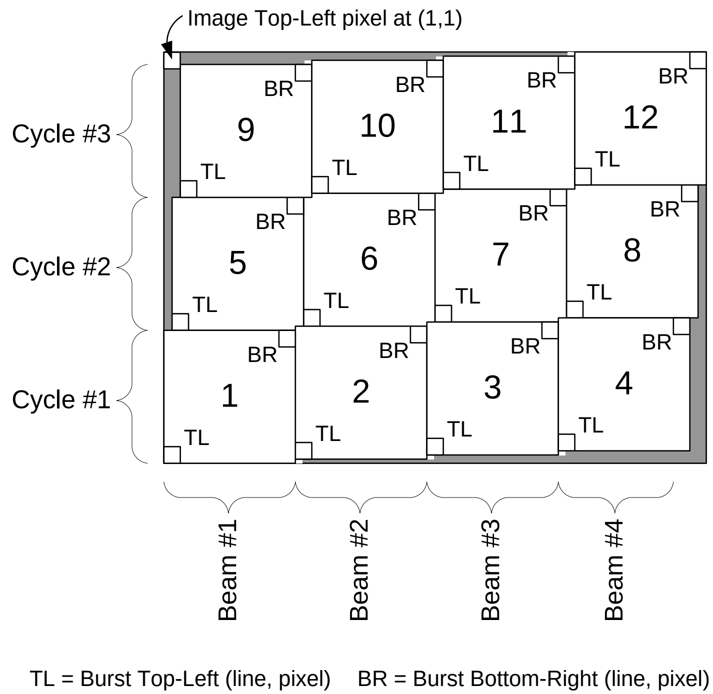

Figure 5-2 Illustration Showing Top-Left (i.e. earliest image pixel) and Bottom-Right (i.e. latest image pixel) Corners of the ScanSAR Image Blocks in the Raster Image

product→imageAttributes→geographicInformation

Table 5-26 Geographic Information

Name	Min,Max	Type	Attributes	Description
geographicInformationDataStore				Geographic Information Data Store
geolocationGrid	0,1	rs2prod:geolocationGridDataStore		A grid of tie points is included that relates the line/pixel positions in the image to latitude/longitude. May be omitted for geocoded products (SSG, SPG).
rationalFunctions	0,1	rs2prod:rationalFunctionsDataStore		Rational function geopositioning models for non-geocoded products. The rational functions provide a simplified mechanism for geo-positioning pixels in the image. It is computed from image tie points and is included for convenience only. Not included for geocoded products (SSG, SPG).
mapProjection	0,1	rs2prod:mapProjectionDataStore		Map Projections available for geocoded products only
referenceEllipsoidParameters	1,1	rs2prod:ellipsoidParametersDataStore		

product→imageAttributes→geographicInformation→geolocationGrid

Table 5-27 Geolocation Grid

Name	Min,Max	Type	Attributes	Description
geolocationGridDataStore				Geolocation Grid Datastore
imageTiePoint	0,∞	rs2prod:imageTiePoint		The estimated geodetic coordinates for a 2D grid of points including the image corner pixels and points at regular intervals in between.

Table 5-28 Image Tie Point

Name	Min,Max	Type	Attributes	Description
imageTiePoint				Image Tie-Point Data Store
imageCoordinate	1,1	rs2prod:imageCoordinate		Image coordinates of this tie point. Co-ordinate Data Stores are described in the Section on Common Parameters (refer to Appendix A for further details on image co-ordinate systems used)
geodeticCoordinate	1,1	rs2prod:geodeticCoordinate		Estimated geodetic coordinates of this tie point in the reference ellipsoid coordinate system. These estimates are approximate and will be affected by ground range projection errors arising from differences between the given terrain height and the true terrain height above the ellipsoid. Co-ordinate Data Stores are described in the Section on Common Parameters.

product→imageAttributes→geographicInformation→rationalFunctions

Table 5-29 Rational Functions

Name	Min,Max	Type	Attributes	Description
rationalFunctionsDataStore				Rational Functions Data Store
biasError	1,1	xsd:double	units = rs2prod:distanceUnits	Non-time varying 1-sigma error estimate for correlated images measured in meters (units = m)
randomError	1,1	xsd:double	units = rs2prod:distanceUnits	Time varying 1-sigma error estimate for correlated images measured in meters (units = m)
lineFitQuality	1,1	xsd:double		Indicates the quality of the line rational function fit. This value is the RMS line error
pixelFitQuality	1,1	xsd:double		Indicates the quality of the pixel rational function fit. This value is the RMS pixel error
lineOffset	1,1	xsd:integer		Offset used to linearly transform line values to range of [-1,1]
pixelOffset	1,1	xsd:integer		Offset used to linearly transform pixel values to range of [-1,1]

Name	Min,Max	Type	Attributes	Description
latitudeOffset	1,1	xsd:double	units = rs2prod:angularUnits	Offset used to linearly transform latitude values to range of [-1,1] (units = deg)
longitudeOffset	1,1	xsd:double	units = rs2prod:angularUnits	Offset used to linearly transform longitude values to range of [-1,1] (units = deg)
heightOffset	1,1	xsd:double	units = rs2prod:distanceUnits	Offset used to linearly transform height values to range of [-1,1] (units = m)
lineScale	1,1	xsd:integer		Scale used to linearly transform line values to range of [-1,1]
pixelScale	1,1	xsd:integer		Scale used to linearly transform pixel values to range of [-1,1]
latitudeScale	1,1	xsd:double		Scale used to linearly transform latitude values to range of [-1,1]
longitudeScale	1,1	xsd:double		Scale used to linearly transform longitude values to range of [-1,1]
heightScale	1,1	xsd:double		Scale used to linearly transform height values to range of [-1,1]
lineNumeratorCoefficients	1,1	rs2prod:rationalFunctionCoefficientList		20 coefficients representing the polynomial in the numerator of the rational function mapping latitude, longitude and height to line. The order of the coefficients is the same as found in Document R-9
lineDenominatorCoefficients	1,1	rs2prod:rationalFunctionCoefficientList		20 coefficients representing the polynomial in the denominator of the rational function mapping latitude longitude and height to line. The order of the coefficients is the same as found in Document R-9
pixelNumeratorCoefficients	1,1	rs2prod:rationalFunctionCoefficientList		20 coefficients representing the polynomial in the numerator of the rational function mapping latitude, longitude and height to pixel. The order of the coefficients is the same as found in Document R-9
pixelDenominatorCoefficients	1,1	rs2prod:rationalFunctionCoefficientList		20 coefficients representing the polynomial in the denominator of the rational function mapping latitude, longitude and height to pixel. The order of the coefficients is the same as found in Document R-9

The following description is extracted from document [R-9] with some modification:

The geometric sensor model describing the precise relationship between image coordinates and ground coordinates is known as a Rigorous Projection Model. A Rigorous Projection Model expresses the mapping of the image space coordinates of rows and columns (r,c) onto the object space reference surface geodetic coordinates (φ, λ, h).

