Soil Moisture Active Passive (SMAP) Project

Level 1A Radar
Product Specification Document

Revision C

Prepared by:

M. Mariyetta 4/12/2016

Barry Weiss, Mariyetta Madatyan
SMAP SDS Data Architect

Date

Approved by:

Richard D West 4/21/2016

Richard West
SMAP Radar Instrument Scientist

Date

4/22/16

Elias Sayfi
SMAP SDS Systems Engineer

Date

4-26-16

Maher Hanna
SMAP SDS Project Element Manager

Date

4/27/16

Simon Yueh
SMAP Project Scientist

Date

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California Institute of Technology

DOCUMENT CHANGE LOG

Revision	Date	Sections Changed	Reason for Change (ECR #)
-	21 March 2013		Initial Release
A	6 Aug 2014		Revision A ECR 113587
A	6 Aug 2014	3.2 Table 6	Fill value for Float32, Float64 changed from -999999.00 to -9999.00
A	6 Aug 2014	4.2 Table 7	Data Volume Estimates for Data Acquired at 06:00 Local Time changed
A	6 Aug 2014	4.4	Updated Metadata
A	6 Aug 2014	4.5.1 Table 10	Added fields for declination, right_ascension and sc_nadir_angle and changed antenna_azimuth to antenna_scan_angle and borsight_angle to antenna_look_angle Valid min and max changed for roll, pitch and yaw to -3.0 and 3.0.
A	6 Aug 2014	4.5.3 Table 12	Added test_load_h, test_load_v, test_load_noise_only_h, test_load_noise_only_v fields
A	6 Aug 2014	4.6.60	Added Receive_only_mode for low_res_status_flag
B	20 Jul 2015	1.5	Modified description of data collection plan for radar.

Revision	Date	Sections Changed	Reason for Change (ECR #)
B	20 Jul 2015	3.2	Added section of attitude and spacecraft slews.
B	20 Jul 2015	4.2	Modified Data Volume Estimates
B	20 Jul 2015	4.4	Added text that describes md5 checksum metadata variables, polygonPosList. Modified ECSVersionID definition. longName, indentifier_product_DOI
B	20 Jul 2015	4.5.3 and 4.6.95	Added rev_end_countdown to Revolution Data Group
B	20 Jul 2015	4.5.4, 4.6.27 and 4.6.28	Modified loop_back_trap_qual_flag and loop_back_trap_status_flag to the Loop Back Trap Data Group
B	20 Jul 2015	4.5.5, 4.6.59 and 4.6.60	Modified low_res_qual_flag and low_res_status_flag in the Low Resolution Data Group
B	20 Jul 2015	4.5.6, 4.6.113 and 4.6.114	Modified high_res_qual_flag and high_res_status_flag in the High Resolution Data Group
B	20 Jul 2015	4.6.61	Modified the maximum and minimum for low_res_interval
B	20 Jul 2015	4.6.102	Modified data type for frequency to Float32
B	20 Jul 2015	4.6.120, 4.6.121	Corrected the definitions of mantissa and exponent

Revision	Date	Sections Changed	Reason for Change (ECR #)
C	15 Oct 2015	3.2, 4.6.122, 4.6.124, 4.6.125, 4.6.126, 4.6.140	Changed reference frame from science orbit to the fixed instrument coordinate system to represent pitch, yaw and roll.
C	15 Oct 2015	4.4	Added highResolutionDataPresent to metadata
C	15 Oct 2015	4.5.1	Changed sc_geodetic_alt_ellipsoid valid_max to 750000 meters

TBD, TBR, TBS LOG

Section/Page	Description	Due Date
Appendix B	References the other Product Specification Documents. Several have not been written at the time of this publication. Thus, dates of publication are not available. In some cases, document identifiers are not available as well.	10/5/14

1 INTRODUCTION

1.1 Identification

This is the Product Specification Document (PSD) for Level 1A Radar data product for the Science Data System (SDS) of the Soil Moisture Active Passive (SMAP) project. The Level 1A radar product provides the complete content of the radar telemetry data that was downloaded from the SMAP spacecraft for a specified half-orbit. Each data element in the telemetry appears in a clearly named data array. This document applies to any standard Level 1A product based upon data acquired by the SMAP radar instrument.

1.2 Scope

This Product Specification Document describes the file format of the Level 1A Radar product. Its intent is to elucidate the Level 1A Radar data structure and content for external software interfaces. The SMAP Science Data Management and Archive Plan provide a more comprehensive explanation of these data within the complete context of the SMAP instrument, algorithms, and software.

1.3 The SMAP Experiment

The Soil Moisture Active Passive (SMAP) mission will enhance the accuracy and the resolution of space-based measurements of terrestrial soil moisture and freeze-thaw state. SMAP data products will have a noteworthy impact on multiple relevant and current Earth Science endeavors. These include:

- Understanding of the processes that link the terrestrial water, the energy and the carbon cycles,
- Estimations of global water and energy fluxes over the land surfaces,
- Quantification of the net carbon flux in boreal landscapes,
- Forecast skill of both weather and climate,
- Predictions and monitoring of natural disasters including floods, landslides and droughts, and
- Predictions of agricultural productivity.

To provide these data, the SMAP mission will deploy a satellite observatory in a near polar, sun synchronous orbit. The observatory will house an L-band radiometer that operates at 1.414 GHz and an L-band radar that operates at 1.225 GHz. The instruments will share a rotating reflector antenna with a 6 meter aperture that scans over a 1000 km swath. The antenna rotation rate varies from 13 revolutions per minute to 14.6 rotations per minute.

As the spacecraft flies from north to south on *descending* orbits, the SMAP instruments will view Earth locations at approximately 06:00 local time. As the spacecraft flies from south to north, on *ascending* orbits, the SMAP instruments will view Earth locations at approximately 18:00 local time. The spacecraft will operate in a cycle of 117 repeatable orbits.

Each time that the spacecraft repeats the orbit cycle, the nadir path on the Earth's surface may not vary by more than 20 km. The flight plan enables scientists to collect data over any region of the Earth over seasonal and annual cycles and avoid diurnal variations. The combined flight pattern and viewing design will enable the observatory to view almost all of the Earth's land mass once every three days.

The SMAP radiometer records microwave emissions from the top 5 cm in the soil with a spatial resolution of about 40 km. Scientific applications based on radiometer measure in the same frequency range have established this approach as an accurate means to detect the presence or water in near surface soil. SMAP radar will provide backscatter measurements at 1 km resolution. The combined instrumentation will enable SMAP to generate highly accurate global soil moistures at 9 km resolution.

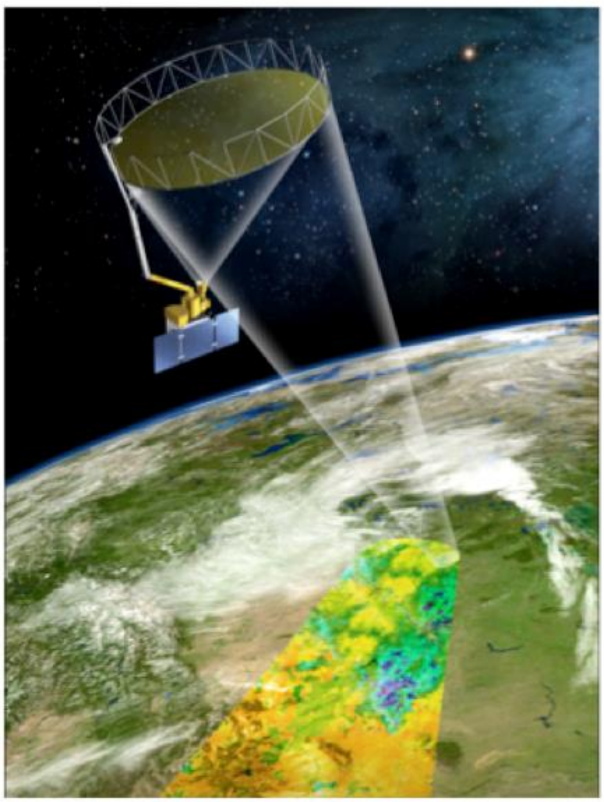

Figure 1: Artist's Concept of SMAP Observatory

Geophysical retrievals based on SMAP radar will indicate the presence of standing water, the freeze/thaw condition of the surface as well as measures of surface roughness and vegetation. The additional information will enable SMAP processors to select appropriate locations for soil moisture retrievals and modeling. In addition, the freeze/thaw data will contribute to models that measure the Net Ecosystem Exchange (NEE) of carbon between the Earth's surface and the atmosphere in Boreal regions.

1.4 SMAP Data Products

The SMAP mission will generate 15 distributable data products. The products represent four levels of data processing. Level 1 product contains instrument related data. Level 1 product appears in granules that are based on half orbits of the SMAP satellite. The Northernmost and Southernmost orbit locations demarcate half orbit boundaries. Level 2 products contain output from geophysical retrievals that are based on instrument data. Level 2 products also appear in half orbit granules. Level 3 products contain global output of the Level 2 geophysical retrievals for an entire day. Level 4 products contain output from geophysical models that employ SMAP data.

Table 1 lists the distributable SMAP data products. The colors in the table categorize the products by level. The table specifies two sets of short names. The SMAP Mission product short names were adopted by the SMAP mission to identify products. Users will find those short names in SMAP mission documentation, SMAP product file names and in the product metadata. The Data Centers will use short names defined for the Earth Observing System Data and Information System (EOSDIS) Core System (ECS). These short names categorize data products in local databases managed by the ECS. ECS short names will also appear in SMAP product metadata.

SMAP Mission Product Short Name	ECS Short Names	Description
L1A_Radar	SPL1AA	Parsed Radar Instrument Telemetry
L1A_Radiometer	SPL1AP	Parsed Radiometer Instrument Telemetry
L1B_S0_LoRes	SPL1BS0	Low Resolution Radar σ_o in Time Order
L1C_S0_HiRes	SPL1CS0	High Resolution Radar σ_o on Swath Grid
L1B_TB	SPL1BTB	Radiometer T_B in Time Order
L1C_TB	SPL1CTB	Radiometer T_B
L2_SM_A	SPL2SMA	Radar Soil Moisture, includes Freeze/Thaw State
L2_SM_P	SPL2SMP	Radiometer Soil Moisture
L2_SM_AP	SPL2SMAP	Active-Passive Soil Moisture
L3_FT_A	SPL3FTA	Daily Global Composite Freeze/Thaw State
L3_SM_A	SPL3SMA	Daily Global Composite Radar Soil Moisture
L3_SM_P	SPL3SMP	Daily Global Composite Radiometer Soil Moisture
L3_SM_AP	SPL3SMAP	Daily Global Composite Active-Passive Soil Moisture
L4_SM	SPL4TSM	Surface and Root Zone Soil Moisture
L4_C	SPL4C	Carbon Net Ecosystem Exchange

Table 1: SMAP Data Products

1.5 Content Overview

The SMAP Level 1A Radar data product contains parsed radar telemetry. The product lists all of the data elements in the telemetry as individual arrays with names that reflect their content. The product employs groups to collate data that are related. Thus, all of the data that are used for Synthetic Aperture Radar processing appear in one group. The data associated with Real Aperture Radar processing appear in a second group. A third group contains the loop back data that traverse directly from transmitter to receiver, and are used for calibration processing. A fourth group contains the instrument Health and Status that are downlinked with the radar instrument data. Yet another group tracks standard instrument conditions associated with each complete rotation of the SMAP antenna. Finally, the product includes a group that specifies spacecraft position and attitude as well as the azimuth of the SMAP rotating antenna.

The SMAP mission distributes this data product in half orbit granules. The northernmost and southernmost locations on the SMAP spacecraft path demarcate granule boundaries.

SMAP orbits begin at the southernmost point on the orbit path. The SMAP spacecraft will launch into orbit 0. Orbit 1 will begin as the spacecraft crosses the southernmost location for the first time. The SMAP radar instrument gathers data whenever the instrument is on. Based on acquired echo measurements, the radar flight software generates synthetic aperture radar data and real aperture radar data. The SMAP Level 1C Radar product contains processed synthetic aperture data. The SMAP Level 1B Radar product contains processed real aperture data.

The radar data are voluminous. The synthetic aperture radar data consumes the vast majority of the data volume. Thus, even with the high data transmission bandwidth, the SMAP spacecraft will not be able to downlink SAR resolution data all of the time. To ensure that adequate data were downlinked regularly, mission objectives determine when the spacecraft will downlink SAR data. The following criteria determine when the mission will downlink SAR data:

- The mission's major objective is the measurement of soil moisture,
- Since heavy rainfall more often takes place during afternoon hours, soil scientists prefer acquisition of data during the early morning hours, and
- Scientists interested in freeze/thaw require some evidence of change in condition during each day.

The following downlink plan was adopted to meet those objectives:

- During the descending orbit, when local time is approximately 06:00 hours, the spacecraft downlinks SAR data over land except the Antarctic. These data are collected when the rotating antenna is looking either forward or aft of the spacecraft.
- During the descending orbit, when local time is approximately 06:00 hours, the spacecraft downlinks SAR data over coastal regions. Coastal regions are defined as ocean or sea regions that lie within 1000 km of land. These data are collected only when the rotating antenna is looking forward of the spacecraft.
- During the ascending orbit, when local time is approximately 18:00 hours, the spacecraft downlinks SAR data over land except the Antarctic. These data are collected when the rotating antenna is looking either forward or aft of the spacecraft.

On board flight software tracks radar instrument data in four distinct channels based on the polarization of the transmitted and received signal. The instrument produces h-pol chirps at a center frequency that is 1.5 MHz higher than the center of the noise channel. The instrument produces v-pol chirps at a center frequency that is 1.5 MHz lower than the center of the noise channel. Two co-polarized channels contain data transmitted and received in the same polarization. Data elements labeled with *hh* are based on horizontally polarized signals that are detected in the instrument h-pol receiver. Data elements labeled with *vv* are based on vertically polarized signals that are detected by the instrument v-pol receiver.

The two cross-pol channels contain data transmitted in one polarization but received by the receiver for the other polarization. To save space, the spacecraft downlinks data from just one of the two cross-pol channels. Flight software design includes a switch that specifies which cross-pol channel will be downlinked. Nominally, the spacecraft will downlink data based on horizontally polarized signals that the v-pol receiver detects. Thus, in the nominal case, the product contains *vh* data. To maintain the possibility that cross-polarization channel may change, the product employs the suffix *xpol* to describe all data elements associated with cross-pol data.

1.6 Related SMAP Project Documents

SMAP SAR High Rate Data Dictionary Initial Release, S. Chan, JPL D-52436, October 3, 2011

SMAP Radar Health and Status Data List, Initial Release, M. Fischman, JPL D-52395, February 14, 2012

SMAP L1B_S0, L1C_S0 Algorithm Theoretical Basis Document, R. West, JPL D-53052, May 31, 2012.

SMAP Science Data Management and Archive Plan, JPL D-45973, August 29, 2011.

SMAP Pointing, Positioning, Phasing and Coordinate Systems, Volume 0: Definitions and Principle Coordinate Systems, JPL D-46018, Initial Release, May 18, 2010

1.7 Applicable Documents

ISO 19115:2003(E) International Standard – Geographic Information – Metadata, May 1, 2003.

ISO 19115-2:2009 International Standard – Geographic Information – Part 2:Extensions for imagery and gridded data, December 12, 2009.

ISO 19139:2007 International Standard – Geographic Information – Metadata – XML schema implementation, May 14 2009.

Introduction to HDF5, The HDF Group, http://www.hdfgroup.org/HDF5/doc/H5.intro.html.

HDF5: API Specification Reference Manual, The HDF Group http://www.hdfgroup.org/HDF5/doc/RM/RM_H5Front.html

HDF5 User's Guide Release 1.8.9, The HDF Group, http://hdfgroup.com/HDF5/doc/UG, May 2012.

NetCDF Climate and Forecast (CF) Metadata Conventions, Version 1.6, December 5, 2011.

EASE-Grid 2.0: Incremental but Significant Improvements for Earth-Gridded Data Sets, Brodzik, M.J., et. al., National Snow and Ice Data Center, Cooperative Institute of Environmental Sciences, University of Colorado, ISPRS International Journal of Geo-Information, ISSN 2220-9964, DOI: 10.3390/igji1010032.

2 DATA PRODUCT ORGANIZATION

2.1 File Format

All SMAP standard products are in the Hierarchical Data Format version 5 (HDF5). HDF5 is a general purpose file format and programming library for storing scientific data. The National Center for Supercomputing Applications (NCSA) at the University of Illinois developed HDF to help scientists share data regardless of the source. Use of the HDF library enables users to read HDF files on multiple platforms regardless of the architecture the platforms use to represent integer and floating point numbers. HDF files are equally accessible to routines written either in Fortran, C or C++.

A spin-off organization of the NCSA, named The HDF Group, is responsible for development and maintenance of HDF. Users should reference The HDF Group website at http://www.hdfgroup.org to download HDF software and documentation.

2.2 HDF5 Notation

HDF5 represents a significant departure from the conventions of previous versions of HDF. The changes that appear in HDF5 provide flexibility to overcome many of the limitations of previous releases. The basic building blocks have been largely redefined, and are more powerful but less numerous. The key concepts of the HDF5 Abstract Data Model are Files, Groups, Datasets, Datatypes, Attributes and Property Lists. The following sections provide a brief description of each of these key HDF5 concepts.

2.2.1 HDF5 File

A File is the abstract representation of a physical data file. Files are containers for HDF5 Objects. These Objects include Groups, Datasets, and Datatypes.

2.2.2 HDF5 Group

Groups provide a means to organize the HDF5 Objects in HDF5 Files. Groups are containers for other Objects, including Datasets, named Datatypes and other Groups. In that sense, groups are analogous to directories that are used to categorize and classify files in standard operating systems.

The notation for files is identical to the notation used for Unix directories. The root Group is "/". A Group contained in root might be called "/myGroup." Like Unix directories, Objects appear in Groups through "links". Thus, the same Object can simultaneously be in multiple Groups.

2.2.3 HDF5 Dataset

The Dataset is the HDF5 component that stores user data. Each Dataset associates with a Dataspace that describes the data dimensions, as well as a Datatype that describes the basic unit of storage element. A Dataset can also have Attributes.

2.2.4 HDF5 Datatype

A Datatype describes a unit of data storage for Datasets and Attributes. Datatypes are subdivided into Atomic and Composite Types.

Atomic Datatypes are analogous to simple basic types in most programming languages. HDF5 Atomic Datatypes include Time, Bitfield, String, Reference, Opaque, Integer, and Float. Each atomic type has a specific set of properties. Examples of the properties associated with Atomic Datatypes are:

- Integers are assigned size, precision, offset, pad byte order, and are designated as signed or unsigned.
- Strings can be fixed or variable length, and may or may not be null-terminated.
- References are constructs within HDF5 Files that point to other HDF5 Objects in the same file.

HDF5 provides a large set of predefined Atomic Datatypes. Table 2 lists the Atomic Datatypes that are used in SMAP data products.

Table 2: HDF5 Atomic Datatypes

HDF5 Atomic Datatypes	Description
H5T_STD_U8LE	unsigned, 8-bit, little-endian integer
H5T_STD_U16LE	unsigned, 16-bit, little-endian integer
H5T_STD_U32LE	unsigned, 32-bit, little-endian integer
H5T_STD_U64LE	unsigned, 64-bit, little-endian integer
H5T_STD_I8LE	signed, 8-bit, little-endian integer
H5T_STD_I16LE	signed, 16-bit, little-endian integer
H5T_STD_I32LE	signed, 32-bit, little-endian integer
H5T_STD_I64LE	Signed, 64-bit, little-endian integer
H5T_IEEE_F32LE	32-bit, little-endian, IEEE floating point
H5T_IEEE_F64LE	64-bit, little-endian, IEEE floating point
H5T_C_S1	character string made up of one or more bytes

Composite Datatypes incorporate sets of Atomic Datatypes. Composite Datatypes include Array, Enumeration, Variable Length and Compound.

- The Array Datatype defines a multi-dimensional array that can be accessed atomically.
- Variable Length presents a 1-D array element of variable length. Variable Length Datatypes are useful as building blocks of ragged arrays.
- Compound Datatypes are composed of named fields, each of which may be dissimilar Datatypes. Compound Datatypes are conceptually equivalent to structures in the C programming language.

Named Datatypes are explicitly stored as Objects within an HDF5 File. Named Datatypes provide a means to share Datatypes among Objects. Datatypes that are not explicitly stored as Named Datatypes are stored implicitly. They are stored separately for each Dataset or Attribute they describe.

None of the SMAP data products employ Enumeration or Compound data types.

2.2.5 HDF5 Dataspace

A Dataspace describes the rank and dimension of a Dataset or Attribute. For example, a “Scalar” Dataspace has a rank of 1 and a dimension of 1. Thus, all subsequent references to “Scalar” Dataspace in this document imply a single dimensional array with a single element.

Dataspaces provide considerable flexibility to HDF5 products. They incorporate the means to subset associated Datasets along any or all of their dimensions. When associated with specific properties, Dataspaces also provide the means for Datasets to expand as the application requires.

2.2.6 HDF5 Attribute

An Attribute is a small aggregate of data that describes Groups or Datasets. Like Datasets, Attributes are also associated with a particular Dataspace and Datatype. Attributes cannot be subsetted or extended. Attributes themselves cannot have Attributes.

2.3 SMAP File Organization

2.3.1 Structure

SMAP data products follow a common convention for all HDF5 Files. Use of this convention provides uniformity of data access and interpretation.

The SMAP Project uses HDF5 Groups to provide an additional level of data organization. All metadata that pertain to the complete data granule are members of the "/Metadata" Group. All other data are organized within Groups that are designed specifically to handle the structure and content of each particular data product.

2.3.2 Data

All data in HDF5 files are stored in individual Datasets. All of the Datasets in an SMAP product are assigned to an HDF5 Group. A standard field name is associated with each Dataset. The field name is a unique string identifier. The field name corresponds to the name of the data element the Dataset stores. This document lists these names with the description of each data element that they identify.

Each Dataset is associated with an HDF5 Dataspace and an HDF5 Datatype. They provide a minimally sufficient set of parameters for reading the data using standard HDF5 tools.

2.3.3 Element Types

SMAP HDF5 employs the Data Attribute "Type" to classify every data field as a specific data type. The "Type" is an embellishment upon the standard HDF5 Datatypes that is designed specifically to configure SMAP data products.

Table 3 lists all of the "Type" strings that appear in the SMAP data products. The table maps each SMAP "Type" to a specific HDF5 Datatype in both the HDF5 file and in the data buffer. The table also specifies the common conceptual data type that corresponds to the "Type" in SMAP executable code.

Table 3: Element Type Definitions

Type	HDF5 Datatype (File)	HDF5 Datatype (Buffer)	Conceptual Type
Unsigned8	H5T_STD_U8LE	H5T_NATIVE_UCHAR	unsigned integer
Unsigned16	H5T_STD_U16LE	H5T_NATIVE_USHORT	unsigned integer
Unsigned24	H5T_STD_U16LE, with precision set to 24 bits, and size set to 3 bytes.	H5T_NATIVE_INT	unsigned integer

Type	HDF5 Datatype (File)	HDF5 Datatype (Buffer)	Conceptual Type
Unsigned32	H5T_STD_U32LE	H5T_NATIVE_UINT	unsigned integer
Unsigned64	H5T_STD_U64LE	H5T_NATIVE_ULLONG	unsigned integer
Signed8	H5T_STD_I8LE	H5T_NATIVE_SCHAR	signed integer
Signed16	H5T_STD_I16LE	H5T_NATIVE_SHORT	signed integer
Signed32	H5T_STD_I32LE	H5T_NATIVE_INT	signed integer
Signed64	H5T_STD_I64LE	H5T_NATIVE_LLONG	signed integer
Float32	H5T_IEEE_F32LE	H5T_NATIVE_FLOAT	floating point
Float64	H5T_IEEE_F64LE	H5T_NATIVE_DOUBLE	floating point
FixLenStr	H5T_C_S1	H5T_NATIVE_CHAR	character string
VarLenStr	H5T_C_S1, where the length is set to H5T_VARIABLE	H5T_NATIVE_CHAR	character string

SMAP HDF5 files employ two different types of string representation. “VarLenStr” are strings of variable length. “VarLenStr” provides greater flexibility to represent character strings. In an effort to make SMAP HDF5 more friendly to users who wish to use netCDF software, SMAP products restrict the use of “VarLenStr”. “FixLenStr” are strings with a prescribed fixed-length. “FixLenStr” are useful for fixed length strings that are stored in large multi-dimension array. UTC time stamps are an excellent example of the type of data that store well in a “FixLenStr”.

2.3.4 File Level Metadata

All metadata that describe the full content of each granule of the SMAP data product are stored within the explicitly named "/Metadata" Group. SMAP metadata are handled using exactly the same procedures as those that are used to handle SMAP data. The contents of each Attribute that stores metadata conform to one of the SMAP Types. Like data, each metadata element is also assigned a shape. Most metadata elements are stored as scalars. A few metadata elements may be stored as arrays.

SMAP data products represent file level metadata in two forms. One form appears in two Attributes within the Metadata Group. Combined, those two Attributes contain a complete representation of the product metadata. The content conforms to the ISO 19115-2 models in ISO 19139 compliant XML.

The second form of the metadata appears in a set of HDF5 Groups under the "/Metadata" Group. Each of these HDF5 Groups represents one of the major classes in the ISO 19115-2 model. These HDF5 Groups contain a set of HDF5 Attributes. Each HDF5 Attributes represents a specific ISO attribute of the associated ISO class. Although this representation inherits design from the ISO model, it does not completely conform to the model. In many cases, the names of the HDF5 Attributes match those used in the ISO model. In some situations, names were changed to provide greater clarity to SMAP users who are not familiar with the ISO model. Furthermore, to ease metadata searches, the structure of Groups within Groups was limited to four levels.

2.3.5 Local Metadata

SMAP standards incorporate additional metadata that describe each HDF5 Dataset within the HDF5 file. Each of these metadata elements appear in an HDF5 Attribute that is directly associated with the HDF5 Dataset. Wherever possible, these HDF5 Attributes employ names that conform to the Climate and Forecast (CF) conventions. Table 4 lists the CF names for the HDF5 Attributes that SMAP products typically employ.

Table 4: SMAP Specific Local Attributes

CF Compliant Attribute Name	Description	Required?
units	Units of measure. Appendix E lists applicable units for various data elements in this product.	Yes
valid_max	The largest valid value for any element in the Dataset. The data type in valid_max matches the type of the associated Dataset.	No

CF Compliant Attribute Name	Description	Required?
	Thus, if the associated Dataset stores float32 values, the corresponding valid_max will also be float32.	
valid_min	The smallest valid value for any element in the Dataset. The data type in valid_min matches the type of the associated Dataset. Thus, if the associated Dataset stores float32 values, the corresponding valid_min will also be float32.	No
_FillValue	Specification of the value that will appear in the Dataset when an element is missing or undefined. The data type of _FillValue matches the type of the associated Dataset. Thus, if the associated Dataset stores float32 values, the corresponding _FillValue will also be float32.	Yes for all numeric data types
long_name	A descriptive name that clearly describes the content of the associated Dataset.	Yes
coordinates	Identifies auxiliary coordinate variables in the data product.	No
flag_values	Provides a list of flag values that appear in bit flag variables. Should be used in conjunction with local HDF5 attribute *flag_meanings*. Only appears with bit flag variables.	No
flag_masks	Provides a list of bit fields that express Boolean or enumerated flags. Only appears with bit flag variables or enumerated data types.	No
flag_meanings	Provides descriptive words or phrases for each potential bit flag value. Should be used in conjunction with local HDF5 attribute *flag_values*.	No

2.4 Data Definition Standards

Section 4.6 of this document specifies the characteristics and definitions of every data element stored in this SMAP data product. Table 5 defines each of the specific characteristics that are listed in that section of this document. Some of these characteristics correspond with the SMAP HDF5 Attributes that are associated with each Dataset. Data element characteristics that correspond to SMAP HDF5 Attributes bear the same name. The remaining characteristics are descriptive data that help users better understand the data product content.

In some situations, a standard characteristic may not apply to a data element. In those cases, the field contains the character string 'n/a'. Hexadecimal representation sometimes indicates data content more clearly. Numbers represented in hexadecimal begin with the character string '0x'.

Table 5: Data Element Characteristic Definitions

Characteristic	Definition
Type	The data representation of the element within the storage medium. The storage class specification must conform to a valid SMAP type. The first column in table 3 lists all of the valid values that correspond to this characteristic.
Shape	The name of the shape data element that specifies the rank and dimension of a particular data set. Appendix C lists all of the valid shapes that appear in this data product.
Valid_max	The expected minimum value for a data element. In most instances, data element values never fall below this limit. However, some data elements, particularly when they do not reflect normal geophysical conditions, may contain values that fall below this limit.
Valid_min	The expected maximum value for a data element. In most instances, data element values never exceed this limit. However, some data elements, particularly when they do not reflect normal geophysical conditions, may contain values that exceed this limit.
Valid Values	Some data elements may store a restricted set of values. In those instances, this listing specifies the values that the data element may store.
Nominal Value	Some data elements have an expected value. In those instances, this listing provides that expected value. Nominal values are particularly common among a subset of the metadata elements.

Characteristic	Definition
String Length	This characteristic specifies the length of the data string that represents a single instance of the data element. This characteristic appears exclusively for data elements of FixLenStr type.
Units	Units of measure. Typical values include “deg”, “degC”, “Kelvins”, “m/s”, “m”, “m**2”, “s” and “counts”. Appendix A and Appendix E include references to important data measurement unit symbols.

2.4.1 Double Precision Time Variables

SMAP double precision time variables contain measurements relative to the J2000 epoch. Thus, these variables represent a real number of Standard International (SI) compatible seconds since 11:58:55.816 on January 1, 2000 UTC.

2.4.2 Array Representation

This document employs array notation to demonstrate and clarify the correspondence among data elements in different product data elements. The array notation adopted in this document is similar to the standards of the Fortran programming language. Indices are one based. Thus, the first index in each dimension is one. This convention is unlike C or C++, where the initial index in each dimension is zero. In multidimensional arrays, the leftmost subscript index changes most rapidly. Thus, in this document, array elements ARRAY(15,1,5) and ARRAY(16,1,5) are stored contiguously.

HDF5 is designed to read data seamlessly regardless of the computer language used to write an application. Thus, elements that are contiguous using the dimension notation in this document will appear in contiguous locations in arrays for reading applications in any language with an HDF5 interface.

This document differentiates among array indices based on relative contiguity of storage of elements referenced with consecutive numbers in that index position. A faster or fastest moving index implies that the elements with consecutive numbers in that index position are stored in relative proximity in memory. A slower or slowest moving index implies that the elements referenced with consecutive indices are stored more remotely in memory. For instance, given array element ARRAY(15,1,5) in Fortran, the first index is the fastest moving index and the third index is the slowest moving index. On the other hand, given array element array[4][0][14] in C, the first index is the slowest moving index and the third index is the fastest moving index.

3 INTERFACE CHARACTERISTICS

3.1 Coordinate Systems

The SMAP mission will use the Science Orbit Reference Frame (SRF) and the Earth Centered Rotating (ECR) coordinate systems to represent spacecraft attitude, position and relative motion. The SMAP project document entitled SMAP Pointing, Positioning, Phasing and Coordinate Systems, Volume 0: Definitions and Principle Coordinate Systems fully describes both of these coordinate systems.

The Science Orbit Reference Frame (SRF) is a right-handed coordinate system with its three axes mutually orthogonal. The SRF is defined such that the origin is at the spacecraft center of mass (CM). The +Z axis points toward Geodetic Nadir. Due to the oblateness of the Earth, the vector from the spacecraft to the geometric center of the Earth (Geocentric Nadir) is different from the vector from the spacecraft to the local WGS84 ellipsoid normal (Geodetic Nadir). The +X axis is coplanar with both the +Z axis and the spacecraft inertial velocity vector. The +X axis closely adheres to the direction of the spacecraft inertial velocity vector. The +Y axis completes the right-handed, orthogonal coordinate system. The +Y axis is normal to the orbit plane with positive sense in the direction opposite the orbit angular momentum vector.

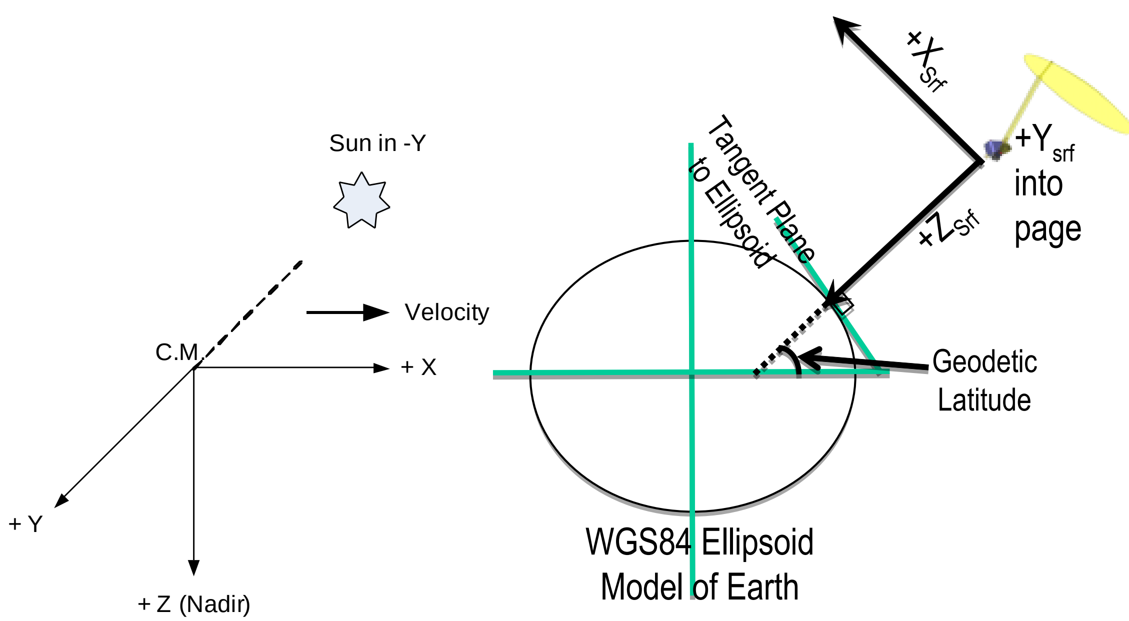

Figure 2: The Science Reference Frame Coordinate System

The Earth Centered Rotating (ECR) or Earth Centered Fixed coordinate system is a right-handed coordinate system with three mutually orthogonal axes. The origin of the system is the Earth's center of mass. The positive x-axis extends from the origin through the intersection of the Equator at 0° latitude and the Greenwich Meridian at 0° longitude. The positive z-axis extends directly North from the origin of the ECR system. Due to a slight wobbling of the Earth, the z-axis does not coincide exactly with the instantaneous rotation axis of the Earth. The y-axis completes the right-handed coordinate system as a vector from the origin to the intersection of the Equator and 90° East longitude.

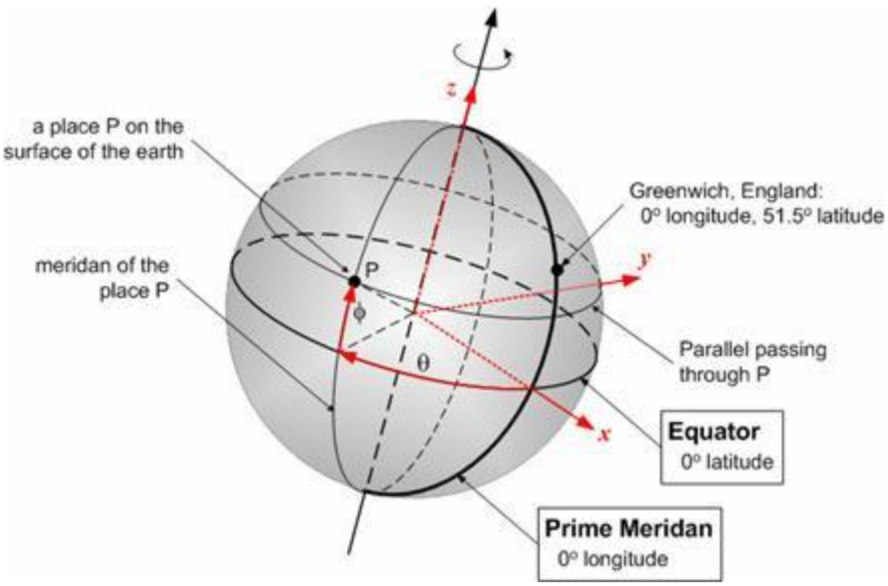

Figure 3: Earth Centered Rotating Coordinate System

The SMAP mission adopted the World Reference System WGS84 ellipsoid to define the horizontal Earth reference coordinates. The WGS84 geoid was adopted as the vertical Earth reference coordinates. Geodetic measure is used to define both the spacecraft location and the instrument target location relative to the Earth's surface.

3.2 Spacecraft Attitude and Modeling Spacecraft Slews

The SMAP SDS receives spacecraft attitude data on a regular basis from the Navigation and Ancillary Information Facility (NAIF) at JPL. Upon arrival from NAIF, these data specify the orientation of the Spacecraft Coordinate System with respect to J2000 coordinates. The NAIF data are represented in quaternions. A frames kernel describes the slight offset measured between the Spacecraft Coordinate System and the Instrument Fixed Coordinate System (INSF) from which the pitch, yaw and roll angles will be referenced.

The Science Data System converts these data into pitch, yaw and roll angles relative to the SMAP Science Orbit Reference Frame (SRF). Those angular measures appear in the SMAP Level 1 Science Data Products. Both the Science Orbit Reference Frame and the Instrument Fixed Coordinate System are defined in the SMAP Pointing, Positioning, Phasing and Coordinate System Volume 0, Revision B, April 15, 2014.

During nominal operations, after a 180 degree roll to align the Z axes of the two systems, the resulting pitch, yaw and roll angles will be very small. Indeed, in order to retain anticipated incidence angles for radar and radiometer measure, these angles will almost always be less than 1 degree. Thus, under these conditions, the definitions of pitch, yaw and roll conform to the definitions found in the SMAP Level 1 Product Specification Documents.

- Pitch is the angular rotation of the spacecraft body about the Y axis of the SMAP Science Orbit Reference Frame (SRF). The Y axis of the SRF is normal to the spacecraft orbital plane.
- Roll is the angular rotation of the spacecraft body about the X axis of the SMAP Science Orbit Reference Frame (SRF) coordinate system. The X axis of the SRF approximates the direction of spacecraft motion.
- Yaw is the angular rotation of the spacecraft body about the Z axis of the SMAP Science Orbit Reference Frame (SRF) coordinate system. The Z axis of the SRF runs from the center of mass of the spacecraft toward geodetic nadir.

The SMAP mission will maneuver the spacecraft from time to time. Of particular interest are maneuvers that enable the spacecraft antenna to view cold sky. Knowledge of the Euler angle that represents the spacecraft attitude during these maneuvers is critical. Generation of the Euler angle requires specification of the proper order of rotation from the science orbit reference frame to the spacecraft frame. The order of rotation that users should employ is pitch, followed by roll and then yaw. **If SMAP product users wish to reconstruct the Euler angles associated with spacecraft maneuvers, they should employ the following processing steps based on provided values of pitch, yaw and roll:**

- Roll the spacecraft angle by 180 degrees. The roll aligns the Z axis of the Instrument Fixed Coordinate System with the SMAP Science Orbit Reference Frame (it also changes the sign of the pitch and yaw).
- Perform a pitch rotation. The pitch rotation is executed about the position of the Y axis of the Instrument Fixed Coordinate System at the completion of the previous roll rotation.
- Perform roll rotation. The roll rotation is executed about the position of the X axis of the Instrument Fixed Coordinate System at the completion of the previous pitch rotation.
- Perform the yaw rotation. The yaw rotation is executed about the position of the Z axis of the Instrument Fixed Coordinate System at the completion of the roll rotation.

To enable representation of maneuver conditions, the pitch, roll and yaw angles will need to take on larger measures. SMAP software thus enables pitch values to range from –180 degrees to 180 degrees, roll values to range from –90 to 90 degrees and yaw values to range from –180 degrees to 180 degrees.

3.3 Fill and Gap Values

SMAP data products employ fill and gap values to indicate when no valid data appear in a particular data element. Fill values ensure that data elements retain the correct shape. Gap values locate portions of a data stream that do not appear in the output data file.

Fill values appear in the SMAP Radar L1A Product when the Level 1A SPS can process some, but not all, of the input data for a particular swath grid cell. Fill data may appear in the product in any of the following circumstances:

- One of Science Production Software (SPS) executables that generate the SMAP Level 1A Radar Product is unable to calculate a particular science or engineering data value. The algorithm encounters an error. The error disables generation of valid output. The SPS reports a fill value instead.
- Some of the required science or engineering algorithmic input are missing. Data over the region that contributes to particular grid cell may appear in only some of the input data streams. Since data are valuable, the Level 1A Radar Product records any outcome that can be calculated with the available input. Missing data appear as fill values.
- Non-essential information is missing from the input data stream. The lack of non-essential information does not impair the algorithm from generating needed output. The missing data appear as fill values.

SMAP data products employ a specific set of data values to connote that an element is fill. The selected values that represent fill are dependent on the data type. With the exception of bit flag variables, Table 6 lists the values that represent fill in SMAP products based on data type. Section 3.4 describes SMAP standard processing for bit flag variables.

Table 6: SMAP Product Fill Values

Type	Value	Pattern
Float32, Float64	-9999.00	Large, negative number
Signed8, NormSigned8	-127	Type minimum + 1
Signed16, NormSigned16	-32767	Type minimum + 1

Type	Value	Pattern
Signed24	-8388607	Type minimum + 1
Signed32	-2147483647	Type minimum + 1
Signed64	-9223372036854775807	Type minimum + 1
Unsigned8	254	Type maximum - 1
Unsigned16	65534	Type maximum - 1
Unsigned24	16777214	Type maximum - 1
Unsigned32	4294967294	Type maximum - 1
Unsigned64	18446744073709551614	Type maximum - 1
FixedLenString, VarLenString	NA	Not available

With the exception of the *mantissa* dataset in the High Resolution Data Group, all of the elements in the Level 1A Radar product will employ values specified in table 6 to represent fill. The compact design of the *mantissa* dataset disables the use of fill values. Instead, data element *num_hires_blocks* provides the means to determine whether a value in the *mantissa* array represents a null. *Num_hires_blocks* indicates how many blocks of 32 elements appear in each High Resolution Data record. The second of four indices in the mantissa array represents these blocks. If the second index of any element in the *mantissa* array is greater than the value of *num_hires_blocks* for the corresponding high resolution record, that mantissa value is null.

If any other elements in the product should have valid values that might be equal to predesigned null values, the Level 1A Radar content will provide a means for users to discern between elements that contain fill and elements that contain genuine data values. This document will also contain a description of the method used to ascertain which elements are fill and which elements are genuine.

The Level 1A Radar product records gaps when entire telemetry frames within the time span of a particular data granule do not appear. Gaps can occur under one of two conditions:

- One or more complete telemetry frames of data are missing the radar science data stream.
- The subset of input data that is available for a particular frame is not sufficient to process any frame output.

The Level 1A Radar Product records gaps in the product level metadata. The following conditions will indicate that no gaps appear in the data product:

- Only one instance of the attributes *Extent/rangeBeginningDateTime* and *Extent/rangeEndingDateTime* will appear in the product metadata.
- The character string stored in metadata element *Extent/rangeBeginningDateTime* will match the character string stored in metadata element *OrbitMeasuredLocation/halfOrbitStartDateTime*.
- The character string stored in metadata element *Extent/rangeEndingDateTime* will match the character string stored in metadata element *OrbitMeasuredLocation/halfOrbitStopDateTime*.

One of two conditions will indicate that gaps appear in the data product:

- The time period covered between *Extent/rangeBeginningDateTime* and *Extent/RangeEndingDateTime* does not cover the entire half orbit as specified in *OrbitMeasuredLocation/halfOrbitStartDateTime* and *OrbitMeasuredLocation/halfOrbitStartDateTime*.
- More than one pair of *Extent/rangeBeginningDateTime* and *Extent/rangeEndingDateTime* appears in the data product. Time periods within the time span of the half orbit that do not fall within the sets of *Extent/rangeBeginningDateTime* and *Extent/rangeEndingDateTime* constitute data gaps.

Bit flag elements in the Level 1A Radar product often provide additional information about missing data. For example, the data element *hi_res_qual_flag* in the Radar Level 1 product contains bit flags that indicate the quality of data for each high resolution data record. When data within the high resolution data packet frame is deemed unusable, the appropriate bits in the *hi_res_qual_flag* should indicate the rationale.

3.4 Bit Flag Variables

SMAP data products contain bit flag variables. Bit flag variables provide quality information and processing conditions for individual data pixels within the product. This document contains a full description of each of the bit flag variables in the correct product.

SMAP executables that generate data products employ a standard method to set and clear the values of individual bits in the bit flag variables. At the beginning of the process, the executable initializes bit flag variable content. When product content is initializes, all of the defined bits in the bit flag variable contain a value of ‘1’ and all of the bits that are undefined contain a value of ‘0’. As the process proceeds, conditions and quality information will lead the executable to convert appropriate defined bit values from ‘1’ to ‘0’.