The RADARSAT-2 product supports a common approximation to the Rigorous Projection Models. The approximation used is a set of rational polynomials expressing the normalized row and column values, (r_n , c_n), as a function of normalized geodetic latitude, longitude, and height, (P, L, H), given a set of normalized polynomial coefficients (LINE_NUM_COEF_n, LINE_DEN_COEF_n, SAMP_NUM_COEF_n, SAMP_DEN_COEF_n). Normalized values, rather than actual values are used in order to minimize introduction of errors during the calculations. The transformation between row and column values (r,c), and normalized row and column values (r_n , c_n), and between the geodetic latitude, longitude, and height (φ, λ, h), and normalized geodetic latitude, longitude, and height (P, L, H), is defined by a set of normalizing translations (offsets) and scales that ensure all values are contained in the range -1 to +1.

P = (Latitude	- LAT_OFF)	÷ LAT_SCALE
L = (Longitude	- LONG_OFF)	÷ LONG_SCALE
H = (Height	- HEIGHT_OFF)	÷ HEIGHT_SCALE
r_n = (Row	- LINE_OFF)	÷ LINE_SCALE
c_n = (Column	- SAMP_OFF)	÷ SAMP_SCALE

The rational function polynomial equations are defined as:

$$r_n = \frac{\sum_{i=1}^{20} \text{LINE\_NUM\_COEF}_i \cdot \rho_i(P, L, H)}{\sum_{i=1}^{20} \text{LINE\_DEN\_COEF}_i \cdot \rho_i(P, L, H)} \text{ and } c_n = \frac{\sum_{i=1}^{20} \text{SAMP\_NUM\_COEF}_i \cdot \rho_i(P, L, H)}{\sum_{i=1}^{20} \text{SAMP\_DEN\_COEF}_i \cdot \rho_i(P, L, H)}$$

The rational function polynomial equation numerators and denominators each are 20-term cubic polynomial functions of the form:

$$\sum_{i=1}^{20} C_1 \cdot \rho_i (P, L, H) =$$

$$\begin{array}{llll} C_1 & +C_6 \cdot L \cdot H & +C_{11} \cdot P \cdot L \cdot H & +C_{16} \cdot P^3 \\ +C_2 \cdot L & +C_7 \cdot P \cdot H & +C_{12} \cdot L^3 & +C_{17} \cdot P \cdot H^2 \\ +C_3 \cdot P & +C_8 \cdot L^2 & +C_{13} \cdot L \cdot P^2 & +C_{18} \cdot L^2 \cdot H \\ +C_4 \cdot H & +C_9 \cdot P^2 & +C_{14} \cdot L \cdot H^2 & +C_{19} \cdot P^2 \cdot H \\ +C_5 \cdot L \cdot P & +C_{10} \cdot H^2 & +C_{15} \cdot L^2 \cdot P & +C_{20} \cdot H^3 \end{array}$$

where coefficients $C_1 \cdots C_{20}$ LC represent the following sets of coefficients:

LINE_NUM_COEF_n, LINE_DEN_COEF_n, SAMP_NUM_COEF_n, SAMP_DEN_COEF_n

The image coordinates are in units of pixels. The ground coordinates are latitude and longitude in units of decimal degrees and the geodetic elevation in units of meters. The ground coordinates are referenced to WGS-84, and pixel and line numbers start at 0.

product→imageAttributes→geographicInformation→mapProjection

Table 5-30 Map Projection

Name	Min,Max	Type	Attributes	Description
mapProjectionDataStore				Map Projection Data Store
mapProjectionDescriptor	1,1	xsd:string		Presently defined entries in mapProjection types include: “ARC”, “LCC”, “STPL”, “UTM”, “UPS”
mapProjectionOrientation	1,1	xsd:double	units=rs2prod:angularUnits	(units = deg)
productOrientation	1,1	rs2prod:productOrientationIdentifiers		

Name	Min,Max	Type	Attributes	Description
resamplingKernel	1,1	xsd:string		Kernel type used to resample SAR data during geocoding to map projection. Presently defined kernel types include: "NN" "Bilinear" "CC" "8 point Sinc" "DS8" "DS16" "16 point Sinc" "Kaiser 16 point Sinc" "KD16". Note: This applies to SAR data resampling only. Interpolation of DEM data during geocoding (if applicable) is always bilinear.
elevationCorrection	1,1	rs2prod:elevationCorrectionIdentifiers		
baseElevation	0,1	xsd:double	units=rs2prod:distanceUnits	Provided only when elevationCorrection = "Base". (units = m)
satelliteHeading	1,1	xsd:double	units=rs2prod:angularUnits	Satellite ground track heading in degrees east of North. (units = deg)
start choice				
utmProjectionParameters	1,1	rs2prod:utmProjectionParameters DataStore		Universal Transverse Mercator Projection. Universal Polar Stereographic (UPS) projection used from lat 84N and 80S to the respective poles
nspProjectionParameters	1,1	rs2prod:nspProjectionParametersDataStore		National Systems Projection (any others)
end choice				
positioningInformation	1,1	rs2prod:mapCornersDataStore		Corner positioning of output image

product→imageAttributes→geographicInformation→mapProjection→utmProjectionParameters

Table 5-31 UTM Projection Parameters

Name	Min,Max	Type	Attributes	Description
utmProjectionParametersDataStore				UTM Projection Data Store
utmZone	0,1	xsd:integer		Range from 1 to 60
hemisphere	1,1	rs2prod:hemisphereIdentifiers		Northern or Southern. Required for UTM and UPS

Name	Min,Max	Type	Attributes	Description
mapOriginFalseEasting	0,1	xsd:double	units=rs2prod:distanceUnits	(units = m)
mapOriginFalseNorthing	0,1	xsd:double	units=rs2prod:distanceUnits	(units = m)

product→imageAttributes→geographicInformation→mapProjection→nspProjectionParameters

Table 5-32 NSP Projection Parameters

Name	Min,Max	Type	Attributes	Description
nspProjectionParametersDataStore				NSP Projection Data Store. To support ARC, LCC, STPL, for which not all the following entries are required.
MapOriginFalseEasting	0,1	xsd:double	units=rs2prod:distanceUnits	(units = m)
mapOriginFalseNorthing	0,1	xsd:double	units=rs2prod:distanceUnits	(units = m)
centerOfProjectionLongitude	0,1	xsd:double	units=rs2prod:angularUnits	(units = deg)
centerOfProjectionLatitude	0,1	xsd:double	units=rs2prod:angularUnits	(units = deg)
standardParallels1	0,1	xsd:double	units=rs2prod:angularUnits	(units = deg)
standardParallels2	0,1	xsd:double	units=rs2prod:angularUnits	(units = deg)
zone	0,1	xsd:integer		Range 0 to 65535. Applicable for STPL

product→imageAttributes→geographicInformation→mapProjection→mapCorners

Table 5-33 Map Corners

Name	Min,Max	Type	Attributes	Description
mapCornersDataStore				Map Corners Data Store
upperLeftCorner	1,1	rs2prod:mapTiePoint		Co-ordinates of upper left corner of product
upperRightCorner	1,1	rs2prod:mapTiePoint		Co-ordinates of upper right corner of product
lowerRightCorner	1,1	rs2prod:mapTiePoint		Co-ordinates of lower right corner of product
lowerLeftCorner	1,1	rs2prod:mapTiePoint		Co-ordinates of lower left corner of product

product→imageAttributes→geographicInformation→mapProjection→mapCorners→mapTiePoint