Thus, for bit flag variables, the initialized value of the bit flag is equivalent to the Fill value.

3.5 Flexible Data Design

HDF5 format gives the SMAP Level Products a high degree of flexibility. This flexibility in turn gives SMAP end product users the capability to write software that does not need to be modified to accommodate unforeseeable changes in the SMAP products. Since changes to the products are certain to take place over the life of the SMAP mission, users are encouraged to use software techniques that take advantage of some of the features in HDF5.

For example, users can write a product reader that selects only those product data elements they wish to read from an SMAP Level Product file. With the appropriate design, this software will not need to change, regardless of the number, the size, or the order of the current data product entries. Indeed, the only changes users need to implement would take place if they should choose to read a newly defined data element after a product upgrade.

For those users who wish to extract a specific subset of the data from an SMAP Product, the HDF5 routines H5Dopen and H5Dread (h5dopen_f and h5dread_f in FORTRAN) are very useful. H5Dopen requires two input parameters, the first is an HDF5 file/group identifier, the second is a character string that contains the name of a Dataset. H5Dopen returns the identifier for the specified Dataset in the product file. HDF5 routine H5Dread then uses the Dataset identifier to fetch the contents. H5Dread places the contents of the Dataset in a specified output variable.

Once the data element is located and read, users can generate standardized code that reads the metadata associated with each element. Users of the SMAP Level Products should employ the same methods to read metadata and standard data elements.

3.6 Access to Product Element Dimensions

Each data element in every SMAP data product is assigned a specific shape. Elements with the same shape have the same number of dimensions, and each of those dimensions have the same extent and meaning. Thus, if two data elements have the same shape, then their constituent array elements with identical indices correspond.

The SMAP Level 1A Radar Product employs a naming convention for shapes. The convention specifies the component dimensions. The final word in all shape names is always “Array”. The text that precedes the word “Array” provides the order of dimensions. The word that just precedes “Array” represents the dimension with the “fastest moving” index. In other words, consecutive indices in this dimension, provided the other dimension indices are identical, represent contiguous storage. For example, the Shape name HiRes_HiResBlock_Channel_Array implies that the dimension where consecutive indices imply contiguous storage represents the two radar co-pol channels and the one cross-pol channel that appear in the high resolution data.

The middle dimension represents the number of blocks that the product employs to store high resolution data. The slowest moving dimension represents each high resolution data record in the Level 1A Radar Product. Appendix C provides the nominal rank and dimension sizes for each shape that appears in the Level 1A Radar Product.

Appendix D provides the nominal or expected maximum product dimensions. A wise user should not, however, rely solely on Appendix D to write code that sizes arrays in the Level 1A Radar Product. The actual dimension sizes for some of the Shapes may vary from product granule to product granule. For example, the number of high resolution data records and low resolution data records will not remain constant among all Level 1A Radar data product granules. Thus, the HiRes_HiResBlock_Channel_Array Shape may be (8000000,13,3) in one product granule and (8100000,12,3) in another.

Appendix F contains an example of code that reads dimensions for a particular data element directly from the L1C_S0_HiRes product.

4 DATA DEFINITION

4.1 Product Overview

4.1.1 Level 1A Radar Product

Each Level 1A Radar product granule incorporates all of the radar telemetry that was downlinked from the SMAP spacecraft for one specific half orbit. The product also includes information about the spacecraft position and attitude, as well as the antenna azimuth position over the same time period that the radar telemetry covers. The SMAP project delineates half orbits at the northernmost and southernmost point of each orbit path.

The major contents of the Level 1A Radar product include high resolution synthetic aperture radar data, low resolution real aperture radar data, instrument loopback data, instrument health and status data as well as standard operating conditions at antenna rotation granularity. Nearly all of the content are parsed values from the telemetry stored in distinctly defined HDF5 datasets. The product does include some voltages and temperatures converted from telemetry data numbers (DN) to standard engineering units (EU).

4.1.2 Level 1A Radar Metadata

The SMAP Level 1A Radar metadata are representative of the entire contents of the file. The metadata appear in two forms. One form of the metadata appears in single HDF5 Attribute. That Attribute contains the complete representation of the product metadata that conforms to the ISO 19115-2 model in ISO 19139 compliant XML. The second form of the metadata appears in a set of HDF5 groups. Each HDF5 group contains a set of HDF5 attributes. The arrangement and names of the groups and their attribute components approximate major contents of the ISO model.

Metadata in ISO 19139 conformant XML enables users who are familiar with the ISO metadata standards to extract the metadata they need using software that operates with the ISO 19115-2 model and its formal representation. The set of groups and attributes enable users who are not as familiar with the ISO standard to find the particular metadata elements they need to better comprehend product content and format.

4.1.3 Level 1A Radar Data

All product elements in the Level 1A Radar Product are stored as HDF5 Datasets. Each of these datasets belong to one of six distinct HDF5 Groups. The data design employs HDF5 Groups to categorize datasets that have corresponding array elements and that relate to a common application.

The HDF5 Groups in the Level 1A Radar product include the Spacecraft Data Group, the Health and Status Data Group, the Revolution Data Group, the Loop Back Trap Data Group, the Low Resolution Data Group and the High Resolution Data Group. Section 4.5 of this document includes more detailed descriptions of each of the HDF5 Groups in the data product.

All of the Level 1A Radar HDF5 Groups record the complete content of available data that is relevant for the associated half orbit. The single array index for all data elements in the Spacecraft Data Group represents each 0.1 second interval in the duration of the half orbit. The SMAP Level 1A process interpolates all of the data elements in the Spacecraft Data Group to the time specified in element *time*. Thus, *sc_data_time(264)* contains the time when the spacecraft nadir crosses the point with longitude specified in *sc_nadir_lat(264)* and latitude specified in *sc_nadir_lon(264).* Likewise, element *yaw(264)* specifies the spacecraft yaw interpolated to that instant.

The other groups in the Level 1A Product employ a common storage design. The slowest moving index in each of those groups specifies the number of records of the associated type that appear in the half orbit. The indices in the slowest moving dimension in the Low Resolution Group specify each of the low resolution records that appear in the half orbit. Likewise, the indices in the slowest moving dimension in the High Resolution Group specify each of the high resolution records that appear in the half orbit. Thus, all of the elements with a matching slowest moving index in any HDF5 Group in the Level 1A Radar Product reference the same data record.

Most of the elements in the Level 1A Radar Product are one dimensional arrays. For those one dimensional items, all of the elements in the same group with the same index reference the same record. Some product elements are two, three or four dimensional arrays. The additional array dimensions reference specific attributes that are required to track and reference these data elements. Section 4.5 defines each of these dimensions within each data group and indicates how users may employ these dimensions.

4.2 Data Volume Estimates

Due to limits in communication bandwidth, complex rules dictate when synthetic aperture radar data are downlinked to the ground and subsequently processed into data products. The high resolution synthetic aperture radar data are by far the most voluminous in the Level 1A Radar Product. The mission downlinks synthetic aperture radar data acquired over land and coastal ocean that are acquired at 6:00 AM local time. The mission restricts downlink of synthetic aperture radar data acquired at 6:00 PM to land that is North of 45 North latitude. Furthermore, data acquired forward of the SMAP spacecraft are always included in any downlink of synthetic aperture data. Data acquired aft of the SMAP spacecraft are downlinked only over land during an AM pass. Given these requirements, and the fact that the Earth's land mass is not evenly distributed, the volume of the Level 1A Radar data products varies considerably.

Two tables below provide users with an estimated average volume for uncompressed Level 1A Radar data products. Both tables specify the contribution of each of the data Groups to the total data volume of the Product. The final row in each table provides an estimate of the volume of an average data granule.

Table 7 estimates the Level 1A Radar data volume for descending half orbits where the spacecraft flies over ground targets at 6:00 AM local time. The data in table 7 assumes that an entire half orbit that includes both land and coastal oceans covers about 50% of the region the spacecraft antenna views.

Table 7: Data Volume Estimates for Data Acquired at 06:00 Local Time

Group	Number of Entries	Bytes Per Entry	Expected Total Volume (MBytes)
Level 1A Radar Metadata	1	10000	.010
XML Version of ISO Metadata	1	124000	0.124
Spacecraft Data Group	29538	112	3.308
Health and Status Data Group	2954	522	1.542
Revolution Data Group	640	160	0.102
Loopback Trap Data Group	10240	1074	10.998
Low Resolution Data Group	175825	2105	370.112
High Resolution Data Group	3544616	1229	4356.333
Level 1A Radar Product			4742.529

Table 8 estimates the Level 1A Radar data volume for ascending half orbits where the spacecraft flies over ground targets at 6:00 PM local time. Since the ascending half orbits do not include coastal oceans, the total volume for these products is somewhat smaller.

Table 8: Data Volume Estimates for Data Acquired at 18:00 Local Time

Group	Number of Entries	Bytes Per Entry	Expected Total Volume (MBytes)
Level 1A Radar Metadata	1	10000	.010
XML Version of ISO Metadata	1	190000	0.190
Spacecraft Data Group	29538	112	3.308
Health and Status Data Group	2954	522	1.542
Revolution Data Group	640	160	0.102
Loopback Trap Data Group	10240	1074	10.998
Low Resolution Data Group	175825	2105	370.112
High Resolution Data Group	2616264	1229	3215.388
Level 1A Radar Product			3601.456

4.3 SMAP Level 1A Radar Product File Names

Distributable SMAP Level 1A Radar data product file names are 56 characters in length. The first 5 characters in the name of all mission distributable products are 'SMAP_'. These characters identify all products generated by the SMAP mission. The following 10 characters are always 'L1A_RADAR_'. These characters identify the Level 1A Radar Science Data Product. The following 35 characters uniquely identify the data stored in the file. The final 3 characters of each SMAP Product file name are '.h5'. These characters specify the format of the data in the file.

More specifically, all SMAP Level 1A Radar data product file names must conform to the following convention:

SMAP_L1A_RADAR_[Orbit Number]_[A|D]_[First Date/Time Stamp]_ [Composite Release ID]_[Product Counter].[extension]

The outline below describes the content of each field in the file naming convention:

Orbit Number – The sequential number of the orbit that the SMAP spacecraft flew when the data in the associated product were acquired. Orbit 0 will begin at launch. The orbit number must occupy five digits. Orbit numbers that are smaller than 10000 will appear with leading zeroes.

The Half Orbit Designator - SMAP divides orbits into two distinct parts. Division of half orbits takes place at the northernmost and southernmost point on the spacecraft path. Half orbits where the spacecraft moves from North to South are *descending* half orbits. Local time for measurements acquired during a *descending* half orbit is approximately 6 AM. The character “D” appears as the Half Orbit Designator in the file names of products that contain data representing *descending* half orbits. Half orbits where the spacecraft moves from South to North are classified as *ascending* half orbits. Local time for measurements acquired during an *ascending* half orbit is approximately 6 PM. The character “A” appears as the Half Orbit Designator in the file names of products that contain data represent *ascending* half orbits.

First Date/Time Stamp – The date/time stamp of the first data element that appears in the product. Date/time stamps in SMAP file names are always recorded in Universal Coordinated Time (UTC). Date/time stamps conform to the following convention:

YYYYMMDD**T**hhmmss

where:

YYYY is the calendar year. The full calendar year must appear in the file name.

MM designates the month of the year. The month designator always occupies two digits. Months that can be represented with fewer than two digits must employ a leading zero.

DD designates the day of the month. The day designator always occupies two digits. Days of the month that can be represented with fewer than two digits must employ a leading zero.

T delineates the date from the time, and is a required character in all time stamps in product names.

hh designates the hour of the day on a 24 hour clock in UTC. The hour designator always occupies two digits. Hours that can be represented with fewer than two digits must employ a leading zero.

mm designates the minute of the hour in UTC. The minute designator always occupies two digits. Minutes that can be represented with fewer than two digits must employ leading zeroes.

ss designates the truncated second of the minute in UTC. Fractional second specification is not necessary in file names. The second designator always occupies two digits. Seconds that can be represented with fewer than two digits must employ leading zeroes.

Composite Release ID – The Composite Release ID incorporates changes to any processing condition that might impact product results. The format of the Composite Release ID is as follows:

"R"	The character "R" always precedes this identifier
Launch indicator	Distinguishes between pre-launch or pre-instrument commissioned data and data generated under mission operation conditions. A launch indicator of "0" implies the data are simulated or acquired under early mission conditions that exempt the content from mission requirements. A launch indicator of "1" implies the data are acquired by the instrument at or after the time of instrument commissioning, and must therefore meet mission requirements.
Major ID	One digit that indicates major releases. Major changes in algorithm or processing approach will generate an update to this identifier.
Minor ID	Three digits that indicate minor releases. Any change to any component that impacts data processing, such as algorithm, software or parameters will lead to a change in this identifier.

Product Counter – Files that represent the same half orbit of any particular product type may be generated multiple times over the life of the mission. This counter tracks the number of times that a particular product type for a specific half orbit was generated. The system assigns the first instance of a file that represents a half orbit of a particular product type with a Product Counter of 001. The system assigns each subsequent instance of the same half orbit and same product type with the next consecutive integer. The Product Counter always occupies three digits. Product Counters that do not require three digits contain leading zeroes.

Extension – The extension for all SMAP Level 1A Radar data products is "h5". That extension indicates that the product contents are in HDF5 format. The SMAP SDS will generate a QA file with every data granule. The QA file contains statistical information that will enable users to better assess the quality of the associated granule. QA products bear exactly the same name as the products that they represent. The only difference in names is the extension. The extension for all QA products is ".qa".

Example File Names – Based on the above standard, the following name describes a simulated data product from pre-launch release 4 of the Level 1A Radar data product that is labeled to cover the ascending half of orbit 934. The first data point acquired 7:49:51 UTC on December 25, 2014. The file represents the second time a Radar L1A product was generated for the ascending half of orbit 924:

SMAP_L1A_RADAR_00934_A_20141225T074951_R04000_002.h5

The name of the QA product that assesses the output of the above L1A_Radar granule would be:

SMAP_L1A_RADAR_00934_A_20141225T074951_R04000_002.qa

4.4 Level 1A Radar Product Metadata

As mentioned in section 4.1.2, the metadata elements in the Level 1A Radar product appear in two forms.

One form appears in two specific HDF Attributes within the Metadata Group. The content of the first of these two HDF Attributes is the complete set of series metadata. The series metadata apply to all L1A_Radar files in a SMAP mission release. The content of the second HDF Attribute is the complete set of dataset metadata. The dataset metadata are specific to each product file. Combined, these two Attributes represent all of the metadata associated with L1A_Radar product. The content of these Attributes conforms to the ISO 19115-2 models in ISO 19139 compliant XML.

The second form of the metadata appears in a set of HDF5 groups under the Metadata Group. Each of these HDF5 Groups represents one of the major classes in the ISO structure. These groups contain a set of HDF5 attributes. Each HDF5 Attribute represents a specific ISO attribute of the associated ISO class. Although this representation inherits design from the ISO model, it does not completely conform to the model. In many cases, the names of the HDF5 Attributes match those used in the ISO model. In some situations, names were changed to provide greater clarity to SMAP users who are not familiar with the ISO model. Furthermore, to ease metadata searches, the structure of Groups within Groups was limited to four levels.

In addition, the Metadata group includes two attributes that contain MD5 checksums. These two checksum attributes specify the size of the two ISO metadata sets expressed in XML. Thus, *attribute iso_19139_dataset_xml_md5* contains the MD5 checksum of the contents of element *iso_19139_dataset_xml*. Likewise, attribute *iso_19139_series_xml_md5* contains the MD5 checksum of the contents of element *iso_19139_series_xml*.

Table 9 describes the subgroups of the Metadata group, and the attributes within each group. The first column of table 9 specifies a major class in the ISO 19115 metadata model. The second column provides the name of the HDF5 Group under "/Metadata" where attributes associated with the corresponding class will appear. The third column lists the names of the subgroups and attributes where specific metadata values appear. The fourth column provides valid values for each element. Constant values appear with no diacritical marks. Variable values are encapsulated by brackets <>. All of the metadata elements that appear in table 9 should also appear in every Level 1A Radar Product file.

Table 9: Granule Level Metadata in the L1A Radar Data Product

ISO Major Class	SMAP HDF5 Metadata SubGroup	Subgroup/Attribute in SMAP HDF5	Valid Values
DQ_DataQuality	DataQualiity	Scope	exponent, manitssa
		CompletenssOmission/evaluationMethod Type	directInternal
		CompletenessOmission/measureDescripti on	Percent of time period covered by the half orbit when data appear to be missing.
		CompletenessOmission/nameOfMeasure	Percent of Missing Data
		CompletenessOmission/value	<A measure between 0 and 100>
		CompletenessOmission/unitOfMeasure	Percent
		CompletenssOmission/evaluationMethod Type	directInternal
		BitFlipOmission/measureDescription	Percent of telemetry records negatively impacted by uncorrectable big flip errors.
		BitFlipOmission/nameOfMeasure	Percent of Missing Data due to Bit Flips
		BitFlipOmission/value	<A measure between 0 and 100>
		BitFlipOmission/unitOfMeasure	Percent
		HiResCompletenssOmission/evaluationM	directInternal

		ethodType	
		HiResCompletenessOmission/measureDescription	Fraction of time period covered by the half orbit when high resolution data appear to be missing.
		HiResCompletenessOmission/nameOfMeasure	Percent of Missing High Resolution Data
		HiResCompletenessOmission/value	<A measure between 0 and 100>
		HiResCompletenessOmission/unitOfMeasure	Percent
		DomainConsistency/evaluationMethodType	directInternal
		DomainConsistency/measureDescription	Fraction of the number of high resolution data packets that are deemed usable for SMAP processing relative to those that appear in the input telemetry.
		DomainConsistency/nameOfMeasure	Percent of Usable High Resolution Data Packets.
		DomainConsistency/value	<A measure between 0 and 100>
		DomainConsistency/unitOfMeasure	Percent
EX_Extent	Extent	description	Time range of the telemetry that contains both synthetic aperture radar data and real aperture radar data that were downlinked from the SMAP spacecraft.

		polygonPosList	<An array of vertices of a polygon the defines the region occupied by the data set in the corresponding data product. Each vertex is represented by an ordered pair. Latitudes precede longitudes. Vertices appear in clockwise order. Spaces delineate each value.>
		rangeBeginningDateTime	<Time stamp that indicates the initial time element in the product. The SMAP antenna rotates. Data measurements extend 500 km from the spacecraft nadir point. To ensure that all data within a particular half orbit appear in the Level 1A product, the time of the first element in the product is several seconds before the time when the spacecraft passes over the half orbit boundary.>
		rangeEndingDateTime	<Time stamp that indicates the final time of data in the product. The SMAP antenna rotates. Data measurements extend 500 km from the spacecraft nadir point. To ensure that all data within a particular half orbit appear in the Level 1A product, the time of the final element in the product is several seconds after the time when the spacecraft passes over the half orbit boundary.>

LI_Lineage/LE_ProcessStep	ProcessStep	processor	Soil Moisture Active Passive (SMAP) Mission Science Data System (SDS) Operations Facility
		stepDateTime	< A date time stamp that specifies when the product was generated.>
		processDescription	Parses Radar Telemetry into discretely defined elements. Converts temperature and voltage measures from data numbers to engineering units.
		Identifier	L1A_RADAR_SPS
		SWVersionID	<A software version identifier that runs from 001 to 999>
		softwareDate	<A date stamp that specifies when software used to generate this product was released.>
		softwareTitle	L1A Radar SPS
		documentation	<References a software description document if one exists.>
		documentDate	<Date of the software description document>
		runTimeParameters	<Specify any run time parameters if they were used.>
		timeVariableEpoch	J2000

		epochJulianDate	2451545.00
		epochUTCDateTime	2000-01-01T11:58:55.816Z
		highResolutionDataPresent	True or False
		parameterVersionID	<A software and algorithm parameter version identifier that runs from 001 to 999>
		algorithmTitle	Soil Moisture Active Passive (SMAP) Radar telemetry parsing and interpretation algorithm
		algorithmVersion	<An algorithm version identifier that runs from 001 to 999>
		algorithmDate	<Date of the algorithm that is employed in the corresponding executable.>
		algorithmDescription	Parses Radar Telemetry into discretely defined elements. Converts temperature and voltage measures from data numbers to engineering units.
		ATBDTitle	Radar Level 1A Design Memorandum SMAP-860-028-11
		ATBDDate	<Time stamp that specifies the release date of the Algorithm Theoretical Basis Document>
		ATBDVersion	Initial

LI_Lineage/LE_Source	L0B_Radar, Ephemeris, Attitude, AntennaAzimuth, SpacecraftClockUTC, RunConfiguration, InputConfiguration, OutputConfiguration, MetadataConfiguration SCLK-UTC Correlation, Reconstructed High Resolution Earth Orientation, SpiceProjectFrames, SpiceLeapSeconds, SpicePlanetaryConstants, SpiceEarthFixedFrame, SpicePlanetaryTrajectory	description	<Description of each of the input files used to generate the Level 1A Radar product.>
		fileName	<Complete file name of the input data product>
		creationDate	<A date stamp that specifies when the input data product was generated.>
		version	<The SMAP Composite Version ID associated with the input data product.>
		identifier	<The short name associated with the product.>
DS_Dataset/MD_DataIdentification	DataSetIdentification	creationDate	<Date when the Level 1A Radar data product file was created>
		CompositeReleaseID	<SMAP Composite Release ID associated with this data product – See section 4.3>

		fileName	<Name of the Radar Level 1A output data file.>
		originatorOrganizationName	Jet Propulsion Laboratory
		shortName	SPL1AA
		SMAPShortName	L1A_Radar
		UUID	<A universally unique identifier for each data granule.>
		ECSVersionID	<Identifier that specifies major version delivered to ECS. Value runs from 001 to 999.>
		abstract	Parsed high resolution and low resolution radar instrument telemetry with spacecraft position, attitude and antenna azimuth information as well as voltage and temperature sensor measurements converted from telemetry data numbers to engineering units.
		purpose	This product enables users to interpret and read the content of the SMAP Radar telemetry using clearly delineated and described data elements.
		credit	The software that generates the Level 1A Radar product and the data system that automates its production were designed and implemented at the Jet Propulsion Laboratory,

			California Institute of Technology in Pasadena, California.
		status	onGoing
		characterSet	utf8
		language	Eng
		topicCategory	geoscientificInformation
DS_Dataset/MD_DataIdentification/MD_AggregateInformation		fileName	<The name of QA product.>
		creationDate	<The date when the QA product that accompanies the L1A_RADAR data granule was generated.>
		abstract	An ASCII product that contains statistical information on data product results. These statistics enable data producers and users to assess the quality of the data product granule.
DS_Series/MD_DataIdentification	SeriesIdentification	revisionDate	<Date and time of the software release that was used to generate this data product.>
		CompositeReleaseID	<SMAP Composite Release ID that identifies the release used to generate this data product – See section 4.3>
		longName	SMAP L1A Radar Time-Ordered Parsed Telemetry

		shortName	SPL1AA
		identifier_product_DOI	http://dx.doi.org/10.5067/DM0U37IYZ6NK
		ECSVersionID	<Identifier that specifies major version delivered to ECS. Value runs from 001 to 999.>
		resourceProviderOrganizationName	National Aeronautics and Space Administration
		abstract	Parsed high resolution and low resolution radar instrument telemetry with spacecraft position, attitude and antenna azimuth information as well as voltage and temperature sensor measurements converted from telemetry data numbers to engineering units.
		purpose	This product enables users to interpret and read the content of the SMAP Radar telemetry using clearly delineated and described data elements.
		credit	The software that generates the Level 1A Radar product and the data system that automates its production were designed and implemented at the Jet Propulsion Laboratory, California Institute of Technology in Pasadena, California.

		status	onGoing
		characterSet	utf8
		language	eng
		topicCategory	geoscientificInformation
		pointOfContact	Alaska Satellite Facility, Fairbanks, Alaska
		mission	Soil Moisture Active Passive (SMAP)
		maintenanceAndUpdateFrequency	asNeeded
		maintenanceDate	<Specifies a date when the next update to this product might be anticipated>
		format	HDF5
		formatVersion	1.8.11
DS_Series/MD_DataIdentification	ProductSpecificationDocument	characterSet	utf8
		language	eng
		publicationDate	<Date of publication of the Product Specification Document>
		edition	<Edition identifier for the Product Specification Document>
		title	Soil Moisture Active Passive Mission Level 1A Radar Product

			Specification Document
		SMAPShortName	L1A_Radar
MD_AcquisitionInformation	AcquisitionInformation	platform/antennaRotationRate	<Rate the antenna rotates when these data were acquired.>
		platformDocument/publicationDate	<The date of publication of the document that describes the SMAP platform, if available to the general public>
		platformDocument/edition	<The edition of publication of the document that describes the SMAP platform, if available to the general public.>
		platformDocument/title	<The title of the publication of the document that describes the SMAP platform, if available to the general public.>
		platform/description	The SMAP observatory houses an L-band radiometer that operates at 1.414 GHz and an L-band radar that operates at 1.225 GHz. The instruments share a rotating reflector antenna with a 6 meter aperture that scans over a 1000 km swath. The bus is a 3 axis stabilized spacecraft that provides momentum compensation for the rotating antenna.
		platform/identifier	SMAP

		radarDocument/publicationDate	<The date of publication of the document that describes the SMAP radar instrument, if available to the general public.>
		radarDocument/edition	<The edition of publication of the document that describes the SMAP radar instrument, if available to the general public.>
		radarDocument/title	<The title of the publication of the document that describes the SMAP radar instrument, if available to the general public.>
		radar/description	The SMAP radar instrument employs an L-band conically scanned system and SAR processing techniques to achieve moderate resolution (1 km) backscatter measurements over a very wide 1000 km swath.
		radar/identifier	SMAP SAR
		radar/type	L-band Synthetic Aperture Radar
		radiometerDocument/publicationDate	<The date of publication of the document that describes the SMAP radiometer instrument, if available to the general public.>
		radiometerDocument/edition	<The edition of publication of the document that describes the SMAP radiometer instrument, if available to the general public.>

		radiometerDocument/title	<The title of the publication of the document that describes the SMAP radiometer instrument, if available to the general public.>
		radiometer/description	The SMAP L-band Radiometer records V-pol, H-pol, 3rd and 4th Stokes brightness temperatures at 40 km resolution at 4.3 Megatbits per second with accuracies of 1.3 Kelvin or better.
		radiometer/identifier	SMAP RAD
		radiometer/type	L-band Radiometer
MD_AcquisitionInformation	OrbitMeasuredLocation	argumentOfPerigee	<The angle in the satellite's orbit plane between the point of perigee and ascending node. The angle is measured in the direction of spacecraft motion.>
		cycleNumber	<The SMAP satellite flies in a cycle that repeats after 117 orbits. This element specifies the cycle of orbits when the data were taken. First cycle is assigned the number 1.>
		eccentricity	<The eccentricity of the satellite orbit.>
		epoch	<The effective time of the data in the OrbitMeasuredLocation class. This

			may be identical to the equatorCrossingDateTime.>
		equatorCrossingDateTime	<A time stamp that specifies the date and time of the equator crossing within the current half orbit granule.>
		equatorCrossingLongitude	<The longitude of the ascending node crossing for the current orbit.>
		Inclination	<The angle between the spacecraft's orbital plane and the Earth's equatorial plane. An angle greater than 90 degrees indicates a orbit retrograde path.>
		meanMotion	<The constant angular speed that would be required for a body travelling in an undisturbed elliptical orbit with the specified semi-major axis to complete one revolution in the actual orbital period, expressed as a number of revolutions per day.>
		orbitDirection	<SMAP Level 1 and Level 2 products appear in half orbit granules. This element provides direction of orbital path relative to equatorial plane. Values are "Ascending" or "Descending":>
		halfOrbitStartDateTime	<A time stamp that specifies the date and time of the instant the spacecraft crosses either the southernmost point or the northernmost point in its path, marking the beginning of the

			half orbit.>
		halfOrbitStopDateTime	<A time stamp that specifies the date and time of the instant the spacecraft crosses either the southernmost point or the northernmost point in its path, marking the end of the half orbit.>
		orbitPathNumber	< The SMAP satellite flies in a cycle the repeats after 117 orbits. This element specifies which of the 117 possible paths the spacecraft flew when the data in the file were acquired. The orbitPathNumber varies from 1 to 117.>
		orbitPeriod	<Time required to complete a the spacecraft orbit.>
		reference_CRS	<A description of the coordinate reference system used to describe spacecraft orbital data.>
		revNumber	<The count of orbits from beginning of mission to the orbit that the spacecraft flew when the data in the file were acquired. Orbit zero begins at launch and extends until the spacecraft crosses the southernmost point in its path for the first time. Orbit one commences at that instant.>
		rightAscensionAscendingNode	<The angle eastward on the equatorial plan from the vernal

			equinox to the orbit ascending node.>
		semiMajorAxis	<The length of the semi-major axis of the spacecraft orbit.>

[1] The metadata will allocate a group for each input data set that requires provenance tracking. The most critical ones are those that are likely to vary from one orbit granule to the next. The metadata will track and list additional files for user information.

4.5 Data Structure

4.5.1 Spacecraft Data Group

The Spacecraft Data contain elements that specify either geometric or geographic information that are representative of an entire along track row in the instrument swath in the L1A Radar product. All of the product elements in the Spacecraft Data Group are stored in a single HDF5 Group named "/Spacecraft_Data". A distinct HDF5 Dataset stores each data element. The name of each Dataset object matches the data element that it stores. Table 10 lists all of the elements in the Spacecraft Data Group.

All the HDF5 Datasets in the Spacecraft Data Group have SpacecraftData_Array shape. The SpacecraftData_Array shape describes a one-dimensional array, where each array element represents each 10^{th} of second within the time period represented in the Level 1A product. Thus, array element *x_pos(6212)* lists the representative spacecraft position in the x dimension, array element *yaw(6212)* lists the representative spacecraft yaw, and array element *sc_geodetic_alt(6212)* lists the representative spacecraft altitude at the instant recorded in array element *along_track_time_utc(6212).*

Table 10: The Spacecraft Data Group

Element Name	Type	Shape	Valid_Min	Valid_Max	Units
sc_data_time	Float64	SpacecraftData_Array	0	946000000	seconds
sc_data_time_utc	FixedLenString	SpacecraftData_Array	n/a	n/a	n/a
sc_mode_flag	Uint16	SpacecraftData_Array	n/a	n/a	n/a
sc_qual_flag	Uint16	SpacecraftData_Array	n/a	n/a	n/a
sc_nadir_lat	Float32	SpacecraftData_Array	-90	90	degrees_north
sc_nadir_lon	Float32	SpacecraftData_Array	-180.00	179.999	degrees_east

declination	Float32	SpacecraftData_Array	-90	90	degrees
right_ascension	Float32	SpacecraftData_Array	0.0	359.999	degrees
sc_geodetic_alt_ellipsoid	Float32	SpacecraftData_Array	650000	750000	meters
sc_alongtrack_velocity	Float32	SpacecraftData_Array	-8000	8000	meters/second
sc_radial_velocity	Float32	SpacecraftData_Array	-8000	8000	meters/second
antenna_scan_angle	Float32	SpacecraftData_Array	0	359.999	degrees
antenna_look_angle	Float32	SpacecraftData_Array	0	180	degrees
sc_nadir_angle	Float32	SpacecraftData_Array	0	180	degrees
x_pos	Float32	SpacecraftData_Array	-9999999	99999999	meters
y_pos	Float32	SpacecraftData_Array	-9999999	99999999	meters
z_pos	Float32	SpacecraftData_Array	-9999999	99999999	meters
x_vel	Float32	SpacecraftData_Array	-8000	8000	meters/second
y_vel	Float32	SpacecraftData_Array	-8000	8000	meters/second
z_vel	Float32	SpacecraftData_Array	-8000	8000	meters/second
roll	Float32	SpacecraftData_Array	-3.0	3.0	degrees
pitch	Float32	SpacecraftData_Array	-3.0	3.0	degrees
yaw	Float32	SpacecraftData_Array	-3.0	3.0	degrees

4.5.2 Health and Status Data Group

The Health and Status Data group contains data parsed directly for the Health and Status data packets that are folded into the radar telemetry. Each Health and Status packet corresponds to the receipt of a One Second Time Command (OSTC) from the spacecraft clock. Thus, the number of records in the Health and Status Data Group is roughly equivalent to the number of seconds that transpire over the time period that each file represents. All of the product elements in the Health and Status Data Group are stored in a single HDF5 Group named “/Health_and_Status_Data”. A distinct HDF5 Dataset stores each data element. The name of each Dataset object matches the data element that it stores. Table 11 lists the elements in the Health and Status Data Group.

All of the elements in the Health and Status Data Group are either one or two dimensional arrays. All of the elements in the Health and Status Data Group share the same slower moving array dimension. That dimension index represents each of the Health and Status Data records that appear in the radar telemetry over the time period covered by the Level 1A product. Thus, array elements that share the same slower moving dimension index reference the Health and Status Data that was recorded at the same second. Arrays with a second dimension reference multiple elements within the same Health and Status Data record.

Table 11: The Health and Status Data Group

Element Name	Type	Shape	Valid_Min	Valid_Max	Units
hsd_time	Float64	HSD_Array	0	946000000	seconds
hsd_time_utc	FixedLenString	HSD_Array	n/a	n/a	n/a
hsd_time_second_ticks	Uint32	HSD_Array	0	946000000	seconds
hsd_time_subsecond_ticks	Uint32	HSD_Array	0	1048575	counts
hsd_status_flag	Uint16	HSD_Array	n/a	n/a	n/a
spacecraft_synch_time	Uint32	HSD_Array	0	946000000	seconds
radar_synch_time	Float64	HSD_Array	0	946000000	seconds

Element Name	Type	Shape	Valid_Min	Valid_Max	Units
radar_synch_time_utc	FixedLenString	HSD_Array	n/a	n/a	n/a
radar_synch_time_second_ticks	Uint32	HSD_Array	0	946000000	seconds
radar_synch_time_subsecond_ticks	Uint32	HSD_Array	0	1048575	counts
beam_index_crossing_time	Float64	HSD_Array	0	946000000	seconds
beam_index_crossing_time_utc	FixedLenString	HSD_Array	n/a	n/a	n/a
beam_index_crossing_time_second_ticks	Uint32	HSD_Array	0	946000000	seconds
beam_index_crossing_time_subsecond_ticks	Uint32	HSD_Array	0	1048575	counts
rev_start_time	Float64	HSD_Array	0	946000000	seconds
rev_start_time_utc	FixedLenString	HSD_Array	n/a	n/a	n/a
rev_start_time_second_ticks	Uint32	HSD_Array	0	946000000	seconds
rev_start_time_subsecond_ticks	Uint32	HSD_Array	0	1048575	counts
hsd_flags	Uint32	HSD_HSDFlags_Array	n/a	n/a	n/a
hsd_spares	Uint32	HSD_HSDSpares_Array	0	4294967295	n/a
digital_analog_telemetry_flags	Uint16	HSD_Array	n/a	n/a	n/a
voltage_sensors_dn	Uint16	HSD_HSDVoltSensor_Array	0	65535	n/a
voltage_sensors_eu	Float32	HSD_HSDVoltSensor_Array	-20.0	60.0	volts

Element Name	Type	Shape	Valid_Min	Valid_Max	Units
temperature_sensors_dn	Uint16	HSD_HSDTempSensor_Array	0	65535	n/a
temperature_sensors_eu	Float32	HSD_HSDTempSensor_Array	-100.0	100.0	Celsius
version_identifiers	Uint32	HSD_Array	0	4294967295	n/a
loopback_hh	Uint16	HSD_Array	0	65535	n/a
loopback_vv	Uint16	HSD_Array	0	65535	n/a
echo_hh	Uint16	HSD_Array	0	65535	n/a
echo_vv	Uint16	HSD_Array	0	65535	n/a
dp_flags	Uint32	HSD_Array	n/a	n/a	n/a
hsd_frame_counter	Uint32	HSD_Array	0	4294967295	n/a

4.5.3 Revolution Data Group

The Revolution Data Group contains elements that are representative of a single rotation of the SMAP antenna. The SMAP antenna rotation rate will vary between 12.3 revolutions per minute and 14.6 revolutions per minute. Thus, each entry in the Revolution Data Group represents a 4 to 5 second time period. All of the product elements in the Revolution Data Group are stored in a single HDF5 Group named "/Revolution_Data". A distinct HDF5 Dataset stores each data element. The name of each Dataset object matches the data element that it stores. Table 12 lists the elements in the Revolution Data Group.

All of the elements in the Revolution Data Group are either one or two dimensional arrays. Each data element in the Revolution Data Group shares the same slower moving array dimension. That dimension index represents each of the Revolution Data records that appear in the radar telemetry over the time period covered by the Level 1A product. Thus, array elements that share the same slower moving dimension index reference the Revolution Data that represents the same rotation of the SMAP antenna. Arrays with a second dimension reference multiple elements within the same Revolution Data record.

Table 12: The Revolution Data Group

Element Name	Type	Shape	Valid_Min	Valid_Max	Units
revolution_counter	Uint16	AntennaRev_Array	1	65535	counts
pri_length	Uint16	AntennaRev_Array	2800	3780	0.1 μsec
rev_end_countdown	Uint32	AntennaRev_Array	0	231000	10 μsec
high_resolution_start	Uint16	AntennaRev_HiResInterval_Array	0	300	n/a
high_resolution_stop	Uint16	AntennaRev_HiReInterval_Array	0	300	n/a
frequency	Float32	AntennaRev_Segment_Array	1218.75	1296.25	MHz

beam_index_crossing_time	Float64	AntennaRev_Array	0	946000000	seconds
beam_index_crossing_time_utc	FixedLenString	AntennaRev_Array	n/a	n/a	n/a
beam_index_crossing_time_second_ticks	Uint32	AntennaRev_Array	0	946000000	seconds
beam_index_crossing_time_subsecond_ticks	Uint32	AntennaRev_Array	0	1048575	counts
rev_start_time	Float64	AntennaRev_Array	0	946000000	seconds
rev_start_time_utc	FixedLenString	AntennaRev_Array	n/a	n/a	n/a
rev_start_time_second_ticks	Uint32	AntennaRev_Array	0	946000000	seconds
rev_start_time_subsecond_ticks	Uint32	AntennaRev_Array	0	1048575	counts
test_load_h	Float32	AntennaRev_Array	-99999.9	99999.9	dBm
test_load_v	Float32	AntennaRev_Array	-99999.9	99999.9	dBm
test_load_noise_only_h	Float32	AntennaRev_Array	-99999.9	99999.9	dBm
test_load_noise_only_v	Float32	AntennaRev_Array	-99999.9	99999.9	dBm

4.5.4 Loop Back Trap Data Group

The Loop Back Trap Data Group contains elements that SMAP radar processing employs to calibrate backscatter measure. The radar telemetry generates a loop back trap record once each antenna rotation segment. The SMAP antenna rotates at a rate that varies between 12.3 revolutions per minute and 14.6 revolutions per minute. Each rotation is divided into 16 segments. All of the product elements in the Loop Back Trap Data Group are stored in a single HDF5 Group named "/Loop_Back_Trap_Data". A distinct HDF5 Dataset stores each data element in the Loop Back Trap Data Group. The name of each Dataset object matches the data element that it stores. Table 13 lists the elements in the Loop Back Trap Data Group.

All of the elements in the Loop Back Trap Data Group are either one or two dimensional arrays. Each data element in the Loop Back Trap Data Group shares the same slower moving array dimension. That dimension index represents each of the Loop Back Trap Data records that appear in the radar telemetry over the time period covered by a Level 1A product. Thus, array elements that share the same slower moving dimension index reference the Loop Back Trap Data that represents the same segment of the same rotation of the SMAP antenna. Arrays with a second dimension reference the 21 samples that accompany each Loop Back Trap Data element.

Table 13: The Loop Back Trap Data Group

Element Name	Type	Shape	Valid_Min	Valid_Max	Units
loop_back_trap_time	Float64	LoopBackTrap_Array	0	946000000	seconds
loop_back_trap_time_utc	FixedLenString	LoopBackTrap_Array	n/a	n/a	n/a
loop_back_trap_qual_flag	Uint16	LoopBackTrap_Array	n/a	n/a	n/a
loop_back_trap_status_flag	Uint8	LoopBackTrap_Array	n/a	n/a	n/a
rev_loop_back_trap	Uint16	LoopBackTrap_Array	0	65535	counts
rev_segment_loop_back_trap	Uint8	LoopBackTrap_Array	0	15	n/a

Element Name	Type	Shape	Valid_Min	Valid_Max	Units
loop_back_noise_only_h_dn	Uint16	LoopBackTrap_Array	0	65535	n/a
loop_back_noise_only_v_dn	Uint16	LoopBackTrap_Array	0	65535	n/a
loop_back_prime_hh_dn	Uint16	LoopBackTrap_Array	0	65535	n/a
loop_back_prime_vv_dn	Uint16	LoopBackTrap_Array	0	65535	n/a
dc_offset_hh_dn	Uint16	LoopBackTrap_Array	0	65535	n/a
dc_offset_vv_dn	Uint16	LoopBackTrap_Array	0	65535	n/a
loop_back_trap_hh_i_dn	Uint16	LoopBackTrap_LBTSamples_Array	0	65535	n/a
loop_back_trap_hh_q_dn	Uint16	LoopBackTrap_LBTSamples_Array	0	65535	n/a
loop_back_trap_vh_i_dn	Uint16	LoopBackTrap_LBTSamples_Array	0	65535	n/a
loop_back_trap_vh_q_dn	Uint16	LoopBackTrap_LBTSamples_Array	0	65535	n/a
loop_back_trap_vv_i_dn	Uint16	LoopBackTrap_LBTSamples_Array	0	65535	n/a
loop_back_trap_vv_q_dn	Uint16	LoopBackTrap_LBTSamples_Array	0	65535	n/a
loop_back_trap_hv_i_dn	Uint16	LoopBackTrap_LBTSamples_Array	0	65535	n/a
loop_back_trap_hv_q_dn	Uint16	LoopBackTrap_LBTSamples_Array	0	65535	n/a
loop_back_noise_only_h_eu	Float32	LoopBackTrap_Array	-90.0	40.0	dBm
loop_back_noise_only_v_eu	Float32	LoopBackTrap_Array	-90.0	40.0	dBm

Element Name	Type	Shape	Valid_Min	Valid_Max	Units
loop_back_prime_hh_eu	Float32	LoopBackTrap_Array	-115.0	20.0	dBm
loop_back_prime_vv_eu	Float32	LoopBackTrap_Array	-115.0	20.0	dBm
loop_back_trap_hh_i_eu	Float32	LoopBackTrap_LBTSamples_Array	-2.0	2.0	volts
loop_back_trap_hh_q_eu	Float32	LoopBackTrap_LBTSamples_Array	-2.0	2.0	volts
loop_back_trap_vh_i_eu	Float32	LoopBackTrap_LBTSamples_Array	-2.0	2.0	volts
loop_back_trap_vh_q_eu	Float32	LoopBackTrap_LBTSamples_Array	-2.0	2.0	volts
loop_back_trap_vv_i_eu	Float32	LoopBackTrap_LBTSamples_Array	-2.0	2.0	volts
loop_back_trap_vv_q_eu	Float32	LoopBackTrap_LBTSamples_Array	-2.0	2.0	volts
loop_back_trap_hv_i_eu	Float32	LoopBackTrap_LBTSamples_Array	-2.0	2.0	volts
loop_back_trap_hv_q_eu	Float32	LoopBackTrap_LBTSamples_Array	-2.0	2.0	volts

4.5.5 Low Resolution Data Group

The Low Resolution Data Group provides the data required to calculate radar backscatter using real aperture methodologies. Each set of low resolution data represents the integration of 48 radar pulse repetition intervals (PRIs). All of the product elements in the Low Resolution Data Group are stored in a single HDF5 Group named "/Low_Resolution_Data". A distinct HDF5 Dataset stores each data element in the Low Resolution Data Group. The name of each Dataset object matches the data element that it stores. Table 14 lists the elements in the Low Resolution Data Group.

All of the elements in the Low Resolution Data Group are either one or two dimensional arrays. Each data element in the Low Resolution Data Group shares the same slower moving array dimension. That dimension index represents each of the Low Resolution Data records that appear in the radar telemetry over the time period covered by a Level 1A product. Thus, array elements that share the same slower moving dimension index reference the Low Resolution Data that represents the same set of 48 instrument PRIs.