Table 5-34 Map Tie Point

Name	Min,Max	Type	Attributes	Description
mapTiePoint				Map Tie-Point Data Store
mapCoordinate	1,1	rs2prod:mapCoordinate		Co-ordinate Data Stores are described in the Section on Common Parameters
geodeticCoordinate	1,1	rs2prod:geodeticCoordinate		Co-ordinate Data Stores are described in the Section on Common Parameters

product→imageAttributes→geographicInformation→referenceEllipsoidParameters

Table 5-35 Ellipsoid Parameters

Name	Min,Max	Type	Attributes	Description
ellipsoidParametersDataStore				Ellipsoid Parameters Data Store
ellipsoidName	1,1	xsd:string		Name of ellipsoid used to process this product. Presently defined entries in earthEllipsoid types include: “Airy 1830” “Airy 1849” “Australian 1965” “Bessel 1841” “Bessel Modified” “Bessel 1841 Namibia” “Clarke 1858” “Clarke 1866” “Clarke 1866 MICHIGAN” “Clarke 1880 FOOT” “Clarke 1880 ARC” “Clarke 1880 BENOIT” “Clarke 1880 IGN” “Clarke 1880 RGS” “Clarke 1880 SGA 1922” “Everest 1830 1937” “Everest 1830 1967” “Everest 1830 1975” “Everest 1830 Modified” “GEM 10C” “GRS 1980” “Helmert 1906” “Indonesian 1974” “International 1924” “International 1967” “Krassowsky 1940” “NWL 9D” “NWL 10D” “OSU 86F” “OSU 91A” “Plessis 1817” “Struve 1860” “War Office” “WGS84”
semiMajorAxis	1,1	xsd:double	units=rs2prod:distanceUnits	Semi-major axis of the ellipsoid. (units = m)
semiMinorAxis	1,1	xsd:double	units=rs2prod:distanceUnits	Semi-minor axis of the ellipsoid. (units = m)

Name	Min,Max	Type	Attributes	Description
datumShiftParameters	1,1	rs2prod:datumShiftParametersList	units=rs2prod:distanceUnits	Datum shift parameter referenced to Greenwich: dx. Datum shift parameter perpendicular to Greenwich: dy. Datum shift parameter direction of rotation axis: dz. (units = m)
geodeticTerrainHeight	1,1	xsd:double	units=rs2prod:distanceUnits	Estimated geodetic terrain height used as base elevation for geometric calculations and radiometric corrections during processing. (units = m above reference ellipsoid) For SPG products and for SSG products with DEM corrections, this applies before geocoding and does not necessarily represent the elevations used to geocode the final image data.

product→imageAttributes→radiometricInformation

Table 5-36 Radiometric Information

Name	Min,Max	Type	Attributes	Description
radiometricInformationDataStore			pole=rs2prod:polarizationIdentifiers	Radiometric measurements for the output image
mean	1,2	xsd:double	dataStream=rs2prod:dataStreamIdentifiers	Mean value of output pixels
standardDeviation	1,2	xsd:double	dataStream=rs2prod:dataStreamIdentifiers	Standard deviation of output pixels

NOTE: for SSG and SPG products, the radiometric information described above is computed on the SAR image prior to geocoding.

5.3.5 Common Parameters

This section describes the data that can be used by any of the Data Stores. Other than describing the image, geodetic and map coordinate Data Stores, it provides details on the enumerated values of the identifiers, units used for attributes, and information on lists. The tables in this section are not preceded by arrow diagrams since they can occur in multiple locations within the hierarchy.

Table 5-37 Image Coordinate

Name	Min,Max	Type	Attributes	Description
imageCoordinate				Image Co-ordinate Data Store. Each image coordinate represents a point (as opposed to the top left corner of an area).
line	1,1	xsd:double		Image line (row) number starting from zero at the top of the image
pixel	1,1	xsd:double		Image pixel (column) number starting from zero for the leftmost image pixel

Table 5-38 Geodetic Coordinate

Name	Min,Max	Type	Attributes	Description
geodeticCoordinate				Geodetic Co-ordinate Data Store
latitude	1,1	xsd:double	units=rs2prod:angularUnits	Geodetic latitude. (units = deg)
longitude	1,1	xsd:double	units=rs2prod:angularUnits	Geodetic longitude. (units = deg)
height	1,1	xsd:double	units=rs2prod:distanceUnits	Geodetic height above reference ellipsoid (units = m)

Table 5-39 Map Coordinate

Name	Min,Max	Type	Attributes	Description
mapCoordinate				Map Co-ordinate Data Store
northing	1,1	xsd:double	units=rs2prod:distanceUnits	(units = m)
easting	1,1	xsd:double	units=rs2prod:distanceUnits	(units = m)

Table 5-40 Identifiers

Name	Type	Description
acquisitionIdentifiers	xsd:string	“Standard” “Wide” “Fine” “Multi-Look Fine” “Extra Fine” “Ultrafine” “Low Incidence” “High Incidence” “Standard Quad Polarization” “Fine Quad Polarization” “ScanSAR Narrow” “ScanSAR Wide” “SpotlightA” “SpotlightB”, “Ocean Surveillance”, “Detection of Vessels”. The Wide Ultra-Fine, Wide Multi-Look Fine, Wide Fine, Wide Standard-Quad Polarization, and Wide Fine-Quad Polarization beam modes all share the same acquisitionIdentifier as their corresponding non-Wide beam modes. So, for example, the Wide Ultra-Fine and Ultra-Fine beam modes both use the “Ultrafine” acquisitionIdentifier. To differentiate between these beam modes, refer to beamModeMnemonic.
antennaPointingIdentifiers	xsd:string	“Left” “Right”
attitudeSourceIdentifiers	xsd:string	“Downlink” “User Specified”
dataStreamIdentifiers	xsd:string	“Real” “Imaginary” “Magnitude”
dataTypeIdentifiers	xsd:string	“Complex” “Magnitude Detected”
dopplerSourceIdentifiers	xsd:string	“Adaptive Analysis” “Orbit and Attitude” “Default”
elevationCorrectionIdentifiers	xsd:string	“None” “Base” “Coarse DEM” “Fine DEM”
geodeticFlagIdentifiers	xsd:string	“On-Geodetic” “Off-Geocentric”
hemisphereIdentifiers	xsd:string	“N” “S”
incidenceAngleCorrectionIdentifiers	xsd:string	“Beta Nought” “Sigma Nought” “Gamma”
orbitDataSourceIdentifiers	xsd:string	“Predicted” “Definitive” “Downlinked”
outputMediaInterleavingIdentifiers	xsd:string	“BSQ” “BIP”
passDirectionIdentifiers	xsd:string	“Ascending” “Descending”
polarizationIdentifiers	xsd:string	“HH” “VV” “HV” “VH”
productFormatIdentifiers	xsd:string	“GeoTIFF” “NITF 2.1”
productOrientationIdentifiers	xsd:string	“Satellite” “Map North” “True North”
productTypeIdentifiers	xsd:string	“SLC” “SGF” “SGX” “SGC” “SSG” “SPG” "SCF" "SCS"
pulseIdentifiers	xsd:string	“11.58” “17.28” “30” “50” “Lower_50” “Upper_50”
rangeReferenceFunctionSourceIdentifiers	xsd:string	“Nominal Chirp” “Extracted Chirp Replica”
RawBitsPerSampleIdentifier	xsd:integer	BAQ rate for Raw Data Quantization
satelliteIdentifiers	xsd:string	"RADARSAT-1" "RADARSAT-2"
sensorIdentifiers	xsd:string	"SAR"

Name	Type	Description
windowNameIdentifiers	xsd:string	"Kaiser" "Hamming"
wingIdentifiers	xsd:string	"Fore" "Aft" “Combined”
yawSteeringFlagIdentifiers	xsd:string	“YawSteeringOn" "YawSteeringOff"
timeOrderingIdentifiers	xsd:string	“Increasing” “Decreasing”

Table 5-41 Units

Name	Type	Description
angularUnits	xsd:string	"deg" "rad"
angularVelocityUnits	xsd:string	"deg/s" "rad/s"
distanceUnits	xsd:string	"mm" "cm" "m" "km"
frequencyUnits	xsd:string	"Hz" "kHz" "MHz"
powerUnits	xsd:string	"dB" "W/m^2"
timeUnits	xsd:string	"s" "ms" "us" "ns"
velocityUnits	xsd:string	"m/s" "km/s"

Table 5-42 Lists

Name	Type	From	To	Description
beamList	rs2prod:stringListType	1	∞	
coefficientsList	rs2prod:doubleListType	1	10	
datumShiftParametersList	rs2prod:doubleListType	3	3	
histogramList	rs2prod:integerListType	1	256	
gainList	rs2prod:doubleListType	1	20000	
lookWeightList	rs2prod:doubleListType	1	∞	
polarizationList	rs2prod:polarizationListType	1	4	
pulseList	rs2prod:pulseListType	1	2	
rationalFunctionCoefficientList	rs2prod:doubleListType	20	20	
noiseLevelValuesList	rs2prod:doubleListType	1	∞	

Name	Type	From	To	Description
stringListType	xsd:string			This is a declaration of a list type whose entries are strings
doubleListType	xsd:double			This is a declaration of a list type whose entries are doubles
integerListType	xsd:integer			This is a declaration of a list type whose entries are integers
polarizationListType	rs2prod:polarizationIdentifiers			This is a declaration of a list type whose entries are polarizationIdentifiers
pulseListType	rs2prod:pulseIdentifiers			This is a declaration of a list type whose entries are pulseIdentifiers

Table 5-43 Data Types

Name	Type	Min	Max	Pattern (if applicable)	Description
beamModeIdType	xsd:integer	0	4294967295		A unique value (32-bit) will be defined for each Beam/Mode Definition. This identifier will not change when the Beam/Mode Definition is updated.
beamModeMnemonicType	xsd:string	1	6	[a-zA-Z0-9]+	String must be alphanumeric
imageIdType	xsd:integer	0	4294967295		Unique ID of an Image (32-bit) (generated by Ground Segment when the Acquisition Schedule is generated; it is flowed through to the spacecraft in Ground Pass-Through Data)
inputDataSetFacilityNameType	xsd:token	1	32	[0-9A-Za-z_ \.\-]+	Name of an Archive facility, which maintains Archive Segments (datasets) from which RADARSAT-2 products are produced.
inputDataSetIdType	xsd:token	1	256	[0-9A-Za-z_/:\\\.\-]+	Identifier of an Archive Segment (dataset). When combined with the archiveFacilityId uniquely identifies a dataset.
prfType	xsd:double	>0.0	10000.0		SAR Pulse Repetition Frequency in Hz
priPerDwellType	xsd:integer	0	65535		Number of transmitted pulse repetition intervals per dwell (if Number of Beams > 1)
processingFacilityNameType	xsd:token	1	32	[0-9A-Za-z_ \.\-]+	Name of the Processing Facility which generated the product.
pulseBandwidthType	xsd:double				In MHz unless overridden by attribute, e.g. units=Hz
pulseDurationType	xsd:double				In micro-seconds unless overridden by attribute, e.g. units=s (seconds)
rangeSamplingRateType	xsd:double				The range sampling rate (sampling rate of echo data within each sample window). In MHz unless overridden by attribute, e.g. units=Hz
rankType	xsd:integer	>0	100		Number of transmitted pulse repetition intervals between transmission and reception.

Name	Type	Min	Max	Pattern (if applicable)	Description
transmittedPulsesPerDwellType	xsd:integer	0	65535		Number of pulses transmitted per dwell (required if Number of Beams > 1). It is assumed that the start of pulse transmissions is the first PRI of the dwell.
utcTimeType	xsd:dateTime			\d\d\d\d-\d\d-\d\dT\d\d:\d\d:\d\d(\.\d+)?Z	UTC Time - this is stored in XML dateTime format as "CCYY-MM-DDThh:mm:ss.uuu...uuZ". Decimal fraction of seconds is optional.

5.4 Example Uses of Product Information

This section provides further understanding of the Product Information File format through examples of selected post-processing calculations.

5.4.1 Geocoding and Geolocation

A description of methods for geolocating RADARSAT-2 georeferenced SAR image products using the orbit data, tie-points and rational function coefficients provided in the Product Information File is provided in a separate technote, Geolocation of RADARSAT-2 Georeferenced Products (Document R-10), which is available to RADARSAT-2 data users upon request.

5.4.2 Image Ambiguity Calculations

5.4.2.1 Range Ambiguities

If a bright point is within the illuminated area of a beam in range (which includes the areas outside of the left and right sides of the image product) with a slant range of R_T (in m), then a range ambiguity of this bright point may appear at the following slant ranges:

$$R_A = R_T + k \cdot \left(\frac{c}{2 \cdot PRF_i} \right)$$

Where PRF_i is the transmit pulseRepetitionFrequency (in Hz) as given in Table 5-3 for beam i , which may be any of the beams that illuminated the bright point, c is the speed of light, and k is an integer, …, -2, -1, +1, -2, …

5.4.2.2 Azimuth Ambiguities

If a bright point is within the illuminated area of a beam in azimuth (which includes the areas outside of the top and bottom ends of the image product) with an azimuth position of A_T (in m), then an azimuth ambiguity of this bright point may appear at the following azimuth positions:

$$A_A = A_T + k \cdot \left(\frac{\lambda \cdot R_T \cdot PRF_i}{2V_S} \right)$$

Where:

- λ is the wavelength (i.e. 0.0554658m),
- R_T (in m) is the slant range to the bright point,
- PRF_i is the transmit pulseRepetitionFrequency (in Hz) as given in Table 5-3 for the beam that is used to image targets at range R_T, The beam number i can be determined from knowledge of the pixel index at range R_T in conjunction with the image pixel coordinates of the image block attributes described in Table 5-25, The relationship between pixel index and range R_T is governed by the slant range to ground range information given in Table 5-21,
- V_S is the spacecraft speed (in m/s), which is the modulus of the xVelocity, yVelocity and zVelocity values given in Table 5-10 at the approximate time of imaging, and
- k is an integer, …, -2, -1, +1, -2, …

5.4.3 2D Noise Estimation for Single-Look ScanSAR Products

In single-look ScanSAR products, the mean image noise levels vary significantly in both the range and azimuth directions. A first order approximation of the expected 2D varying mean noise level for a given image block can be obtained by cross-multiplying the portion of the Reference Noise Profile that covers the image block, with the Azimuth Noise Level Scaling factors (Table 5-5) for the applicable beam, where:

- The Reference Noise Profile is described in Table 5-4.
- The Azimuth Noise Level Scaling factors are described in Table 5-5 (and are defined at the mid-range point of the image block).
- The nominal bounds of the image block are provided in the Burst Attributes as per Table 5-25.
- The applicable beam number B can be obtained from the image block burst number K as B = mod(K/number of beams in the beams list of Table 5-3).
- This is illustrated in Figure 5-3 below, for the special case when the earliest pixel in the image block corresponds to its top-left corner in the image (other cases can be handled as described previously per Figure 5-2).