Table 14: The Low Resolution Data Group

Element Name	Type	Shape	Valid_Min	Valid_Max	Units
low_res_time	Float64	LoRes_Array	0	946000000	seconds
low_res_time_utc	FixedLenString	LoRes_Array	n/a	n/a	n/a
low_res_qual_flag	Uint16	LoRes_Array	n/a	n/a	n/a
low_res_status_flag	Uint8	LoRes_Array	n/a	n/a	n/a
low_res_interval	Uint16	LoRes_Array	0	511	n/a
rev_lores	Uint16	LoRes_Array	0	65535	counts
rev_segment_lores	Uint8	LoRes_Array	0	15	n/a
num_lores_bins	Uint8	LoRes_Array	0	13	n/a

Element Name	Type	Shape	Valid_Min	Valid_Max	Units
loop_back_hh_dn	Uint16	LoRes_Array	0	65535	n/a
loop_back_hv_dn	Uint16	LoRes_Array	0	65535	n/a
loop_back_vh_dn	Uint16	LoRes_Array	0	65535	n/a
loop_back_vv_dn	Uint16	LoRes_Array	0	65535	n/a
noise_only_h_i_dn	Uint16	LoRes_PRI_Array	0	65535	n/a
noise_only_h_q_dn	Uint16	LoRes_PRI_Array	0	65535	n/a
noise_only_h_sum_dn	Uint16	LoRes_PRI_Array	0	65535	n/a
noise_only_v_i_dn	Uint16	LoRes_PRI_Array	0	65535	n/a
noise_only_v_q_dn	Uint16	LoRes_PRI_Array	0	65535	n/a
noise_only_v_sum_dn	Uint16	LoRes_PRI_Array	0	65535	n/a
pulse_hh_dn	Uint16	LoRes_LoResBin_Array	0	65535	n/a
pulse_hv_dn	Uint16	LoRes_LoResBin_Array	0	65535	n/a
pulse_vh_dn	Uint16	LoRes_LoResBin_Array	0	65535	n/a
pulse_vv_dn	Uint16	LoRes_LoResBin_Array	0	65535	n/a
loop_back_hh_eu	Float32	LoRes_Array	-110.0	20.0	dBm
loop_back_hv_eu	Float32	LoRes_Array	-110.0	20.0	dBm

Element Name	Type	Shape	Valid_Min	Valid_Max	Units
loop_back_vh_eu	Float32	LoRes_Array	-110.0	20.0	dBm
loop_back_vv_eu	Float32	LoRes_Array	-110.0	20.0	dBm
noise_only_h_i_eu	Float32	LoRes_PRI_Array	-99999.9	99999.9	volts
noise_only_h_q_eu	Float32	LoRes_PRI_Array	-99999.9	99999.9	volts
noise_only_h_sum_eu	Float32	LoRes_PRI_Array	-99999.9	99999.9	dBm
noise_only_v_i_eu	Float32	LoRes_PRI_Array	-99999.9	99999.9	volts
noise_only_v_q_eu	Float32	LoRes_PRI_Array	-99999.9	99999.9	volts
noise_only_v_sum_eu	Float32	LoRes_PRI_Array	-99999.9	99999.9	dBm
pulse_hh_eu	Float32	LoRes_LoResBin_Array	-99999.9	99999.9	dBm
pulse_hv_eu	Float32	LoRes_LoResBin_Array	-99999.9	99999.9	dBm
pulse_vh_eu	Float32	LoRes_LoResBin_Array	-99999.9	99999.9	dBm
pulse_vv_eu	Float32	LoRes_LoResBin_Array	-99999.9	99999.9	dBm

4.5.6 High Resolution Data Group

The High Resolution Data Group provides the data required to calculate radar backscatter using synthetic aperture methodologies. Each set of high resolution data represents a single Pulse Repetition Interval (PRI) of the radar instrument. All of the product elements in the High Resolution Data Group are stored in a single HDF5 Group named "/High_Resolution_Data". A distinct HDF5 Dataset stores each data element in the High Resolution Data Group. The name of each Dataset object matches the data element that it stores. Table 15 lists the elements in the High Resolution Data Group.

The elements in the High Resolution Data Group are either one, three or four dimensional arrays. Each data element in the High Resolution Data Group shares the same slowest moving array dimension. That dimension index represents each of the High Resolution Data records that appear in the radar telemetry over the time period covered by a Level 1A product. Thus, array elements that share the same slowest moving dimension index reference the High Resolution Data that represents the same instrument PRI.

Table 15: The High Resolution Data Group

Element Name	Type	Shape	Valid_Min	Valid_Max	Units
high_res_time	Float64	HiRes_Array	0	946000000	seconds
high_res_time_utc	FixedLenString	HiRes_Array	n/a	n/a	n/a
high_res_qual_flag	Uint16	HiRes_Array	n/a	n/a	n/a
high_res_status_flag	Uint8	HiRes_Array	n/a	n/a	n/a
pri_counter	Uint16	HiRes_Array	0	24000	counts
rev_hires	Uint16	HiRes_Array	0	65535	counts
rev_segment_hires	Uint8	HiRes_Array	0	15	n/a
num_hires_blocks	Uint8	HiRes_Array	9	13	n/a

Element Name	Type	Shape	Valid_Min	Valid_Max	Units
num_lastblock_samples	Uint8	HiRes_Array	0	32	n/a
mantissa	Uint8	HiRes_HiResBlock_Channel_BlockSize_Array	0	255	n/a
exponent	Uint8	HiRes_HiResBlock_Channel_Array	0	31	n/a

4.6 Element Definitions

4.6.1 hsd_time

The representative time for each Health and Status Data record. *hsd_time* corresponds to the recorded radar clock time at the instant of the first Pulse Repetition Interval (PRI) after the most recent One Second Time Command (OSTC) issued from the spacecraft clock. Radar clock times count seconds since the most recent instrument Power On Reset (POR).

The time values are counts of International System (SI) seconds based on the J2000 epoch in Ephemeris Time (ET). Time counts in the J2000 epoch are equivalent to the number of Standard International (SI) compatible seconds since 11:58:55.816 on January 1, 2000 UTC.

hsd_time_utc is a one-dimensional array. Each element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product.

Type:	Float64
Group:	Health and Status Data
Shape:	HSD_Array
Valid_min:	0
Valid_max:	946000000
Units:	seconds

4.6.2 hsd_time_utc

The representative time for each Health and Status Data record. *hsd_time_utc* corresponds to the recorded radar clock time at the instant of the first Pulse Repetition Interval (PRI) after the most recent One Second Time Command (OSTC) issued from the spacecraft clock. Radar clock times count seconds since the most recent instrument Power On Reset (POR).

Each element of the *hsd_time_utc* array records the same time instant as the element with matching index in the *hsd_time* array. The *hsd_time_utc* appears as an easily interpretable character string, while the *hsd_time* contains the count of Standard International (SI) compatible seconds since 11:58:55.816 on January 1, 2000 UTC.

The format of the *hsd_time_utc* is YYYY-MM-DDThh:mm:ss.dddZ, where YYYY represents the calendar year, MM represents the month of the year and DD represents the day of the month. The character ‘T’ demarcates the date from the time. hh represents the hour in twenty-four hour time, mm represents the minutes, ss represents the seconds, and ddd represents thousandths of a second. The character ‘Z’ designates Greenwich Mean Time. All numerical fields must occupy the allotted space. If any numerical value does not require the allotted space to represent the appropriate number, the field that specifies the number must contain leading zeroes.

hsd_time_utc is a one-dimensional array. Each element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product.

Type:	FixLenStr
String Length:	24 characters
Group:	Health and Status Data
Shape:	HSD_Array
Valid_min:	‘2014-10-31T00:00:00.000Z’
Valid_max:	‘2030-12-31T23:59:60.999Z’
Units:	n/a

4.6.3 hsd_time_second_ticks

The number of full second time ticks recorded by the spacecraft clock at the instant of the first Pulse Repetition Interval (PRI) after the most recent One Second Time Command (OSTC) issued from the spacecraft clock.

SMAP telemetry employs two registers to record spacecraft time. One register employs 32 bits to record whole seconds since the most recent reset. A second register employs 20 bits to record subseconds. Thus, each subsecond tick is equivalent to $½^{20}$ seconds.

hsd_time_second_ticks is a one-dimensional array. Each element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product.

Type:	Uint32
Group:	Health and Status Data
Shape:	HSD_Array
Valid_min:	0
Valid_max:	946000000
Units:	seconds

4.6.4 hsd_time_subsecond_ticks

The number of subsecond time ticks recorded by the spacecraft clock at the instant of the first Pulse Repetition Interval (PRI) after the most recent One Second Time Command (OSTC) issued from the spacecraft clock.

SMAP telemetry employs two registers to record spacecraft time. One register employs 32 bits to record whole seconds since the most recent reset. A second register employs 20 bits to record subseconds. Thus, each subsecond tick is equivalent to $½^{20}$ seconds.

hsd_time_subsecond_ticks is a one-dimensional array. Each element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product.

Type: Uint32

Group: Health and Status Data

Shape: HSD_Array

Valid_min: 0

Valid_max: 1048575

Units: counts

4.6.5 hsd_status_flag

Bit flags that indicate the status or the mode of instrument operation based on information in the Health and Status Data Group.

hsd_status_flag is a one dimensional array. Each element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product.

Table 16 specifies the meaning of individual bits in the *hsd_status_flag*:

Table 16: The hds_status_flag

Bits	Value	Interpretation
0		**Receive Only Mode**
	0	Radar instrument is operating in transmit/receive mode.
	1	Radar instrument is operating in receive only mode.
1-7		**Undefined**

Type: Uint16

Group: Health and Status Data

Shape: HSD_Array

Units: n/a

4.6.6 hsd_flags

The contents of data word 13 through data word 22 of the Health and Status Data set. The SMAP Radar Health and Status Data List details the contents of each of these ten data words. Many of the elements in these data sets are one bit flags that are most likely not needed for science data processing. Thus, the Level 1A SPS does not parse these elements into distinct product elements. The Level 1A product provides these bytes for those who might want to parse individual flags.

hsd_flags is a two dimensional array. The slower moving index corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product. The faster moving index represents each of the ten data words in the Health and Status Data Packet.

Type: Uint32

Group: Health and Status Data

Shape: HSD_HSDFlags_Array

Valid_min: n/a

Valid_max: n/a

Units: n/a

4.6.7 hsd_spares

The contents of data word 23 through data word 25 of the Health and Status Data set. The SMAP Radar Health and Status Data List details the contents of each of these data words. In the current definition, almost all of the content of these data elements are spares. The small number of bits that are defined in these data words constitute flags that occupy four or fewer bits and are most likely not needed for science data processing. Thus, the Level 1A SPS does not parse these elements into distinct product elements. The Level 1A product provides these bytes for those who might want to parse individual flags.

hsd_spares is a two dimensional array. The slower moving index corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product. The faster moving index represents each of the three data words in Health and Status data packet.

Type:	Uint32
Group:	Health and Status Data
Shape:	HSD_HSDSpares_Array
Valid_min:	0
Valid_max:	4294967295
Units:	n/a

4.6.8 digital_analog_telemetry_flags

The contents of higher order 16 bits of data word 26 of the Health and Status Data set. The SMAP Radar Health and Status Data List details the contents of these two bytes. All of the meaningful values are single bits that are not needed for science data processing. Thus, the Level 1A SPS does not parse these elements into distinct product elements. The Level 1A product provides these two bytes for those who might want to parse individual flags.

hsd_status_flag is a one dimensional array. Each element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product.

Type:	Uint16
Group:	Health and Status Data
Shape:	HSD_Array
Valid_min:	n/a
Valid_max:	n/a
Units:	n/a

4.6.9 voltage_sensors_dn

Voltage measures downloaded from 15 on-board sensors. Each value is represented as a telemetry data number.

voltage_sensors_dn is a two dimensional array. The slower moving index corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product. The faster moving index represents each of the fifteen voltage sensors in Health and Status data packet.

Table 17 lists the correspondence between the value of the faster moving index and the voltage sensor stored in that location.

Table 17: Voltage Sensor Indices

Voltage Sensor Index (Zero Based)	Voltage Sensor Mnemonic	Voltage Sensor Description
0	CG_+3.3V_MON	Chirp generator +3.3 volt primary supply monitor
1	HPS_+7V_MON	V/H high-power switch +7 volt monitor
2	HPS_-12V_MON	V/H high-power switch -12 volt monitor
3	LVPS_+30V_MON	Voltage monitor for HPA +30 volt power supply.
4	TX_PWR_MON	High power amplifier RF Transmit Power Monitor (TPM).
5	960M_PLM_TUNE	Upconverter (960 MHz) LO PLM tuning voltage.
6	LVPS_+45V_CUR_MON	Peak-hold load current monitor for the HPA +45 volt power supply
7	SYNTH_+12V_MON	Synthesizer +12 volt monitor
8	DNLO_PLM_TUNE	Downconverter LO PLM tuning voltage
9	RF_+12V_MON	RF electronics +15 volt monitor
10	SYNTH_+7V_MON	Synthesizer +7 volt monitor
11	RF_-12V_MON	RF electronics -12 volt monitor
12	RF_+7V_MON	RF electronics +7 volt monitor
13	ADPV_+15V_MON	+1.5 volt monitor for the vertical polarization SDE Data Processor FPGA
14	SDE_+5V_MON	SDE +5 volt monitor

Type: Uint16

Group: Health and Status Data

Shape: HSD_HSDVoltSensor_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.10 voltage_sensors_eu

Voltage measures downloaded from 15 on-board sensors. Each value is represented in engineering units.

voltage_sensors_eu is a two dimensional array. The slower moving index corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product. The faster moving index represents each of the fifteen voltage sensors in Health and Status data packet.

Table 17 lists the correspondence between the value of the faster moving index and the voltage sensor stored in that location.

Type: Float32

Group: Health and Status Data

Shape: HSD_HDSVoltSensor_Array

Valid_min: -20.0

Valid_max: 60.0

Units: volts

4.6.11 temperature_sensors_dn

Temperature measures downloaded from 32 on-board sensors. Each value is represented as a telemetry data number.

temperature_sensors_dn is a two dimensional array. The slower moving index corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product. The faster moving index represents each of the thirty-two temperature sensors in Health and Status data packet.

Table 18 lists the correspondence between the faster moving index and the temperature sensor stored in that location.

Table 18: Temperature Sensor Indices

Temperature Sensor Index (Zero Based)	Temperature Sensor Mnemonic	Temperature Sensor Description
0	CSAH_TEMP_MON	Cal switched attenuator temperature monitor for the horizontal polarization down-converter assembly (4 wire PRT)
1	CALRES1	4 wire PRT calibration resistor
2	CLH_RX_TEMP_MON	Receive path temperature monitor for horizontal polarization cal-loop assembly (4 wire PRT)
3	CLH_TX_TEMP_MON	Transmit path temperature monitor for horizontal polarization cal-loop assembly (4 wire PRT)
4	CLH_TLOAD_TEMP_MON	Receive test-load temperature monitor for horizontal polarization cal-loop assembly (4 wire PRT)
5	CLH_LBATTN_TEMP_MON	Loopback attenuator temperature monitor for horizontal polarization cal-loop assembly (4 wire PRT)
6	CSAV_TEMP_MON	Calibration switched attenuator temperature monitor for vertical polarization down-converter assembly (4 wire PRT)
7	BAPTA_TEMP_MON	Temperature monitor for BAPTA coax bulkhead connector (4 wire PRT)
8	CLV_RX_TEMP_MON	Receive path temperature monitor for vertical polarization cal-loop assembly (4 wire PRT)
9	CLV_TX_TEMP_MON	Transmit path temperature monitor for vertical polarization cal-loop assembly (4 wire PRT)

Temperature Sensor Index (Zero Based)	Temperature Sensor Mnemonic	Temperature Sensor Description
10	CLV_TLOAD_TEMP_MON	Receive test-load temperature monitor for vertical polarization cal-loop assembly (4 wire PRT)
11	CLV_LBATTN_TEMP_MON	Loopback attenuator temperature monitor for vertical polarization cal-loop assembly (4 wire PRT)
12	SADCH_TEMP_MON	Temperature monitor for horizontal polarization science ADC (2 wire PRT)
13		Spare
14	DPDU_TEMP_MON	Temperature monitor for SDE power distribution unit (2 wire PRT)
15	SADCV_TEMP_MON	Temperature monitor for vertical polarization science ADC (2 wire PRT)
16	DOWNH_IF_TEMP_MON	IF chain temperature monitor for horizontal polarization down-converter assembly (2 wire PRT)
17	CALRES2	2-wire PRT calibration resistor (DFT unit)
18	XLNXV_TEMP_MON	Temperature monitor for ADP-V Xilinx FPGA (internal temperature diode)
19	HPS_TEMP_MON	Temperature monitor for transmit-V/H high-power switch assembly (2-wire PRT)
20	DOWNV_IF_TEMP_MON	IF chain temperature monitor for vertical polarization down-converter assembly (2 wire PRT)

Temperature Sensor Index (Zero Based)	Temperature Sensor Mnemonic	Temperature Sensor Description
21	XLNXH_TEMP_MON	Temperature monitor for ADP-H Xilinx FPGA (internal temperature diode)
22	LPVS_TEMP_MON	Temperature monitor for HPA Low Voltage Power Supply (2 wire PRT)
23	RFDECK_TEMP_MON	Temperature monitor for HPA RF Deck (2 wire PRT)
24	STALO_TEMP_MON	Temperature monitor for Synthesizer STALO (2 wire PRT)
25	HPA_ISO_TEMP_MON	Temperature monitor for HPA high power output isolator (2 wire PRT)
26	CG_TEMP_MON	Chirp generator temperature monitor (2 wire PRT)
27	RPDU_TEMP_MON	Temperature monitor for RF power distribution unit (2 wire PRT)
28		Spare
29	UCA_TEMP_MON	Temperature monitor for upconverter assembly (2 wire PRT)
30	SDEBPLN_TEMP_MON	Temperature monitor for SDE backplane (2 wire PRT)
31		Spare

Type: Uint16

Group: Health and Status Data

Shape: HSD_HSDTempSensor_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.12 temperature_sensors_eu

Temperature measures downloaded from 32 on-board sensors. Each value is represented in engineering units.

temperature_sensors_eu is a two dimensional array. The slower moving index corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product. The faster moving index represents each of the thirty-two temperature sensors in Health and Status data packet.

Table 18 lists the correspondence between the faster moving index and the temperature sensor stored in that location. Elements in the HSDTempSensor dimension with zero-based indices of 1 and 17 are calibration resistors. These resistor measures are used to calculate the temperature in Kelvins for the remaining elements in the array. Thus, engineering unit entries do not appear for array elements with an HSDTempSensor zero-based index of 1 or 17.

Type: Float32

Group: Health and Status Data

Shape: HSD_HSDTempSensor_Array

Valid_min: -100.0

Valid_max: 100.0

Units: Celsius

4.6.13 version_identifiers

The contents of data word 50 of the Health and Status Data set. The SMAP Radar Health and Status Data List details the contents of this data word. The meaningful values within this word are not needed for science data processing. Thus, the Level 1A SPS does not parse these elements into distinct product elements. The Level 1A product provides these bytes for those who might want to parse these values.

version_identifiers is a one dimensional array. Each element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product.

Type: Uint32

Group: Health and Status Data

Shape: HSD_Array

Valid_min: 0

Valid_max: 4294967295

Units: n/a

4.6.14 loopback_hh

The most recent loopback measure over a 48 PRI interval from the channel that records horizontal polarization transmitted signals in the horizontal polarization receiver.

Users may wish to parse the contents of *loopback_hh*. A mantissa is stored in bits 9 through 0. An exponent is stored in bits 14 through 10. The SMAP Radar Health and Status Data List document provides the means to convert this measure into engineering units.

loopback_hh is a one dimensional array. Each element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product.

Type: Uint16

Group: Health and Status Data

Shape: HSD_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.15 loopback_vv

The most recent loopback measure over a 48 PRI interval from the channel that records vertical polarization transmitted signals in the vertical polarization receiver.

Users may wish to parse the contents of *loopback_vv*. A mantissa is stored in bits 9 through 0. An exponent is stored in bits 14 through 10. The SMAP Radar Health and Status Data List document provides the means to convert this measure into engineering units.

loopback_vv is a one dimensional array. Each element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product.

Type: Uint16

Group: Health and Status Data

Shape: HSD_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.16 echo_hh

The most recent echo measure for range bin number 1 over a 48 PRI interval from the channel that records horizontal polarization transmitted signals in the horizontal polarization receiver.

Users may wish to parse the contents of *echo_hh*. A mantissa is stored in bits 9 through 0. An exponent is stored in bits 14 through 10. The SMAP Radar Health and Status Data List document provides the means to convert this measure into engineering units.

echo_hh is a one dimensional array. Each element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product.

Type: Uint16

Group: Health and Status Data

Shape: HSD_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.17 echo_vv

The most recent echo measure for range bin number 1 over a 48 PRI interval from the channel that records vertical polarization transmitted signals in the vertical polarization receiver.

Users may wish to parse the contents of *echo_vv*. A mantissa is stored in bits 9 through 0. An exponent is stored in bits 14 through 10. The SMAP Radar Health and Status Data List document provides the means to convert this measure into engineering units.

echo_vv is a one dimensional array. Each element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product.

Type: Uint16

Group: Health and Status Data

Shape: HSD_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.18 dp_flags

The contents of data word 53 of the Health and Status Data set. The SMAP Radar Health and Status Data List details the contents of data word 53. Many of the elements in these data sets are one bit flags that are most likely not needed for science data processing. Thus, the Level 1A SPS does not parse these elements into distinct product elements. The Level 1A product provides these bytes for those who might want to parse individual flags.

dp_flags is a one dimensional array. Each element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product.

Type: Uint32

Group: Health and Status Data

Shape: HSD_Array

Valid_min: n/a

Valid_max: n/a

Units: n/a

4.6.19 hsd_frame_counter

A counter of the health and status data packets. Flight software increments this counter with each issue of a new health and status data packet.

hsd_frame_counter is a one dimensional array. Each element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product.

Type: Uint32

Group: Health and Status Data

Shape: HSD_Array

Valid_min: 0

Valid_max: 4294967295

Units: n/a

4.6.20 spacecraft_synch_time

The time of day recorded by the spacecraft clock at the instant of the One Second Time Command (OSTC).

The Time values are counts of International System (SI) seconds based on the J2000 epoch in Ephemeris Time (ET). Time counts in the J2000 epoch are equivalent to the number of Standard International (SI) compatible seconds since 11:58:55.816 on January 1, 2000 UTC.

spacecraft_synch_time is a one-dimensional array. Each element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product.

Type:	Uint32
Group:	Health and Status Data
Shape:	HSD_Array
Valid_min:	0
Valid_max:	946000000
Units:	seconds

4.6.21 radar_synch_time

The radar clock time that corresponds with the most recent One Second Time Command (OSTC) issued from the spacecraft clock. Radar clock times count seconds since the most recent instrument Power On Reset (POR).

The Time values are counts of International System (SI) seconds based on the J2000 epoch in Ephemeris Time (ET). Time counts in the J2000 epoch are equivalent to the number of Standard International (SI) compatible seconds since 11:58:55.816 on January 1, 2000 UTC.

radar_synch_time is a one-dimensional array. Each element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product.