Taking into consideration that some overlapping pixels are discarded as part of the ScanSAR image mosaicking process and that there are minor variations in the height of each output image block from cycle to cycle, the actual image block center line (used, for example, to align the azimuth noise level scaling) will not be precisely aligned with the arithmetic center of each ScanSAR image block. Alternatively, a refined estimate of the image block center line (to within one half of a line) can be determined for each beam using the following approach (which is based on the knowledge that the first image block is complete, i.e., does not have any overlapping pixels discarded, and the cycle period is constant):

a) use least squares to determine the coefficients of a straight line fit to the arithmetic center line of the image blocks over cycles 2 through N, where N is the number of cycles;

b) use these coefficients to recompute the center line of all cycles; and

c) shift all center lines by a constant amount to align the first fitted center line with the arithmetic center line of the first cycle.

However, it is noted that even with refined image block centering, the 2D mean noise level calculations described above are approximations that neglect complicating factors such as the azimuth dependency of the range-varying mean noise levels, and the range dependency of the azimuth-varying noise scaling factors, among others. Therefore, for applications that are sensitive to 2D mean noise level variations, an alternative to these calculations would be to use products processed with noise subtraction, i.e. with the noiseSubtractionPerformed flag (see Table 5-15) set true.

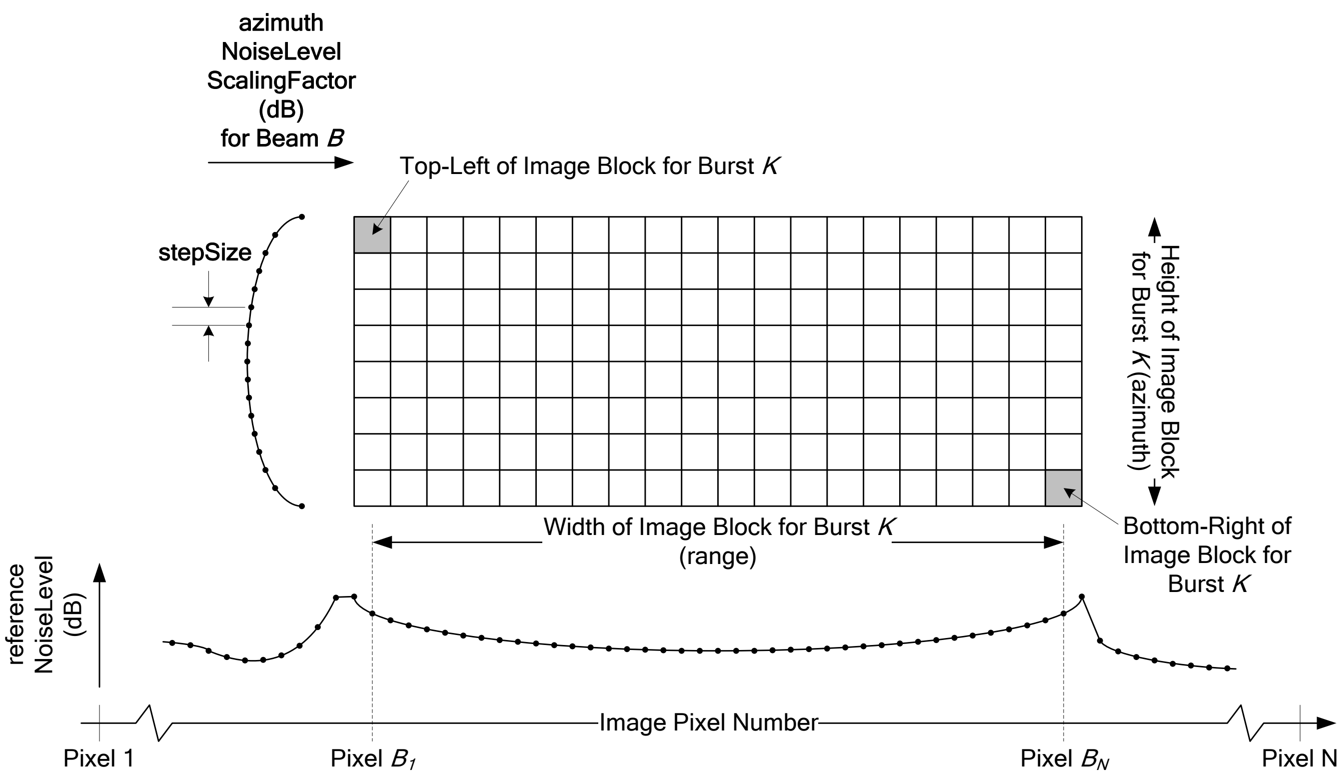

Figure 5-3 Illustration of approximate mean 2D image block noise level computation

5.4.4 Spotlight Synthetic Aperture Time

In Spotlight mode, the synthetic aperture time can be calculated as:

$$\frac{numberOfLinesProcessed - rank}{pulseRepetitionFrequency * \mathrm{Nw}}$$

where *numberOfLinesProcessed*, *rank*, and *pulseRepetitionFrequency* represent named fields as described in the tables above, and Nw is the number of antenna wings, which is 2 (fore and aft) for Spotlight-A mode.

6 RADARSAT-2 PRODUCT IMAGE PIXEL DATA FORMAT

Image pixel data files are oriented such that insofar as practical, North is nominally up and East is nominally on the right. In order to achieve this, georeferenced images are flipped as necessary from top to bottom and/or from left to right, depending on the pass and look directions. (The pass direction is determined based on the Z or North polar component of the velocity of the state vector at mid azimuth: If it is positive, then the pass orientation is ascending.) To determine whether such flipping has occurred, use the lineTimeOrdering and pixelTimeOrdering fields in the Product Information File. If lineTimeOrdering is Decreasing, it means that the image is flipped top to bottom, i.e. the first acquired line is at the bottom of the image. Similarly, if pixelTimeOrdering is Decreasing, it means that the image is flipped left to right, i.e. the nearest-range pixel is at the right edge of the image.

Image pixel data files for RADARSAT-2 products may be provided in either GeoTIFF or NITF format. For NITF products, the image pixel data file format is described in "RADARSAT-2 NITF 2.1 Product Format Definition" (Document R-12). For GeoTIFF products, the image pixel data file format is described below.

6.1 GeoTIFF

GeoTIFF extends Aldus-Adobe's raster Tagged Image File Format (TIFF) with a set of fields that provide additional geographic information. GeoTIFF is described in the GeoTIFF Format Specification (Document R-4).

This section contains three tables. Table 6-1 describes the contents of the TIFF fields used by all the RADARSAT-2 products considered in this format (i.e. all products except RAW). Table 6-2 describes the GeoTIFF fields used for all products that are georeferenced, but not geocorrected (i.e. specified in slant range or ground range coordinate systems). SLC, SGX, SGF, SGC, SCN, SCW, SCF, and SCS products fall into this category and since these products are not geographically corrected, the geographic metadata included in GeoTIFF fields is limited to a set of points tying image location to geographic location. Table 6-3 describes the GeoTIFF fields used for all products that have been geocorrected to a map projection. SSG and SPG products are included in this category.

GeoTIFF images are generated in TIFF strip format. Multipolar images are generated as separate GeoTIFF image files.

Endianness in a TIFF image file is indicated in the first two bytes of the file: for big endian these are "MM" (for Motorola), and for little endian these are "II" (for Intel). For RADARSAT-2 products the endianness varies depending on the hardware used to host the product generation application software.

Depending on RADARSAT-2 product correction level and duration, GeoTIFF products can use either the classic TIFF file format (which is described in Document R-3) or BigTIFF. BigTIFF is a TIFF variant file format that uses 64-bit offsets in order to support file sizes beyond the 4 Gbyte file size limitation of classic TIFF, which uses 32-bit offsets. The use of BigTIFF is indicated by the TIFF version number, which is found in the second two bytes of a TIFF file: for classic TIFF, the version number is “0x2a” (42 in decimal), and for BigTIFF, the version number is “0x2b” (43 in decimal). A reduced-resolution browse image is always a classic TIFF. Further details on how BigTIFF modifies the classic TIFF file formats may be found at web sites http://www.remotesensing.org/libtiff/ or http://www.awaresystems.be/imaging/tiff/bigtiff.html . Note that with reference to the TIFF format specification [Document R-3] Section 2 (Image File Directory), the TIFF format currently allows more than 1 valid type for some fields, regardless of whether classic TIFF or BigTIFF is employed. A TIFF format reader must check the type to verify that it contains an expected value. For example, ImageWidth and ImageLength are usually specified as having type SHORT, but images with more than 64K rows or columns must use the LONG field type. Additional details can be found in [Document R-3].

The contents of TIFF fields used in all GeoTIFF product types are described in Table 6-1.

Table 6-1 TIFF Field Description

TIFF Field Name	TIFF Field Code (Tag)	TIFF Field Type	Description
`ImageWidth`	256	SHORT or LONG	Pixels per line.
`ImageLength`	257	SHORT or LONG	Lines per band.
`BitsPerSample`	258	SHORT	Set to 16 for SLC I and Q and non-geocorrected magnitude-detected Single Beam and Spotlight products. 8 or 16 for ScanSAR products and geocorrected products.
`Compression`	259	SHORT	Set to 1, meaning uncompressed.
`PhotometricInterpretation`	262	SHORT	Set to 1 (black is zero) since multipolar products not represented as RGB
`ImageDescription`	270	ASCII	Contains a single value to identify the polarization.
`StripOffsets`	273	Array of LONG or Array of LONG8	Offsets to image strips in the file. LONG is used for classic TIFF and LONG8 is used for BigTIFF.
`Orientation`	274	SHORT	Set to 1 to indicate that the first sample is the upper left corner.
`SamplesPerPixel`	277	SHORT	Set to 2 for I and Q. Set to 1 in all other cases
`RowsPerStrip`	278	SHORT or LONG	Number of lines per image strip within the file.

TIFF Field Name	TIFF Field Code (Tag)	TIFF Field Type	Description
StripByteCounts	279	Array of LONG	Sizes of the image strips in the file.
PlanarConfiguration	284	SHORT	Set to 1 (Chunky format) to indicate I and Q values are interleaved for SLC product. Irrelevant in all other cases as SamplesPerPixel is 1.
UtcTimeType	306	ASCII	Null terminated string indicating the date and time of file generation in "YYYY:MM:DD HH:MM:SS" format.
SampleFormat	339	Array of SHORT	The array will have SamplesPerPixel elements,. Each set to 2 (signed integer) for SLC products with I and Q values. Set to 1 to indicate (unsigned integer data) for all other products with amplitude values.

The GeoTIFF fields used for georeferenced products are described in Table 6-2.

Table 6-2 GeoTIFF Fields For Georeferenced Products

Field Name	Value	Description
ModelTiepointTag	Array of 6-tuples (column, row, 0, longitude, latitude, height)	This field is used to map raster coordinates to model coordinates. The field contains the full list of image tie points from the geolocationGrid record in the Product Information File. Column and row indices are consistent with the raster type, as described below. See also the description of image coordinate systems in Appendix A.
GTModelTypeGeoKey	ModelTypeGeographic	Indicates that the model coordinates are geodetic latitude, longitude, and height.
GTRasterTypeGeoKey	RasterPixelIsArea	Indicates that raster coordinates model a pixel as having area, rather than being a point sample. The (0,0) origin of the raster coordinate system is in the upper left corner of the upper left pixel.
GTCitationGeoKey	"Uncorrected Satellite Data"	This field gives an ASCII representation of the overall configuration of the GeoTIFF file.
GeographicTypeGeoKey	GCS_WGS_84	Indicates that model coordinates are referenced to the WGS84 datum.

The GeoTIFF fields used for geocorrected products are described in Table 6-3.

Table 6-3 GeoTIFF Fields For Geocorrected Products

Field Name	Value	Description
ModelTiePointTag	Single 6-tuple (column, row, 0, x, y, height)	This field is used to map a single raster coordinate to model coordinate. The mapping will be done at the upper left corner of the image. This field will only be present when the image is map north up. See also the description of image coordinate systems in Appendix A.
ModelPixelScaleTag	Single 3-tuple (pixel scale, line scale, 0)	This field is used to specify the scale factors used when converting between raster and model coordinates. This field will only be present when the image is map north up.
ModelTransformationTag	Single 4x4 double precision transformation matrix	This field is used to transform raster coordinates to model coordinates. This field will only be present when the image is not map north up – images that are in a satellite heading, for example.
GTModelTypeGeoKey	ModelTypeProjected	Indicates that the model coordinates are map projection x, and y.
GTRasterTypeGeoKey	RasterPixelIsArea	Indicates that raster coordinates model a pixel as having area, rather than being a point sample. The (0,0) origin of the raster coordinate system is in the upper left corner of the upper left pixel.
GTCitationGeoKey	"Corrected Satellite Data"	This field gives an ASCII representation of the overall configuration of the GeoTIFF file.
ProjectedCSTypeGeoKey	Projected coordinate system code	Code indicating the map projection and datum of the corrected image.
PCSCitationGeokey	String	This field gives an ASCII representation of the projected coordinate system. The name of the map projection and ellipsoid are used.
The following fields are only included when ProjectedCSTypeGeoKey is user defined.		
ProjectionGeoKey	Map projection code	Code indicating the map projection of the corrected image.
The following fields are only included when ProjectionGeoKey is user defined.		
ProjLinearUnitsGeoKey	Linear units code	Code indicating which units are used for map projection distances.
ProjCoordTransGeoKey	Map projection type code.	Code indicating the type of map projection used to correct the data.
The following fields are only included when necessary for the type of map projection.		
ProjStdParallel1GeoKey	Latitude	First standard parallel for the projection, in degrees.
ProjStdParallel2GeoKey	Latitude	Second standard parallel for the projection, in degrees.
ProjNatOriginLatGeoKey	Latitude	Projection origin latitude, in degrees.
ProjNatOriginLongGeoKey	Longitude	Projection origin longitude, in degrees

Field Name	Value	Description
ProjFalseEastingGeoKey	Distance	Easting (x) value at the projection origin.
ProjFalseNorthingGeoKey	Distance	Northing (y) value at the projection origin.
ProjCenterLongGeoKey	Longitude	Projection center longitude, in degrees.
ProjCenterLatGeoKey	Latitude	Projection center latitude, in degrees.
ProjScaleAtCenterGeoKey	Scale factor	Scale factor at projection center.
ProjAzimuthAngleGeoKey	Angle	Projection azimuth angle in degrees.
ProjStraightVertPoleLongGeoKey	Longitude	Longitude below the pole, in degrees.
The following fields are only included when ProjectedCSTypeGeoKey is user defined.		
GeographicTypeGeoKey	Geographic type code	Code indicating which ellipsoid/datum pair is used to correct the data.
The following fields are only included when GeographicTypeGeoKey is user defined.		
GeogGeodeticDatumGeoKey	User defined code	Indicates that the datum is user defined.
GeogCitationGeoKey	String	Name of the ellipsoid and possibly earth center offset parameters.
GeogEllipsoidGeoKey	Ellipsoid code	Code indicating which ellipsoid was used to correct the data.
The following fields are only included when GeogEllipsoidGeoKey is user defined.		
GeogSemiMajorAxisGeoKey	Distance	Semi-major axis of the ellipsoid in meters.
GeogSemiMinorAxisGeoKey	Distance	Semi-minor axis of the ellipsoid in meters.