Type:	Float64
Group:	Health and Status Data
Shape:	HSD_Array
Valid_min:	0
Valid_max:	946000000
Units:	seconds

4.6.22 radar_synch_time_utc

The radar clock time that corresponds with the most recent One Second Time Command (OSTC) issued from the spacecraft clock. Radar clock times count seconds since the most recent instrument Power On Reset (POR).

Each element of the *radar_synch_time_utc* array records the same time instant as the element with matching index in the *radar_synch_time* array. The *radar_synch_time_utc* appears as an easily interpretable character string, while the *radar_synch_time* contains the count of Standard International (SI) compatible seconds since 11:58:55.816 on January 1, 2000 UTC.

The format of the *radar_synch_time_utc* is YYYY-MM-DDThh:mm:ss.dddZ, where YYYY represents the calendar year, MM represents the month of the year and DD represents the day of the month. The character 'T' demarcates the date from the time. hh represents the hour in twenty-four hour time, mm represents the minutes, ss represents the seconds, and ddd represents thousandths of a second. The character 'Z' designates Greenwich Mean Time. All numerical fields must occupy the allotted space. If any numerical value does not require the allotted space to represent the appropriate number, the field that specifies the number must contain leading zeroes.

radar_synch_time_utc is a one-dimensional array. Each element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product.

Type:	FixLenStr
String Length:	24 characters
Group:	Health and Status Data
Shape:	HSD_Array
Valid_min:	'2014-10-31T00:00:00.000Z'
Valid_max:	'2030-12-31T23:59:60.999Z'
Units:	n/a

4.6.23 radar_synch_time_second_ticks

The number of full second time ticks recorded by the spacecraft clock when the spacecraft clock issues each One Second Time Command (OSTC). If the time correlation algorithm is functioning correctly, this number offset should always be the same with the value recorded in *spacecraft_synch_time* with the same array index.

SMAP telemetry employs two registers to record spacecraft time. One register employs 32 bits to record whole seconds since the most recent reset. A second register employs 20 bits to record subseconds. Thus, each subsecond tick is equivalent to $\frac{1}{2}^{20}$ seconds.

radar_synch_time_second_ticks is a one-dimensional array. Each element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product.

Type: Uint32

Group: Health and Status Data

Shape: HSD_Array

Valid_min: 0

Valid_max: 946000000

Units: seconds

4.6.24 radar_synch_time_subsecond_ticks

The number of subsecond time ticks recorded by the spacecraft clock when the spacecraft clock issues each One Second Time Command (OSTC). If the time correlation algorithm is operating correctly, this number should always be very close to the minimum or maximum value.

SMAP telemetry employs two registers to record spacecraft time. One register employs 32 bits to record whole seconds since the most recent reset. A second register employs 20 bits to record subseconds. Thus, each subsecond tick is equivalent to $\frac{1}{2}^{20}$ seconds.

radar_synch_time_subsecond_ticks is a one-dimensional array. Each element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock during the time period covered by the Level 1A Product.

Type: Uint32

Group: Health and Status Data

Shape: HSD_Array

Valid_min: 0

Valid_max: 1048575

Units: counts

4.6.25 loop_back_trap_time

The representative time for each set of data elements in the Loop Back Trap Data Group. Each rotation of the SMAP antenna is divided into 16 segments.

Every loop back trap record represents one of these segments in each antenna rotation. The specified time is equivalent to the begin time of the first of the 48 pulse repetition intervals in the first low resolution interval in the corresponding antenna rotation segment.

Time values are counts of International System (SI) seconds based on the J2000 epoch in Ephemeris Time (ET). Time counts in the J2000 epoch are equivalent to the number of Standard International (SI) compatible seconds since 11:58:55.816 on January 1, 2000 UTC.

loop_back_trap_time is a one-dimensional array. Each element corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Type:	Float64
Group:	Loop Back Trap Data
Shape:	LoopBackTrap_Array
Valid_min:	0
Valid_max:	946000000
Units:	seconds

4.6.26 loop_back_trap_time_utc

The representative time for each set of data elements in the Loop Back Trap Data Group. Each rotation of the SMAP antenna is divided into 16 segments. Every loop back trap record represents one of these segments in each antenna rotation. The specified time is equivalent to the begin time of the first of the 48 pulse repetition intervals in the first low resolution interval in the corresponding antenna rotation segment.

Each element of the *loop_back_trap_time_utc* array records the same time instant as the element with matching index in the *loop_back_trap_time* array. The *loop_back_trap_time_utc* appears as an easily interpretable character string, while the *loop_back_trap_time* contains the count of Standard International (SI) compatible seconds since 11:58:55.816 on January 1, 2000 UTC.

The format of the *loop_back_trap_time_utc* is YYYY-MM-DDThh:mm:ss.dddZ, where YYYY represents the calendar year, MM represents the month of the year and DD represents the day of the month. The character ‘T’ demarcates the date from the time. hh represents the hour in twenty-four hour time, mm represents the minutes, ss represents the seconds, and ddd represents thousandths of a second. The character ‘Z’ designates Greenwich Mean Time. All numerical fields must occupy the allotted space. If any numerical value does not require the allotted space to represent the appropriate number, the field that specifies the number must contain leading zeroes.

loop_back_trap_time_utc is a one-dimensional array. Each element corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Type: FixLenStr

String Length: 24 characters

Group: Loop Back Trap Data

Shape: LoopBackTrap_Array

Valid_min: '2014-10-31T00:00:00.000Z'

Valid_max: '2030-12-31T23:59:60.999Z'

Units: n/a

4.6.27 loop_back_trap_qual_flag

Bit flags that indicate the quality for each record that appears in the Loop Back Trap Data Group.

loop_back_trap_qual_flag is a one-dimensional array. Each element corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Table 19 specifies the meaning of individual bits in the *loop_back_trap_qual_flag*:

Table 19: The loop_back_trap_qual_flag

Bits	Value	Interpretation
0		**Loop Back Trap Data Quality**
	0	The corresponding loop back trap data has good or acceptable quality.
	1	The corresponding loop back trap data has poor or unacceptable quality.
1		**Bit Error Detection**
	0	No bit errors were detected in the corresponding loop back trap data element.
	1	One or more bit errors were detected in the corresponding loop back trap data element.

Bits	Value	Interpretation
2		**Horizontal polarization receiver data**
	0	Data read from horizontal polarization receiver are usable.
	1	Data read from the horizontal polarization receiver are questionable or unusable.
3		**Vertical polarization receiver data**
	0	Data read from vertical polarization receiver are usable.
	1	Data read from the vertical polarization receiver are questionable or unusable.
4		**Horizontal Polarization RFI Power Monitor**
	0	Horizontal Polarization loop back trap data not subjected to distortion due to RFI in nearby frequency bands
	1	Horizontal Polarization loop back trap data may be subjected to distortion due to RFI in nearby frequency bands
5		**Vertical Polarization RFI Power Monitor**
	0	Vertical Polarization loop back trap data not subjected to distortion due to RFI in nearby frequency bands
	1	Vertical Polarization loop back trap data may be subjected to distortion due to RFI in nearby frequency bands
6-15		**Undefined**

Type: Uint16

Group: Loop Back Trap Data

Shape: LoopBackTrap_Array

Units: n/a

4.6.28 loop_back_trap_status_flag

Bit flags that indicate the status or the mode of the data in each record that appears in the Loop Back Trap Group.

loop_back_trap_status_flag is a one dimensional array. Each element corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Table 20 specifies the meaning of individual bits in the *loop_back_trap_status_flag*:

Table 20: The loop_back_trap_status_flag

Bits	Value	Interpretation
0		**Horizontal Polarization Digital to Analog Data Processor**
	0	Horizontal Polarization Digital to Analog Data Processor is on
	1	Horizontal Polarization Digital to Analog Data Processor is Off
1		**Vertical Polarization Digital to Analog Data Processor**
	0	Vertical Polarization Digital to Analog Data Processor is On
	1	Vertical Polarization Digital to Analog Data Processor is Off
2		**Matched Load Data**
	0	Contents of this record are not matched load data
	1	Contents of this record are matched load data
3		**Correlated Noise Source (CNS)**
	0	The CNS was not active when these data were acquired
	1	The CNS was active when these data were acquired
4		**Canned data**
	0	Contents of this record are not canned data

Bits	Value	Interpretation
	1	Contents of this record are canned data
5		**Nominal Canned Data Values**
	0	The set of canned data samples in the current antenna revolution have nominal values.
	1	The set of canned data samples in the current antenna revolution do not have nominal values.
6-7		**Undefined**

Type: Uint8

Group: Loop Back Trap Data

Shape: LoopBackTrap_Array

Units: n/a

4.6.29 rev_loop_back_trap

The value of the *revolution_counter* in the Revolution Data Group that corresponds to the antenna revolution when the corresponding loop back trap data element was acquired.

rev_loop_back_trap is a one-dimensional array. Each element corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Type: Uint16

Group: Loop Back Trap Data

Shape: LoopBackTrap_Array

Valid_min: 0

Valid_max: 65535

Units: counts

4.6.30 rev_segment_loop_back_trap

The index of the segment within the current revolution when the corresponding loop back trap data element was acquired.

rev_segment loop_back_trap is a one-dimensional array. Each element corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Type: Uint8

Group: Loop Back Trap Data

Shape: LoopBackTrap_Array

Valid_min: 0

Valid_max: 15

Units: n/a

4.6.31 loop_back_noise_only_h_dn

The sum of the squares of the I component and the Q component of the detected horizontal polarization loop back leakage into the noise only channel represented as a telemetry data number. Flight software collects these data over the last PRI of the 48 PRIs within the first low resolution data set within each antenna rotation segment.

loop_back_noise_only_h_dn is a one-dimensional array. Each element corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Type: Uint16

Group: Loop Back Trap Data

Shape: LoopBackTrap_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.32 loop_back_noise_only_v_dn

The sum of the squares of the I component and the Q component of the detected vertical polarization loop back leakage into the noise only channel represented as a telemetry data number. Flight software collects these data over the last PRI of the 48 PRIs within the first low resolution data set within each antenna rotation segment.

loop_back_noise_only_v_dn is a one-dimensional array. Each element corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Type:	Uint16
Group:	Loop Back Trap Data
Shape:	LoopBackTrap_Array
Valid_min:	0
Valid_max:	65535
Units:	n/a

4.6.33 loop_back_prime_hh_dn

Loop back power of horizontal polarization pulses detected in the horizontal polarization receiver before passage through the digital filter as a telemetry data number. These data are collected over the final low resolution interval in each segment of each antenna rotation. The *loop_back_prime_hh_dn* value reflects the power detected in the previous segment.

loop_back_prime_hh_dn is a one-dimensional array. Each element corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Type:	Uint16
Group:	Loop Back Trap Data
Shape:	LoopBackTrap_Array
Valid_min:	0
Valid_max:	65535
Units:	n/a

4.6.34 loop_back_prime_vv_dn

Loop back power of vertical polarization pulses detected in the vertical polarization receiver before passage through the digital filter as a telemetry data number. These data are collected over the final low resolution interval in each segment of each antenna rotation. The *loop_back_prime_vv_dn* value reflects the power detected in the previous segment.

loop_back_prime_vv_dn is a one-dimensional array. Each element corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Type:	Uint16

Group: Loop Back Trap Data

Shape: LoopBackTrap_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.35 dc_offset_hh_dn

The mean of the direct current offset for the HH channel collected over 16,000 samples at the completion of each segment in each antenna revolution.

dc_offset_hh_dn is a one-dimensional array. Each element corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Type: Uint16

Group: Loop Back Trap Data

Shape: LoopBackTrap_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.36 dc_offset_vv_dn

The mean of the direct current offset for the VV channel collected over 16,000 samples at the completion of each segment in each antenna revolution.

dc_offset_vv_dn is a one-dimensional array. Each element corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Type: Uint16

Group: Loop Back Trap Data

Shape: LoopBackTrap_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.37 loop_back_trap_hh_i_dn

A set of samples that display the transmit wave form represented in telemetry data numbers. *loop_back_trap_hh_i_dn* contains the wave form of the I component of transmitted horizontal polarization pulses that are detected by the horizontal polarization receiver.

loop_back_trap_hh_i_dn is a two-dimensional array. The slower moving array index corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. The faster moving array index corresponds to each of the 21 samples that cover the width of the transmit pulse.

Type: Uint16

Group: Loop Back Trap Data

Shape: LoopBackTrap_LBTSamples_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.38 loop_back_trap_hh_q_dn

A set of samples that display the transmit wave form represented in telemetry data numbers. *loop_back_trap_hh_q_dn* contains the wave form of the Q component of transmitted horizontal polarization pulses that are detected by the horizontal polarization receiver.

loop_back_trap_hh_q_dn is a two-dimensional array. The slower moving array index corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. The faster moving array index corresponds to each of the 21 samples that cover the width of the transmit pulse.

Type: Uint16

Group: Loop Back Trap Data

Shape: LoopBackTrap_LBTSamples_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.39 loop_back_trap_vh_i_dn

A set of samples that display the transmit wave form represented in telemetry data numbers. *loop_back_trap_vh_i_dn* contains the wave form of the I component of transmitted horizontal polarization pulses that are detected by the vertical polarization receiver.

loop_back_trap_vh_i_dn is a two-dimensional array. The slower moving array index corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. The faster moving array index corresponds to each of the 21 samples that cover the width of the transmit pulse.

Type: Uint16

Group: Loop Back Trap Data

Shape: LoopBackTrap_LBTSamples_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.40 loop_back_trap_vh_q_dn

A set of samples that display the transmit wave form represented in telemetry data numbers. *loop_back_trap_vh_q_dn* contains the wave form of the Q component of transmitted horizontal polarization pulses that are detected by the vertical polarization receiver.

loop_back_trap_vh_q_dn is a two-dimensional array. The slower moving array index corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. The faster moving array index corresponds to each of the 21 samples that cover the width of the transmit pulse.

Type: Uint16

Group: Loop Back Trap Data

Shape: LoopBackTrap_LBTSamples_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.41 loop_back_trap_hv_i_dn

A set of samples that display the transmit wave form represented in telemetry data numbers. *loop_back_trap_hv_i_dn* contains the wave form of the I component of transmitted vertical polarization pulses that are detected by the horizontal polarization receiver.

loop_back_trap_hv_i_dn is a two-dimensional array. The slower moving array index corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. The faster moving array index corresponds to each of the 21 samples that cover the width of the transmit pulse.

Type: Uint16

Group: Loop Back Trap Data

Shape: LoopBackTrap_LBTSamples_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.42 loop_back_trap_hv_q_dn

A set of samples that display the transmit wave form represented in telemetry data numbers. *loop_back_trap_hv_q_dn* contains the wave form of the Q component of transmitted vertical polarization pulses that are detected by the horizontal polarization receiver.

loop_back_trap_hv_q_dn is a two-dimensional array. The slower moving array index corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. The faster moving array index corresponds to each of the 21 samples that cover the width of the transmit pulse.

Type: Uint16

Group: Loop Back Trap Data

Shape: LoopBackTrap_LBTSamples_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.43 loop_back_trap_vv_i_dn

A set of samples that display the transmit wave form represented in telemetry data numbers. *loop_back_trap_vv_i_dn* contains the wave form of the I component of transmitted vertical polarization pulses that are detected by the vertical polarization receiver.

loop_back_trap_vv_i_dn is a two-dimensional array. The slower moving array index corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. The faster moving array index corresponds to each of the 21 samples that cover the width of the transmit pulse.

Type: Uint16

Group: Loop Back Trap Data

Shape: LoopBackTrap_LBTSamples_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.44 loop_back_trap_vv_q_dn

A set of samples that display the transmit wave form represented in telemetry data numbers. *loop_back_trap_vv_q_dn* contains the wave form of the Q component of transmitted vertical polarization pulses that are detected by the vertical polarization receiver.

loop_back_trap_vv_q_dn is a two-dimensional array. The slower moving array index corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. The faster moving array index corresponds to each of the 21 samples that cover the width of the transmit pulse.

Type: Uint16

Group: Loop Back Trap Data

Shape: LoopBackTrap_LBTSamples_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.45 loop_back_noise_only_h_eu

The sum of the squares of the I component and the Q component of the detected horizontal polarization loop back leakage into the noise only channel represented in engineering data units. Flight software collects these data over the last PRI of the 48 PRIs within the first low resolution data set within each antenna rotation segment.

loop_back_noise_only_h_eu is a one-dimensional array. Each element corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Type:	Float32
Group:	Loop Back Trap Data
Shape:	LoopBackTrap_Array
Valid_min:	-90.0
Valid_max:	40.0
Units:	dBm

4.6.46 loop_back_noise_only_v_eu

The sum of the squares of the I component and the Q component of the detected vertical polarization loop back leakage into the noise only channel represented in engineering data units. Flight software collects these data over the last PRI of the 48 PRIs within the first low resolution data set within each antenna rotation segment.

loop_back_noise_only_v_eu is a one-dimensional array. Each element corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Type:	Float32
Group:	Loop Back Trap Data
Shape:	LoopBackTrap_Array
Valid_min:	-90.0
Valid_max:	40.0
Units:	dBm

4.6.47 loop_back_prime_hh_eu

Loop back power horizontal polarization pulses detected in the horizontal polarization receiver before passage through the digital filter in engineering units. These data are collected over the final low resolution interval in each segment of each antenna rotation. The *loop_back_prime_hh_eu* value reflects the power detected in the previous segment.

loop_back_prime_hh_eu is a one-dimensional array. Each element corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Type: Float32

Group: Loop Back Trap Data

Shape: LoopBackTrap_Array

Valid_min: -115.0

Valid_max: 20.0

Units: dBm

4.6.48 loop_back_prime_vv_eu

Loop back power vertical polarization pulses detected in the vertical polarization receiver before passage through the digital filter in engineering units. These data are collected over the final low resolution interval in each segment of each antenna rotation. The *loop_back_prime_vv_eu* value reflects the power detected in the previous segment.

loop_back_prime_vv_eu is a one-dimensional array. Each element corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Type: Float32

Group: Loop Back Trap Data

Shape: LoopBackTrap_Array

Valid_min: -115.0

Valid_max: 20.0

Units: dBm

4.6.49 loop_back_trap_hh_i_eu

A set of samples that display the transmit wave form represented in engineering units. *loop_back_trap_hh_i_eu* contains the wave form of the I component of transmitted horizontal polarization pulses that are detected by the horizontal polarization receiver.

loop_back_trap_hh_i_eu is a two-dimensional array. The slower moving array index corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. The faster moving array index corresponds to each of the 21 samples that cover the width of the transmit pulse.

Type:	Float32
Group:	Loop Back Trap Data
Shape:	LoopBackTrap_LBTSamples_Array
Valid_min:	-2.0
Valid_max:	2.0
Units:	volts

4.6.50 loop_back_trap_hh_q_eu

A set of samples that display the transmit wave form represented in engineering units. *loop_back_trap_hh_q_eu* contains the wave form of the Q component of transmitted horizontal polarization pulses that are detected by the horizontal polarization receiver.

loop_back_trap_hh_q_eu is a two-dimensional array. The slower moving array index corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. The faster moving array index corresponds to each of the 21 samples that cover the width of the transmit pulse.

Type:	Float32
Group:	Loop Back Trap Data
Shape:	LoopBackTrap_LBTSamples_Array
Valid_min:	-2.0
Valid_max:	2.0
Units:	volts

4.6.51 loop_back_trap_vh_i_eu

A set of samples that display the transmit wave form represented in engineering units. *loop_back_trap_vh_i_eu* contains the wave form of the I component of transmitted horizontal polarization pulses that are detected by the vertical polarization receiver.

loop_back_trap_vh_i_eu is a two-dimensional array. The slower moving array index corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. The faster moving array index corresponds to each of the 21 samples that cover the width of the transmit pulse.

Type: Float32

Group: Loop Back Trap Data

Shape: LoopBackTrap_LBTSamples_Array

Valid_min: -2.0

Valid_max: 2.0

Units: volts

4.6.52 loop_back_trap_vh_q_eu

A set of samples that display the transmit wave form represented in engineering units. *loop_back_trap_vh_q_eu* contains the wave form of the Q component of transmitted horizontal polarization pulses that are detected by the vertical polarization receiver.

loop_back_trap_vh_q_eu is a two-dimensional array. The slower moving array index corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. The faster moving array index corresponds to each of the 21 samples that cover the width of the transmit pulse.

Type: Float32

Group: Loop Back Trap Data

Shape: LoopBackTrap_LBTSamples_Array

Valid_min: -2.0

Valid_max: 2.0

Units: volts

4.6.53 loop_back_trap_hv_i_eu

A set of samples that display the transmit wave form represented in engineering units. *loop_back_trap_hv_i_eu* contains the wave form of the I component of transmitted vertical polarization pulses that are detected by the horizontal polarization receiver.

loop_back_trap_hv_i_eu is a two-dimensional array. The slower moving array index corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

The faster moving array index corresponds to each of the 21 samples that cover the width of the transmit pulse.

Type: Float32

Group: Loop Back Trap Data

Shape: LoopBackTrap_LBTSamples_Array

Valid_min: -2.0

Valid_max: 2.0

Units: volts

4.6.54 loop_back_trap_hv_q_eu

A set of samples that display the transmit wave form represented in engineering units. *loop_back_trap_hv_q_eu* contains the wave form of the Q component of transmitted vertical polarization pulses that are detected by the horizontal polarization receiver.

loop_back_trap_hv_q_eu is a two-dimensional array. The slower moving array index corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. The faster moving array index corresponds to each of the 21 samples that cover the width of the transmit pulse.

Type: Float32

Group: Loop Back Trap Data

Shape: LoopBackTrap_LBTSamples_Array

Valid_min: -2.0

Valid_max: 2.0

Units: volts

4.6.55 loop_back_trap_vv_i_eu

A set of samples that display the transmit wave form represented in engineering units. *loop_back_trap_vv_i_eu* contains the wave form of the I component of transmitted vertical polarization pulses that are detected by the vertical polarization receiver.

loop_back_trap_vv_i_eu is a two-dimensional array. The slower moving array index corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. The faster moving array index corresponds to each of the 21 samples that cover the width of the transmit pulse.

Type: Float32

Group: Loop Back Trap Data

Shape: LoopBackTrap_LBTSamples_Array

Valid_min: -2.0

Valid_max: 2.0

Units: volts

4.6.56 loop_back_trap_vv_q_eu

A set of samples that display the transmit wave form represented in engineering units. *loop_back_trap_vv_q_eu* contains the wave form of the Q component of transmitted vertical polarization pulses that are detected by the vertical polarization receiver.

loop_back_trap_vv_q_eu is a two-dimensional array. The slower moving array index corresponds to one of the 16 segments within each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. The faster moving array index corresponds to each of the 21 samples that cover the width of the transmit pulse.

Type: Float32

Group: Loop Back Trap Data

Shape: LoopBackTrap_LBTSamples_Array

Valid_min: -2.0

Valid_max: 2.0

Units: volts

4.6.57 low_res_time

The beginning time for each set of data elements in the Low Resolution Data Group. The specified time is equivalent to the begin time of the first of the 48 pulse repetition intervals that comprise each low resolution backscatter measure. Time values are counts of International System (SI) seconds based on the J2000 epoch in Ephemeris Time (ET). Time counts in the J2000 epoch are equivalent to the number of Standard International (SI) compatible seconds since 11:58:55.816 on January 1, 2000 UTC.

low_res_time is a one-dimensional array. Each array element corresponds to one set of 48 pulse repetition intervals (PRI) that comprise an element in the Low Resolution Data in the Radar Level 1A Product.

Type: Float64

Group: Low Resolution Data

Shape: LoRes_Array

Valid_min: 0

Valid_max: 946000000

Units: seconds

4.6.58 low_res_time_utc

The beginning time time for each set of data elements in the Low Resolution Data Group. The specified time is equivalent to the begin time of the first of the 48 pulse repetition intervals that comprise each low resolution backscatter measure.

Each element of the *low_res_time_utc* array records the same time instant as the element with matching index in the *low_res_time* array. The low*_res_time_utc* appears as an easily interpretable character string, while the *low_res_time* contains the count of Standard International (SI) compatible seconds since 11:58:55.816 on January 1, 2000 UTC.

The format of the *low_res_time_utc* is YYYY-MM-DDThh:mm:ss.dddZ, where YYYY represents the calendar year, MM represents the month of the year and DD represents the day of the month. The character ‘T’ demarcates the date from the time. hh represents the hour in twenty-four hour time, mm represents the minutes, ss represents the seconds, and ddd represents thousandths of a second. The character ‘Z’ designates Greenwich Mean Time. All numerical fields must occupy the allotted space. If any numerical value does not require the allotted space to represent the appropriate number, the field that specifies the number must contain leading zeroes.

low_res_time_utc is a one-dimensional array. Each array element corresponds to one set of 48 pulse repetition intervals (PRI) that comprise an element in the Low Resolution Data in the Radar Level 1A Product.

Type: FixLenStr

String Length: 24 characters

Group: Low Resolution Data

Shape: LoRes_Array

Valid_min: ‘2014-10-31T00:00:00.000Z’

Valid_max: ‘2030-12-31T23:59:60.999Z’

Units: n/a

4.6.59 low_res_qual_flag

Bit flags that indicate the quality of the real aperture radar data for each record that appears in the Low Resolution Group.

low_res_qual_flag is a one dimensional array. Each array element corresponds to one set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. Low Resolution Data elements with matching array indices represent the same record.

Table 21 specifies the meaning of individual bits in the *low_res_qual_flag*:

Table 21: The low_res_qual_flag

Bits	Value	Interpretation
0		**Low Resolution Packet Quality**
	0	The corresponding low resolution data has good or acceptable quality.
	1	The corresponding low resolution data has poor or unacceptable quality.
1		**Bit Error Detection**
	0	No bit errors were detected in the corresponding low resolution data element.
	1	One or more bit errors were detected in the corresponding low resolution data element.
2		**Horizontal polarization receiver data**
	0	Data read from horizontal polarization receiver are usable.
	1	Data read from the horizontal polarization receiver are questionable or unusable.
3		**Vertical polarization receiver data**
	0	Data read from vertical polarization receiver are usable.
	1	Data read from the vertical polarization receiver are questionable or unusable.
4		**Horizontal Polarization RFI Power Monitor**
	0	Horizontal Polarization low resolution data not subjected

Bits	Value	Interpretation
		to distortion due to RFI in nearby frequency bands
	1	Horizontal Polarization low resolution data may be subjected to distortion due to RFI in nearby frequency bands
5		**Vertical Polarization RFI Power Monitor**
	0	Vertical Polarization low resolution data not subjected to distortion due to RFI in nearby frequency bands
	1	Vertical Polarization low resolution data may be subjected to distortion due to RFI in nearby frequency bands
6-15		**Undefined**

Type: Uint16

Group: Low Resolution Data

Shape: LoRes_Array

Units: n/a

4.6.60 low_res_status_flag

Bit flags that indicate the status or the mode of the real aperture radar data for each record that appears in the Low Resolution Group.

low_res_status_flag is a one dimensional array. Each array element corresponds to one set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. Low Resolution Data elements with matching array indices represent the same record.

Table 22 specifies the meaning of individual bits in the *low_res_status_flag*:

Table 22: The low_res_status_flag

Bits	Value	Interpretation
0		**Horizontal Polarization Digital to Analog Data Processor**
	0	Horizontal Polarization Digital to Analog Data Processor is

Bits	Value	Interpretation
		on
	1	Horizontal Polarization Digital to Analog Data Processor is Off
1		**Vertical Polarization Digital to Analog Data Processor**
	0	Vertical Polarization Digital to Analog Data Processor is On
	1	Vertical Polarization Digital to Analog Data Processor is Off
2		**Matched Load Data**
	0	Contents of this record are not matched load data
	1	Contents of this record are matched load data
3		**Correlated Noise Source (CNS)**
	0	The CNS was not active when these data were acquired
	1	The CNS was active when these data were acquired
4		**Canned data**
	0	Contents of this record are not canned data
	1	Contents of this record are canned data
5		**Nominal Canned Data Values**
	0	The set of canned data samples in the current antenna revolution have nominal values.
	1	The set of canned data samples in the current antenna revolution do not have nominal values.
6		**Receive Only Mode**
	0	Radar is operating in receive-transmit mode
	1	Radar is operating in receive only mode

Bits	Value	Interpretation
7		**Undefined**

Type: Uint8

Group: Low Resolution Data

Shape: LoRes_Array

Units: n/a

4.6.61 low_res_interval

A counter of low resolution intervals that appear within the current antenna revolution.

low_res_interval is a one-dimensional array. Each array element corresponds to one set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. Low Resolution Data elements with matching array indices represent the same record.

Type: Uint16

Group: Low Resolution Data

Shape: LoRes_Array

Valid_min: 0

Valid_max: 511

Units: n/a

4.6.62 rev_lores

rev_lores matches the value of the *revolution_counter* in the Revolution Data Group that corresponds to the antenna revolution when the corresponding low resolution data element was acquired.

rev_lores is a one-dimensional array. Each array element corresponds to one set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. Low Resolution Data elements with matching array indices represent the same record.

Type: Uint16

Group: Low Resolution Data

Shape: LoRes_Array

Valid_min: 0

Valid_max: 65535

Units: counts

4.6.63 rev_segment_lores

The index of the segment within the current revolution when the corresponding low resolution data element was acquired.

rev_segment lores is a one-dimensional array. Each array element corresponds to one set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. Low Resolution Data elements with matching array indices represent the same record.

Type: Uint8

Group: Low Resolution Data

Shape: LoRes_Array

Valid_min: 0

Valid_max: 15

Units: n/a

4.6.64 num_lores_bins

The number of range bins that are used to represent the full real aperture backscatter data in each low resolution data record. The effective Pulse Repetition Interval (PRI) at the time of acquisition determines the number of range bins in use. Since the maximum number of range bins is 13, the Level 1A Product always allocates space for 13 range bins. Counting from the first bin, the value of *num_lores_bins* determines how many array elements that represent range bins have valid data in the corresponding record. Working with software that employs zero-based indices, users should not employ range bins with indices greater than or equal to *num_lores_bins*. Working with software the employs one-based indices, users should not employ range bins with indices greater than *num_lores_bins*.

num_lores_bins is a one-dimensional array. Each array element corresponds to one set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. Low Resolution Data elements with matching array indices represent the same record.

Type: Uint8

Group: Low Resolution Data

Shape: LoRes_Array

Valid_min: 0

Valid_max: 13

Units: n/a

4.6.65 loop_back_hh_dn

The mean loop back measure over the 48 pulse repetition intervals that comprise a single low resolution data record represented as data number from the radar telemetry. The *loop_back_hh_dn* measure employs transmitted horizontal polarization pulses that are transferred directly to the horizontal polarization receiver through a known level of attenuation. These data provide a means to assess the product of the transmit power (P_t) and the receiver gain (R_g) for the HH channel.

loop_back_hh_dn is a one-dimensional array. Each array element corresponds to one set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. Low Resolution Data elements with matching array indices represent the same record.

Type: Uint16

Group: Low Resolution Data

Shape: LoRes_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.66 loop_back_vh_dn

The mean loop back measure over the 48 pulse repetition intervals that comprise a single low resolution data record represented as data number from the radar telemetry. The *loop_back_vh_dn* measure employs transmitted horizontal polarization pulses that are transferred directly to the vertical polarization receiver through a known level of attenuation. These data provide a means to assess the product of the transmit power (P_t) and the receiver gain (R_g) for the VH channel.

loop_back_vh_dn is a one-dimensional array. Each array element corresponds to one set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. Low Resolution Data elements with matching array indices represent the same record.

Type: Uint16

Group: Low Resolution Data

Shape: LoRes_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.67 loop_back_hv_dn

The mean loop back measure over the 48 pulse repetition intervals that comprise a single low resolution data record represented as data number from the radar telemetry. The *loop_back_hv_dn* measure employs transmitted vertical polarization pulses that are transferred directly to the horizontal polarization receiver through a known level of attenuation. These data provide a means to assess the product of the transmit power (P_t) and the receiver gain (R_g) for the HV channel.

loop_back_hv_dn is a one-dimensional array. Each array element corresponds to one set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. Low Resolution Data elements with matching array indices represent the same record.

Type: Uint16

Group: Low Resolution Data

Shape: LoRes_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.68 loop_back_vv_dn

The mean loop back measure over the 48 pulse repetition intervals that comprise a single low resolution data record represented as data number from the radar telemetry. The *loop_back_vv_dn* measure employs transmitted vertical polarization pulses that are transferred directly to the vertical polarization receiver through a known level of attenuation. These data provide a means to assess the product of the transmit power (P_t) and the receiver gain (R_g) for the VV channel.

loop_back_vv_dn is a one-dimensional array. Each array element corresponds to one set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. Low Resolution Data elements with matching array indices represent the same record.

Type: Uint16

Group: Low Resolution Data

Shape: LoRes_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.69 noise_only_h_i_dn

The I component of the detected horizontal polarization power with a frequency that falls between the receive windows for the horizontal polarization channel and the vertical polarization channel represented as a telemetry data number.

noise_only_h_i_dn is a two-dimensional array. The slower moving array index corresponds to each set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. The faster moving array index corresponds to each of the 48 PRIs that comprise the low resolution data record.

Type: Uint16

Group: Low Resolution Data

Shape: LoRes_PRI_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.70 noise_only_h_q_dn

The Q component of the detected horizontal polarization power with a frequency that falls between the receive windows for the horizontal polarization channel and the vertical polarization channel represented as a telemetry data number.

noise_only_h_q_dn is a two-dimensional array. The slower moving array index corresponds to each set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. The faster moving array index corresponds to each of the 48 PRIs that comprise the low resolution data record.

Type: Uint16

Group: Low Resolution Data

Shape: LoRes_PRI_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.71 noise_only_h_sum_dn

The sum of the squares of the I component and the Q component of the detected horizontal polarization power with a frequency that falls between the receive windows for the horizontal polarization channel and the vertical polarization channel represented as a telemetry data number.

noise_only_h_sum_dn is a two-dimensional array. The slower moving array index corresponds to each set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. The faster moving array index corresponds to each of the 48 PRIs that comprise the low resolution data record.

Type: Uint16

Group: Low Resolution Data

Shape: LoRes_PRI_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.72 noise_only_v_i_dn

The I component of the detected vertical polarization power with a frequency that falls between the receive windows for the horizontal polarization channel and the vertical polarization channel represented as a telemetry data number.

noise_only_v_i_dn is a two-dimensional array. The slower moving array index corresponds to each set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. The faster moving array index corresponds to each of the 48 PRIs that comprise the low resolution data record.

Type: Uint16

Group: Low Resolution Data

Shape: LoRes_PRI_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.73 noise_only_v_q_dn

The Q component of the detected vertical polarization power with a frequency that falls between the receive windows for the horizontal polarization channel and the vertical polarization channel represented as a telemetry data number.

noise_only_v_q_dn is a two-dimensional array. The slower moving array index corresponds to each set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. The faster moving array index corresponds to each of the 48 PRIs that comprise the low resolution data record.

Type: Uint16

Group: Low Resolution Data

Shape: LoRes_PRI_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.74 noise_only_v_sum_dn

The sum of the squares of the I component and the Q component of the detected vertical polarization power with a frequency that falls between the receive windows for the horizontal polarization channel and the vertical polarization channel represented as a telemetry data number.

noise_only_v_sum_dn is two-dimensional array. The slower moving array index corresponds to each set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. The faster moving array index corresponds to each of the 48 PRIs that comprise the low resolution data record.

Type: Uint16

Group: Low Resolution Data

Shape: LoRes_PRI_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.75 pulse_hh_dn

Real aperture radar backscatter measure for each range bin in the each resolution data set represented as a telemetry data number. *pulse_hh_dn* contains backscatter measure of the transmitted horizontal polarization pulses that are detected in the horizontal polarization receiver.

pulse_hh_dn is two-dimensional array. The slower moving array index corresponds to each set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. The faster moving array index corresponds to each range bin. The data element *num_lores_bins* with the matching slower dimension index specifies the number of range bins in the corresponding low resolution data record that contain valid data.

Type:	Uint16
Group:	Low Resolution Data
Shape:	LoRes_LoResBin_Array
Valid_min:	0
Valid_max:	65535
Units:	n/a

4.6.76 pulse_hv_dn

Real aperture radar backscatter measure for each range bin in the each resolution data set represented as a telemetry data number. *pulse_hv_dn* contains backscatter measure of the transmitted vertical polarization pulses that are detected in the horizontal polarization receiver.

pulse_hv_dn is two-dimensional array. The slower moving array index corresponds to each set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. The faster moving array index corresponds to each range bin. The data element *num_lores_bins* with the matching slower dimension index specifies the number of range bins in the corresponding low resolution data record that contain valid data.

Type:	Uint16
Group:	Low Resolution Data
Shape:	LoRes_LoResBin_Array
Valid_min:	0
Valid_max:	65535
Units:	n/a

4.6.77 pulse_vh_dn

Real aperture radar backscatter measure for each range bin in the each resolution data set represented as a telemetry data number. *pulse_vh_dn* contains backscatter measure of the transmitted horizontal polarization pulses that are detected in the vertical polarization receiver.

pulse_vh_dn is two-dimensional array. The slower moving array index corresponds to each set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. The faster moving array index corresponds to each range bin. The data element *num_lores_bins* with the matching slower dimension index specifies the number of range bins in the corresponding low resolution data record that contain valid data.

Type: Uint16

Group: Low Resolution Data

Shape: LoRes_LoResBin_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.78 pulse_vv_dn

Real aperture radar backscatter measure for each range bin in the each resolution data set represented as a telemetry data number. *pulse_vv_dn* contains backscatter measure of the transmitted vertical polarization pulses that are detected in the vertical polarization receiver.

pulse_vv_dn is two-dimensional array. The slower moving array index corresponds to each set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. The faster moving array index corresponds to each range bin. The data element *num_lores_bins* with the matching slower dimension index specifies the number of range bins in the correspoding low resolution data record that contain valid data.

Type: Uint16

Group: Low Resolution Data

Shape: LoRes_LoResBin_Array

Valid_min: 0

Valid_max: 65535

Units: n/a

4.6.79 loop_back_hh_eu

The mean loop back measure over the 48 pulse repetition intervals that comprise a single low resolution data record represented in engineering units. The *loop_back_hh_eu* measure employs transmitted horizontal polarization pulses that are transferred directly to the horizontal polarization receiver through a known level of attenuation. These data provide a means to assess the product of the transmit power (P_t) and the receiver gain (R_g) for the HH channel.

loop_back_hh_eu is a one-dimensional array. Each array element corresponds to one set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. Low Resolution Data elements with matching array indices represent the same record.

Type: Float32

Group: Low Resolution Data

Shape: LoRes_Array

Valid_min: -110.0

Valid_max: 20.0

Units: dBm

4.6.80 loop_back_vh_eu

The mean loop back measure over the 48 pulse repetition intervals that comprise a single low resolution data record represented in engineering units. The *loop_back_vh_eu* measure employs transmitted horizontal polarization pulses that are transferred directly to the vertical polarization receiver through a known level of attenuation. These data provide a means to assess the product of the transmit power (P_t) and the receiver gain (R_g) for the VH channel.

loop_back_vh_eu is a one-dimensional array. Each array element corresponds to one set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. Low Resolution Data elements with matching array indices represent the same record.

Type: Float32

Group: Low Resolution Data

Shape: LoRes_Array

Valid_min: -110.0

Valid_max: 20.0

Units: dBm

4.6.81 loop_back_hv_eu

The mean loop back measure over the 48 pulse repetition intervals that comprise a single low resolution data record represented in engineering units. The *loop_back_hv_eu* measure employs transmitted vertical polarization pulses that are transferred directly to the horizontal polarization receiver through a known level of attenuation. These data provide a means to assess the product of the transmit power (P_t) and the receiver gain (R_g) for the HV channel.

loop_back_hv_eu is a one-dimensional array. Each array element corresponds to one set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. Low Resolution Data elements with matching array indices represent the same record.

Type: Float32

Group: Low Resolution Data

Shape: LoRes_Array

Valid_min: -110.0

Valid_max: 20.0

Units: dBm

4.6.82 loop_back_vv_eu

The mean loop back measure over the 48 pulse repetition intervals that comprise a single low resolution data record represented in engineering units. The *loop_back_vv_eu* measure employs transmitted vertical polarization pulses that are transferred directly to the vertical polarization receiver through a known level of attenuation. These data provide a means to assess the product of the transmit power (P_t) and the receiver gain (R_g) for the VV channel.

loop_back_vv_eu is a one-dimensional array. Each array element corresponds to one set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. Low Resolution Data elements with matching array indices represent the same record.

Type: Float32

Group: Low Resolution Data

Shape: LoRes_Array

Valid_min: -110.0

Valid_max: 20.0

Units: dBm

4.6.83 noise_only_h_i_eu

The I component of the detected horizontal polarization power with a frequency that falls between the receive windows for the horizontal polarization channel and the vertical polarization channel represented in engineering units.

noise_only_h_i_eu is a two-dimensional array. The slower moving array index corresponds to each set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. The faster moving array index corresponds to each of the 48 PRIs that comprise the low resolution data record.

Type:	Float32
Group:	Low Resolution Data
Shape:	LoRes_PRI_Array
Valid_min:	-99999.9
Valid_max:	99999.9
Units:	volts

4.6.84 noise_only_h_q_eu

The Q component of the detected horizontal polarization power with a frequency that falls between the receive windows for the horizontal polarization channel and the vertical polarization channel represented in engineering units.

noise_only_h_q_eu is a two-dimensional array. The slower moving array index corresponds to each set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. The faster moving array index corresponds to each of the 48 PRIs that comprise the low resolution data record.

Type:	Float32
Group:	Low Resolution Data
Shape:	LoRes_PRI_Array
Valid_min:	-99999.9
Valid_max:	99999.9
Units:	volts

4.6.85 noise_only_h_sum_eu

The sum of the squares of the I component and the Q component of the detected horizontal polarization power with a frequency that falls between the receive windows for the horizontal polarization channel and the vertical polarization channel represented in engineering units.

noise_only_h_sum_eu is a two-dimensional array. The slower moving array index corresponds to each set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. The faster moving array index corresponds to each of the 48 PRIs that comprise the low resolution data record.

Type: Float32

Group: Low Resolution Data

Shape: LoRes_PRI_Array

Valid_min: -99999.9

Valid_max: 99999.9

Units: dBm

4.6.86 noise_only_v_i_eu

The I component of the detected vertical polarization power with a frequency that falls between the receive windows for the horizontal polarization channel and the vertical polarization channel represented in engineering units.

noise_only_v_i_eu is a two-dimensional array. The slower moving array index corresponds to each set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. The faster moving array index corresponds to each of the 48 PRIs that comprise the low resolution data record.

Type: Float32

Group: Low Resolution Data

Shape: LoRes_PRI_Array

Valid_min: -99999.9

Valid_max: 99999.9

Units: volts

4.6.87 noise_only_v_q_eu

The Q component of the detected vertical polarization power with a frequency that falls between the receive windows for the horizontal polarization channel and the vertical polarization channel represented in engineering units.

noise_only_v_q_eu is a two-dimensional array. The slower moving array index corresponds to each set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. The faster moving array index corresponds to each of the 48 PRIs that comprise the low resolution data record.

Type:	Float32
Group:	Low Resolution Data
Shape:	LoRes_PRI_Array
Valid_min:	-99999.9
Valid_max:	99999.9
Units:	volts

4.6.88 noise_only_v_sum_eu

The sum of the squares of the I component and the Q component of the detected vertical polarization power with a frequency that falls between the receive windows for the horizontal polarization channel and the vertical polarization channel represented in engineering units.

noise_only_v_sum_eu is a two-dimensional array. The slower moving array index corresponds to each set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. The faster moving array index corresponds to each of the 48 PRIs that comprise the low resolution data record.

Type:	Float32
Group:	Low Resolution Data
Shape:	LoRes_PRI_Array
Valid_min:	-99999.9
Valid_max:	99999.9
Units:	dBm

4.6.89 pulse_hh_eu

Real aperture radar backscatter measure for each range bin in the each resolution data set represented in engineering units. *pulse_hh_eu* contains backscatter measure of the transmitted horizontal polarization pulses that are detected in the horizontal polarization receiver.

pulse_hh_eu is two-dimensional array. The slower moving array index corresponds to each set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. The faster moving array index corresponds to each range bin. The data element *num_lores_bins* with the matching slower dimension index specifies the number of range bins in the corresponding low resolution data record that contain valid data.

Type:	Float32
Group:	Low Resolution Data
Shape:	LoRes_LoResBin_Array
Valid_min:	-99999.9
Valid_max:	99999.9
Units:	dBm

4.6.90 pulse_hv_eu

Real aperture radar backscatter measure for each range bin in the each resolution data set represented in engineering units. *pulse_hv_eu* contains backscatter measure of the transmitted vertical polarization pulses that are detected in the horizontal polarization receiver.

pulse_hv_eu is two-dimensional array. The slower moving array index corresponds to each set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. The faster moving array index corresponds to each range bin. The data element *num_lores_bins* with the matching slower dimension index specifies the number of range bins in the corresponding low resolution data record that contain valid data.