7 LOOK-UP TABLE FILES

A set of three output scaling Look-up Table files (LUTs) are included with every product, except for SSG and SPG products. These LUTs allow one to convert the digital numbers found in the output product to calibrated *sigma-nought*, *beta-nought*, or *gamma* values.

7.1 Schema Details

The format of a LUT file is shown in Table 7-1.

Table 7-1 LUT

Name	Min, Max	Type	Attributes	Description
lut			copyright = xsd:string,	RADARSAT-2 Data and Products (c) MacDonald, Dettwiler and Associates Ltd., <year of acquisition> - All Rights Reserved.
offset	1,1	xsd:double		Constant offset (B)
gains	1,1	rs2prod:gainList		Range dependent gain list (A)

There is one entry in the gains list for each range sample in the imagery.

The values in the output scaling LUTs depend, among other factors, on the user-selected application look-up table (application LUT) that is used to convert the processor determined calibrated values into the digital values stored in the product. Document R-11, “RADARSAT-2 Application Look-Up Tables (LUTs)”, contains more detailed information on the application look-up tables (LUTs), as well as a selection guide to assist users when choosing the LUT to be used for product generation.

7.2 Converting Image Data to Calibrated Values

For detected products, in order to convert the digital value of a given range sample to a calibrated value, the digital value is first squared, then the offset (B) is added and the result is divided by the gain value (A) corresponding to the range sample according to the following formula:

$$calibrated\ value = \frac{digital\ value^2 + B}{A}$$

For SLC products, the square of the modulus of the complex digital value is divided by the *square* of the gain value (A) corresponding to the range sample according to the following formula:

$$calibrated\ value = \frac{|digital\ value|^2}{A^2}$$

In both cases, the calibrated value is a real number representing a backscattering coefficient, that is, a radar cross-section per unit area. Each value results from a convolution with the system impulse response function and may be one of sigma-nought, beta-nought, or gamma, depending on the selected LUT, where:

- For beta-nought, the unit area is in the slant range plane;
- For sigma-nought (which is equal to beta-nought multiplied by the sine of the nominal incidence angle), the unit area is on the Earth ellipsoid inflated to the geodetic terrain height that was used as base elevation during SAR processing;
- For gamma (also called gamma-nought, which is equal to beta-nought multiplied by the tangent of the nominal incidence angle), the unit area is perpendicular to the radar line of sight.

The calibrated values include true radar backscatter from the Earth surface, plus equivalent backscatter due to various sources of noise. However, for ScanSAR products of type SCF or SCS with optional noise subtraction applied, the estimated additive instrument noise levels are subtracted from the image data during processing, and the resulting calibrated values are reduced accordingly (see next section). For all georeferenced products, the product information file provides estimates of the additive instrument equivalent noise levels (as described previously in Section 5).

The offset (B) is nominally set to zero, except for ScanSAR products of type SCF or SCS with noise subtraction applied, for which the offset (B) is typically set to a negative value, as described in the next section.

7.3 Calibrated Values in Noise Subtracted ScanSAR Products

For ScanSAR products of type SCF or SCS with noise subtraction applied, an estimate of the expected contribution from additive thermal instrument noise has been subtracted from each image pixel, and the resulting calibrated values are reduced accordingly. Due to the statistical nature of SAR imaging and the randomness of the noise, for some pixels the digital value before noise subtraction may be lower than the subtracted noise estimate, and for such pixels the calibrated value will be negative. If an offset (B) of zero were to be used for such products, these negative calibrated valued pixels would be clipped to zero. Such clipping is undesirable because it has the potential to skew the statistics in areas of low signal. Thus, non-zero offsets (B) are used in order to reduce the number of such clipped pixels, such that the statistics are not excessively skewed given the user selected application LUT and the number of bits per image pixel. Note however that this may not necessarily eliminate all clipped pixels.

When applying an output scaling LUT to a noise subtracted ScanSAR product, the negative calibrated values will be reconstituted. It is up to the user or end application to decide how best to handle pixels having negative calibrated values, for example whether to clip them at zero or to leave them as is.

7.4 Obtaining Calibrated Values from Geocoded Products

For geocoded (SSG, SPG) products, no output scaling LUT files are provided, as the one-dimensional range scaling method described above does not apply to image data that has been rotated to map coordinates. Thus, in general, calibrated values cannot be obtained from geocoded products.

However, for geocoded products processed with certain application LUTs only, specific calibrated values can be obtained by applying the above formula for detected products with the gain value (A) set as per Table 7-2 below, and the offset (B) set to zero. For example, referring to the first line of the table, for geocoded products processed with the “Constant-sigma” application LUT, calibrated sigma-nought values can be obtained by applying the above formula for detected products with A = 1.3583e7 for 16-bit products, A = 3316 for 8-bit products, and B = 0. Please note however that:

- Due to their relatively narrow dynamic range and larger quantization errors, 8-bit products are not recommended for applications that are sensitive to radiometric accuracy.
- The Calibration-1 and Calibration-2 lookup tables are not designed for use with 8-bit geocoded products.
- Good radiometric accuracy can be attained only for targets that are well suited to the dynamic range of the chosen lookup table. This is especially true for geocoded products because pixels within the imaged area are lower-limited to a digital value of 1, instead of zero as in other product types. (This is in order to differentiate them from blackfill pixels, which are set equal to zero.) So applying this method to dark targets near the low end of the dynamic range would tend to give backscatter values that are too high.

Table 7-2 Gain values (A) for calculating calibrated values in geocoded products

Application LUT	Calibrated value	“A” for 16-bit Products	“A” for 8-bit Products
Constant-Sigma	Sigma-nought	1.3583e7	3316
Constant-Gamma	Gamma	1.3583e7	3316
Constant-Beta	Beta-nought	1.3583e7	3316

Application LUT	Calibrated value	"A" for 16-bit Products	"A" for 8-bit Products
Point target	Beta-nought	39811	9.719
Calibration-1	Beta-nought	3981.1	
Calibration-2	Beta-nought	398.11	

8 RADARSAT-2 PRODUCT ORGANIZATION

8.1 Media

Sequential Access Media

RADARSAT products may be created on sequential access (tape) media.

GeoTIFF and ASCII files written to sequential access media use the Portable Operating System Interface (POSIX) Extended Tape Archive (TAR) format.

Random Access Media

RADARSAT products may be created on the following types of random access media:

- local disk devices
- CD-ROM
- DVD-ROM

8.2 Labeling

Physical media (CD-ROM and DVD-ROM) are labeled with:

RADARSAT-2 OrbitNumber_PDSnumber,OrderKey_ProductKey_DeliveryKey

for example: RADARSAT-2 ORBIT
01121,PDS_0005246,OK725_PK5873_DK198

and inserts that include all related metadata information. For example:

RADARSAT-2 SCENE DESCRIPTION

PGS_ID	PDS_0005246
MDA ORDER NUMBER	OK725_PK5873_DK198
SCENE START TIME	2008-03-02 00:25:00.342
SCENE STOP TIME	2008-03-02 00:24:15.583
ORBIT	01121
ORBIT DATA TYPE	Ascending
APPLICATION LUT	Sea
ANTENNA DIR	Right
GEOLOCATION	Placename
POL	VV
BEAM MODE	W2 S5 S6
PRODUCT TYPE	SGF
FORMAT	GeoTiff+XML(Standard)
BITS	16
# OF IMAGE LINES	11922
# OF IMAGE PIXELS	11924
PIXEL SPACING	25.00 m
LINE SPACING	25.00 m
SCENE CENTRE	22°25'34" N 94°02'57" W

CORNER COORDINATES:

23°29'41.73" N 23°59'58.21" N
95°45'38.08" W 92°53'18.97" W

20°50'56.95" N 21°21'40.89" N
95°10'57.05" W 92°21'57.33" W

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8.3 File Organization and Naming

This section applies to GeoTIFF products. The file organization and naming of NITF products are described in Document R-12.

A GeoTIFF RADARSAT-2 product consists of a number of files and one or more sub-directories contained within a parent directory. The name of the parent directory can be considered the name of the product.

The table below lists the contents of the parent directory. Items shown as “Required” in the table must be present for the product to comply with the format definition. Others may be present or not, depending on the date and type of product. Files not shown in the table may be added without affecting compliance with the format definition.

Table 8-1 Product Directory Structure

Directory/File Name	Description	Required
product.xml	Product Information File	√
imagery_<xx>.tif	1 to 4 Image Pixel Data Files. One file for each polarization channel where <xx> = HH, HV VH or VV.	√
BrowseImage.tif	Browse image file in TIFF format	
lutSigma.xml	LUT to convert image to sigma-nought	All products except SSG and SPG
lutBeta.xml	LUT to convert image to beta-nought	All products except SSG and SPG
lutGamma.xml	LUT to convert image to gamma	All products except SSG and SPG
license.txt or license.pdf or <*RS2 EULA*>.pdf	End User License Agreement for Product. Version/format is client-dependent.	√
product.kml	KML file to visualize the product on a map	
Readme.txt	ASCII text “readme” file	√
label.txt	ASCII label file	
schemas/	Location for XML Schema files that validate the Product Information File	√

For electronic FTP delivery, products are typically zipped into a single file named as follows, and after unzipping the parent directory will have the same name as the zip file, without the extension:

RS2_OrderKey_ProductKey_DeliveryKey_BeamMode_Date_Time_Polarizations_ProcessingLevel.zip

For example: **RS2_OK774_PK6404_DK334_MF23_20080328_075402_HV_SGF.zip** where:

RS2 = RADARSAT 2
OK774 = Order Key
PK6404 = Product Key
DK334 = Delivery Key
MF23 = Beam Mode
20080328 = Acquisition Date
075402 = Acquisition Start Time
HV = Polarization
SGF = Processing Level

For local disk product generation, the parent directory is typically named as follows:

productId_<CCYY>_<MM>_<DD>_<hh>_<mm>_<ss>

where <**CCYY**>, <**MM**>, <**DD**>, <**hh**>, <**mm**>, <ss> are obtained from the Product Information File field **processingTime**.

A IMAGE CO-ORDINATE REFERENCE SYSTEMS

Each image data value in a RADARSAT-2 product is located at a point in space. When displayed, each of these points is meant to represent the centre of an image pixel.

Image line (row) and pixel (column) coordinates are measured down and to the right from the upper left corner of the image.

Except within GeoTIFF image file fields, the origin of the image coordinate system (line 0, pixel 0) is by definition the location of the first image data value, which is the centre of the upper left pixel.

However, within GeoTIFF image file fields, the origin of the image coordinate system is shifted by one half (0.5) of a line and one half (0.5) of a pixel. This is because the GeoTIFF format specification (Document R-4) allows for the interpretation of pixels as points or as an area with dimensions by use of the GTRasterTypeGeoKey field being set as either RasterPixelIsPoint or RasterPixelIsArea. For RADARSAT-2 GeoTIFF image products, the GTRasterTypeGeoKey is always set and defined to be RasterPixelIsArea. Therefore, in the coordinate system represented within the GeoTIFF image file fields, pixels are interpreted as having dimensions/area. The origin (0,0) of the GeoTIFF image coordinate system used if pixels are to be interpreted as RasterPixelIsArea is defined to be the upper left corner of the upper left pixel cell. The diagram below illustrates this coordinate system with increasing pixel number to the right and increasing line number down.

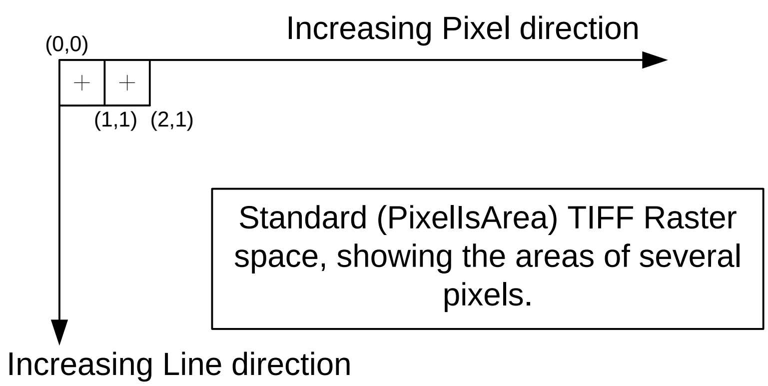

Figure A-1 Illustration of the GeoTIFF RasterPixelIsAreaCoordinate System Represented Within RADARSAT-2 GeoTIFF Image File Fields

Therefore the center of the upper left pixel cell (depicted in the above diagram with a '+') is located at (0.5, 0.5) in the GeoTIFF RasterPixelIsArea coordinate system. Then, with respect to the product image coordinate system, the coordinate system within the GeoTIFF fields is shifted by +0.5 lines and +0.5 pixels for the same geolocation tie-point. The following equations summarize the pixel (P) and line (L) relationship between the product image coordinates and the coordinates of those tie-points found within the GeoTIFF fields:

$$P_{GeoTIFFtag} = P_{product} + 0.5$$
$$L_{GeoTIFFtag} = L_{product} + 0.5$$

For example, in the coordinate system represented by the GeoTIFF image file fields, the centre of the upper left pixel is located at row 0.5, column 0.5 instead of line 0 and pixel 0.

This difference affects the image tie-points, which are used to provide geolocation information at various locations in the image. In the product information file, the tie-point image coordinates start at (0,0), but in the GeoTIFF image file fields, the tie-point image coordinates start at (0.5, 0.5). Despite their different image coordinates, the two sets of tie-points represent the same locations in space.