Type:	Float32
Group:	Low Resolution Data
Shape:	LoRes_LoResBin_Array
Valid_min:	-99999.9
Valid_max:	99999.9
Units:	dBm

4.6.91 pulse_vh_eu

Real aperture radar backscatter measure for each range bin in the each resolution data set represented in engineering units. *pulse_vh_eu* contains backscatter measure of the transmitted horizontal polarization pulses that are detected in the vertical polarization receiver.

pulse_vh_eu is two-dimensional array. The slower moving array index corresponds to each set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. The faster moving array index corresponds to each range bin. The data element *num_lores_bins* with the matching slower dimension index specifies the number of range bins in the corresponding low resolution data record that contain valid data.

Type:	Float32
Group:	Low Resolution Data
Shape:	LoRes_LoResBin_Array
Valid_min:	-99999.9
Valid_max:	99999.9
Units:	dBm

4.6.92 pulse_vv_eu

Real aperture radar backscatter measure for each range bin in the each resolution data set represented in engineering units. *pulse_vv_eu* contains backscatter measure of the transmitted vertical polarization pulses that are detected in the vertical polarization receiver.

pulse_vv_eu is two-dimensional array. The slower moving array index corresponds to each set of 48 pulse repetition intervals (PRI) that represent a single Low Resolution Data element in the Radar Level 1A Product. The faster moving array index corresponds to each range bin. The data element *num_lores_bins* with the matching slower dimension index specifies the number of range bins in the correspoding low resolution data record that contain valid data.

Type:	Float32
Group:	Low Resolution Data
Shape:	LoRes_LoResBin_Array
Valid_min:	-99999.9
Valid_max:	99999.9
Units:	dBm

4.6.93 revolution_counter

A sequential counter of the antenna revolutions extracted from the radar telemetry. The counter resets whenever the radar instrument powers off. During continuous radar operation, the counter resets once every 3.5 days.

Data elements in the Low Resolution Data Group, the High Resolution Data Group and the Loop Back Data Group reference this counter to determine the specific antenna revolution where any particular data was acquired.

revolution_counter is a one-dimensional array. Each element corresponds to an antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Type:	Uint16
Group:	Revolution Data
Shape:	AntennaRev_Array
Valid_min:	0
Valid_max:	65535
Units:	n/a

4.6.94 pri_length

A counter that specifies the length of time associated with each Pulse Repetition Interval that takes place in the corresponding antenna revolution. Values appear as integers, each of which represents 0.1 microseconds.

pri_length is a one-dimensional array. Each element corresponds to each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Type:	Uint16
Group:	Revolution Data
Shape:	AntennaRev_Array
Valid_min:	2800
Valid_max:	3780
Units:	0.1 μsec

4.6.95 rev_end_countdown

A counter the specifies the time span from the reception of the Beam Index Crossing to the pre-zero crossing that took place just before the current revolution. Each count is equivalent to a 10 μsec time span.

rev_end_countdown is a one-dimensional array. Each element corresponds to each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Type:	Uint32
Group:	Revolution Data
Shape:	AntennaRev_Array
Valid_min:	0
Valid_max:	231000
Units:	10 μsec

4.6.96 test_load_h

The average of all low resolution pulse measures in engineering units recorded at the horizontal polarization receiver. The radar instrument collects test load data during the next to last sequence of 48 PRIs in each antenna scan.

test_load_h is a one-dimensional array. Each element corresponds to each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Type:	Float32
Group:	Revolution Data
Shape:	AntennaRev_Array
Valid_min:	-99999.9
Valid_max:	99999.9
Units:	dBm

4.6.97 test_load_v

The average of all low resolution pulse measures in engineering units recorded at the vertical polarization receiver. The radar instrument collects test load data during the next to last sequence of 48 PRIs in each antenna scan.

test_load_v is a one-dimensional array. Each element corresponds to each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Type: Float32

Group: Revolution Data

Shape: AntennaRev_Array

Valid_min: -99999.9

Valid_max: 99999.9

Units: dBm

4.6.98 test_load_noise_only_h

The average of the noise only low resolution pulse measures in engineering units recorded at the horizontal polarization receiver. The radar instrument collects test load data during the next to last sequence of 48 PRIs in each antenna scan.

test_load_noise_only_h is a one-dimensional array. Each element corresponds to each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Type: Float32

Group: Revolution Data

Shape: AntennaRev_Array

Valid_min: -99999.9

Valid_max: 99999.9

Units: dBm

4.6.99 test_load_noise_only_v

The average of the noise only low resolution pulse measures in engineering units recorded at the vertical polarization receiver. The radar instrument collects test load data during the next to last sequence of 48 PRIs in each antenna scan.

test_load_noise_only_v is a one-dimensional array. Each element corresponds to each antenna revolution that takes place during the time period represented in the Radar Level 1A Product.

Type: Float32

Group: Revolution Data

Shape: AntennaRev_Array

Valid_min: -99999.9

Valid_max: 99999.9

Units: dBm

4.6.100 high_resolution_start

The low resolution interval counter that specifies when high resolution data begin to appear within the corresponding antenna revolution. Radar instrument settings enable specification of one or two start times within any given antenna revolution.

high_resolution_start is a two-dimensional array. The slower moving first dimension index corresponds to each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. The second index corresponds to the two possible instances when high resolution starts may appear in one antenna revolution within the downlinked telemetry.

Type: Uint16

Group: Revolution Data

Shape: AntennaRev_HiResInterval_Array

Valid_min: 0

Valid_max: 300

Units: n/a

4.6.101 high_resolution_stop

The low resolution interval counter that specifies when high resolution data no longer appears within the corresponding antenna revolution. Radar instrument settings enable specification of one or two stop times within any given antenna revolution.

high_resolution_stop is a two-dimensional array. The slower moving first dimension index corresponds to each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. The second index corresponds to the two possible instances when high resolution stops may appear in one antenna revolution within the downlinked telemetry.

Type: Uint16

Group: Revolution Data

Shape: AntennaRev_HiResInterval_Array

Valid_min: 0

Valid_max: 300

Units: n/a

4.6.102 frequency

The mid-point frequency of the noise-only channel for each segment of the corresponding antenna revolution. SMAP divides each antenna revolution into 16 distinct segments. Each segment associates with a specific operating frequency.

frequency is a two-dimensional array. The slower moving first dimension index corresponds to each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. The second index corresponds to each of the 16 segments within each antenna revolution.

Type: Float32

Group: Revolution Data

Shape: AntennaRev_Segment_Array

Valid_min: 1218.75

Valid_max: 1296.25

Units: MHz

4.6.103 beam_index_crossing_time

The instant the Spin Mechanism Assembly (SMA) issues a Beam Index Crossing (BIC) to the radar instrument. The Beam Index crossing coincides with the positive Y axis of the spacecraft coordinate system. The Time values are counts of International System (SI) seconds based on the J2000 epoch in Ephemeris Time (ET). Time counts in the J2000 epoch are equivalent to the number of Standard International (SI) compatible seconds since 11:58:55.816 on January 1, 2000 UTC.

beam_index_crossing_time appears in two groups in the Level 1A Product. In both groups, *beam_index_crossing_time* is a one-dimensional array. In the Revolution Data, each array element corresponds to each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. In the Health and Status data, each array element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock. The OSTC is not synchronous with the antenna rotation rate. As a result, the *beam_index_crossing_time* in the Health and Status Group reflects the most recent beam index crossing time when the OSTC was issued. Thus, the correspondence between data elements and *beam_index_crossing_time* is far more clearly defined in the Revolution Data Group, and that dataset is recommended for use.

Type: Float64

Group: Revolution Data

Health and Status Data

Shape: AntennaRev_Array in the Revolution Data

HSD_Array in the Health and Status Data

Valid_min: 0

Valid_max: 946000000

Units: seconds

4.6.104 beam_index_crossing_time_utc

A time stamp that represents the instant the Spin Mechanism Assembly (SMA) issues a Beam Index Crossing (BIC) to the radar instrument. The Beam Index crossing coincides with the positive Y axis of the spacecraft coordinate system.

The format of the *beam_index_crossing_time_utc* is YYYY-MM-DDThh:mm:ss.dddZ, where YYYY represents the calendar year, MM represents the month of the year and DD represents the day of the month. The character ‘T’ demarcates the date from the time. hh represents the hour in twenty-four hour time, mm represents the minutes, ss represents the seconds, and ddd represents thousandths of a second. The character ‘Z’ designates Greenwich Mean Time. All numerical fields must occupy the allotted space. If any numerical value does not require the allotted space to represent the appropriate number, the field that specifies the number must contain leading zeroes.

beam_index_crossing_time_utc appears in two groups in the Level 1A Product. In both groups, *beam_index_crossing_time_utc* is a one-dimensional array. In the Revolution Data, each array element corresponds to each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. In the Health and Status data, each array element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock. The OSTC is not synchronous with the antenna rotation rate. As a result, the *beam_index_crossing_time_utc* in the Health and Status Group reflects the most recent beam index crossing time when the OSTC was issued. Thus, the correspondence between data elements and *beam_index_crossing_time_utc* is far more clearly defined in the Revolution Data Group, and that dataset is recommended for use.

Type: FixLenStr

String Length: 24 characters

Group: Revolution Data

Health and Status Data

Shape: AntennaRev_Array in the Revolution Data
HSD_Array in the Health and Status Data

Valid_min: ‘2014-10-31T00:00:00.000Z’

Valid_max: ‘2030-12-31T23:59:60.999Z’

Units: n/a

4.6.105 beam_index_crossing_time_second_ticks

The number of whole second time ticks recorded by the spacecraft clock at instant the Spin Mechanism Assembly (SMA) issues a Beam Index Crossing (BIC) to the radar instrument. The Beam Index crossing coincides with the positive Y axis of the spacecraft coordinate system.

SMAP telemetry employs two registers to record spacecraft time. One register employs 32 bits to record whole seconds since the most recent reset. A second register employs 20 bits to record subseconds. Thus, each subsecond tick is equivalent to $½^{20}$ seconds.

beam_index_crossing_second_ticks appears in two groups in the Level 1A Product. In both groups, *beam_index_crossing_second_ticks* is a one-dimensional array. In the Revolution Data, each array element corresponds to each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. In the Health and Status data, each array element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock. The OSTC is not synchronous with the antenna rotation rate. As a result, the *beam_index_crossing_second_ticks* in the Health and Status Group reflects the most recent beam index crossing time when the OSTC was issued. Thus, the correspondence between data elements and *beam_index_crossing_second_ticks* is far more clearly defined in the Revolution Data Group, and that dataset is recommended for use.

Type: Uint32

Group: Revolution Data
Health and Status Data

Shape: AntennaRev_Array in the Revolution Data
HSD_Array in the Health and Status Data

Valid_min: 0

Valid_max: 946000000

Units: seconds

4.6.106 beam_index_crossing_time_subsecond_ticks

The number of subsecond time ticks recorded by the spacecraft clock at instant the Spin Mechanism Assembly (SMA) issues a Beam Index Crossing (BIC) to the radar instrument. The Beam Index crossing coincides with the positive Y axis of the spacecraft coordinate system.

SMAP telemetry employs two registers to record spacecraft time. One register employs 32 bits to record whole seconds since the most recent reset. A second register employs 20 bits to record subseconds. Thus, each subsecond tick is equivalent to $½^{20}$ seconds.

beam_index_crossing_subsecond_ticks appears in two groups in the Level 1A Product. In both groups, *beam_index_crossing_subsecond_ticks* is a one-dimensional array. In the Revolution Data, each array element corresponds to each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. In the Health and Status data, each array element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock. The OSTC is not synchronous with the antenna rotation rate. As a result, the *beam_index_crossing_subsecond_ticks* in the Health and Status Group reflects the most recent beam index crossing time when the OSTC was issued. Thus, the correspondence between data elements and *beam_index_crossing_subsecond_ticks* is far more clearly defined in the Revolution Data Group, and that dataset is recommended for use.

Type:	Uint32
Group:	Revolution Data
	Health and Status Data
Shape:	AntennaRev_Array in the Revolution Data
	HSD_Array in the Health and Status Data
Valid_min:	0
Valid_max:	1048575
Units:	counts

4.6.107 rev_start_time

The instant that marks the beginning of each antenna revolution. The revolution start time always corresponds to the beginning of a 48 pulse repetition cycle that represents a single radar low resolution measure. Since the antenna rotation rate and the instrument pulse repetition interval are not synchronized, the antenna rotation does not always begin at exactly the same antenna azimuthal position. Regardless of these variations, antenna revolutions will, however, always begin just before the azimuth crosses the negative Y axis of the spacecraft coordinate system.

The Time values are counts of International System (SI) seconds based on the J2000 epoch in Ephemeris Time (ET). Time counts in the J2000 epoch are equivalent to the number of Standard International (SI) compatible seconds since 11:58:55.816 on January 1, 2000 UTC.

rev_start_time appears in two groups in the Level 1A Product. In both groups, *rev_start_time* is a one-dimensional array. In the Revolution Data, each array element corresponds to each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. In the Health and Status data, each array element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock. The OSTC is not synchronous with the antenna rotation rate. As a result, the *rev_start_time* in the Health and Status Group reflects the most recent revolution start time when the OSTC was issued. Thus, the correspondence between data elements and *rev_start_time* is far more clearly defined in the Revolution Data Group, and that dataset is recommended for use.

Type:	Float64
Group:	Revolution Data
	Health and Status Data
Shape:	AntennaRev_Array in the Revolution Data
	HSD_Array in the Health and Status Data
Valid_min:	0
Valid_max:	946000000
Units:	seconds

4.6.108 rev_start_time_utc

The instant that marks the beginning of each antenna revolution. The revolution start time always corresponds to the beginning of a 48 pulse repetition cycle that represents a single radar low resolution measure. Since the antenna rotation rate and the instrument pulse repetition interval are not synchronized, the antenna rotation does not always begin at exactly the same antenna azimuthal position. Regardless of these variations, antenna revolutions will, however, always begin just before the azimuth crosses the negative Y-axis of the spacecraft coordinate system.

The format of the *rev_start_time_utc* is YYYY-MM-DDThh:mm:ss.dddZ, where YYYY represents the calendar year, MM represents the month of the year and DD represents the day of the month. The character ‘T’ demarcates the date from the time. hh represents the hour in twenty-four hour time, mm represents the minutes, ss represents the seconds, and ddd represents thousandths of a second. The character ‘Z’ designates Greenwich Mean Time. All numerical fields must occupy the allotted space. If any numerical value does not require the allotted space to represent the appropriate number, the field that specifies the number must contain leading zeroes.

rev_start_time_utc appears in two groups in the Level 1A Product. In both groups, *rev_start_time_utc* is a one-dimensional array. In the Revolution Data, each array element corresponds to each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. In the Health and Status data, each array element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock. The OSTC is not synchronous with the antenna rotation rate. As a result, the *rev_start_time_utc* in the Health and Status Group reflects the most recent revolution start time when the OSTC was issued. Thus, the correspondence between data elements and *rev_start_time_utc* is far more clearly defined in the Revolution Data Group, and that dataset is recommended for use.

Type:	FixLenStr
String Length:	24 characters
Group:	Revolution Data
	Health and Status Data
Shape:	AntennaRev_Array in the Revolution Data
	HSD_Array in the Health and Status Data
Valid_min:	'2014-10-31T00:00:00.000Z'
Valid_max:	'2030-12-31T23:59:60.999Z'
Units:	n/a

4.6.109 rev_start_time_second_ticks

The number of second time ticks recorded by the spacecraft clock at instant that marks the beginning of each antenna revolution. The revolution start time always corresponds to the beginning of a 48 pulse repetition cycle that represents a single radar low resolution measure. Since the antenna rotation rate and the instrument pulse repetition interval are not synchronized, the antenna rotation does not always begin at exactly the same antenna azimuthal position. Regardless of these variations, antenna revolutions will, however, always begin just before the azimuth crosses the negative Y-axis of the spacecraft coordinate system.

SMAP telemetry employs two registers to record spacecraft time. One register employs 32 bits to record whole seconds since the most recent reset. A second register employs 20 bits to record subseconds. Thus, each subsecond tick is equivalent to $½^{20}$ seconds.

rev_start_time_second_ticks appears in two groups in the Level 1A Product. In both groups, *rev_start_time_second_ticks* is a one-dimensional array. In the

Revolution Data, each array element corresponds to each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. In the Health and Status data, each array element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock. The OSTC is not synchronous with the antenna rotation rate. As a result, the *rev_start_time_second_ticks* in the Health and Status Group reflects the most recent revolution start time when the OSTC was issued. Thus, the correspondence between data elements and *rev_start_time_second_ticks* is far more clearly defined in the Revolution Data Group, and that dataset is recommended for use.

Type:	Uint32
Group:	Revolution Data
	Health and Status Data
Shape:	AntennaRev_Array in the Revolution Data
	HSD_Array in the Health and Status Data
Valid_min:	0
Valid_max:	946000000
Units:	seconds

4.6.110 rev_start_time_subsecond_ticks

The number of subsecond time ticks recorded by the spacecraft clock at instant that marks the beginning of each antenna revolution. The revolution start time always corresponds to the beginning of a 48 pulse repetition cycle that represents a single radar low resolution measure. Since the antenna rotation rate and the instrument pulse repetition interval are not synchronized, the antenna rotation does not always begin at exactly the same antenna azimuthal position. Regardless of these variations, antenna revolutions will, however, always begin just before the azimuth crosses the negative Y-axis of the spacecraft coordinate system.

SMAP telemetry employs two registers to record spacecraft time. One register employs 32 bits to record whole seconds since the most recent reset. A second register employs 20 bits to record subseconds. Thus, each subsecond tick is equivalent to $½^{20}$ seconds.

rev_start_time_subsecond_ticks appears in two groups in the Level 1A Product. In both groups, *rev_start_time_subsecond_ticks* is a one-dimensional array. In the Revolution Data, each array element corresponds to each antenna revolution that takes place during the time period represented in the Radar Level 1A Product. In the Health and Status data, each array element corresponds to each of the One Second Time Commands (OSTC) issued by the spacecraft clock. The OSTC is not synchronous with the antenna rotation rate. As a result, the *rev_start_time_subsecond_ticks* in the Health and Status Group reflects the most recent revolution start time when the OSTC was issued. Thus, the correspondence between data elements and *rev_start_time_subsecond_ticks* is far more clearly defined in the Revolution Data Group, and that dataset is recommended for use.

Type:	Uint32
Group:	Revolution Data
	Health and Status Data
Shape:	AntennaRev_Array in the Revolution Data
	HSD_Array in the Health and Status Data
Valid_min:	0
Valid_max:	1048575
Units:	counts

4.6.111 high_res_time

The representative time for each set of data elements in the High Resolution Data Group. Time values are counts of International System (SI) seconds based on the J2000 epoch in Ephemeris Time (ET). Time counts in the J2000 epoch are equivalent to the number of Standard International (SI) compatible seconds since 11:58:55.816 on January 1, 2000 UTC.

high_res_time is a one-dimensional array. Each array element corresponds to each Pulse Repetition Interval (PRI) that is represented in the High Resolution Data in the Radar Level 1A Product.

Type:	Float64
Group:	High Resolution Data
Shape:	HiRes_Array
Valid_min:	0
Valid_max:	946000000
Units:	seconds

4.6.112 high_res_time_utc

The representative time for each set of data elements in the High Resolution Data Group. Each element of the *high_res_time_utc* array records the same time instant as the element with matching index in the *high_res_time* array. The *high_res_time_utc* appears as an easily interpretable character string, while the *high_res_time* contains the count of Standard International (SI) compatible seconds since 11:58:55.816 on January 1, 2000 UTC.

The format of the *high_res_time_utc* is YYYY-MM-DDThh:mm:ss.dddZ, where YYYY represents the calendar year, MM represents the month of the year and DD represents the day of the month. The character 'T' demarcates the date from the time. hh represents the hour in twenty-four hour time, mm represents the minutes, ss represents the seconds, and ddd represents thousandths of a second. The character 'Z' designates Greenwich Mean Time. All numerical fields must occupy the allotted space. If any numerical value does not require the allotted space to represent the appropriate number, the field that specifies the number must contain leading zeroes.

high_res_time_utc is a one-dimensional array. Each array element corresponds to each Pulse Repetition Interval (PRI) that is represented in the High Resolution Data in the Radar Level 1A Product.

Type: FixLenStr

String Length: 24 characters

Group: High Resolution Data

Shape: HiRes_Array

Valid_min: '2014-10-31T00:00:00.000Z'

Valid_max: '2030-12-31T23:59:60.999Z'

Units: n/a

4.6.113 high_res_qual_flag

Bit flags that indicate the quality of the synthetic aperture radar data for each record that appears in the High Resolution Group.

high_res_qual_flag is a one dimensional array. Each array element corresponds to each Pulse Repetition Interval (PRI) that is represented in the High Resolution Data in the Radar Level 1A Product. Elements with matching array indices represent the same record.

Table 23 specifies the meaning of individual bits in the *high_res_qual_flag*:

Table 23: The high_res_qual_flag

Bits	Value	Interpretation
0		**High Resolution Packet Quality**
	0	The high resolution data for the associated PRI has good or acceptable quality.
	1	The high resolution data for the associated PRI has poor

Bits	Value	Interpretation
		or unacceptable quality.
1		**Bit Error Detection**
	0	No bit errors were detected in the high resolution data for this PRI.
	1	One or more bit errors were detected in the high resolution data for this PRI.
2		**Horizontal polarization receiver data**
	0	Data read from horizontal polarization receiver are usable.
	1	Data read from the horizontal polarization receiver are questionable or unusable.
3		**Vertical polarization receiver data**
	0	Data read from vertical polarization receiver are usable.
	1	Data read from the vertical polarization receiver are questionable or unusable.
4		**Horizontal Polarization RFI Power Monitor**
	0	Horizontal Polarization high resolution data not subjected to distortion due to RFI in nearby frequency bands
	1	Horizontal Polarization high resolution data may be subjected to distortion due to RFI in nearby frequency bands
5		**Vertical Polarization RFI Power Monitor**
	0	Vertical Polarization high resolution data not subjected to distortion due to RFI in nearby frequency bands
	1	Vertical Polarization high resolution data may be subjected to distortion due to RFI in nearby frequency bands
6-15		**Undefined**

Type: Uint16

Group: High Resolution Data

Shape: HiRes_Array

Units: n/a

4.6.114 high_res_status_flag

Bit flags that indicate the status or the mode of the synthetic aperture radar data for each record that appears in the High Resolution Group.

high_res_status_flag is a one dimensional array. Each array element corresponds to each Pulse Repetition Interval (PRI) that is represented in the High Resolution Data in the Radar Level 1A Product. Elements with matching array indices represent the same record.

Table 24 specifies the meaning of individual bits in the *high_res_status_flag*:

Table 24: The high_res_status_flag

Bits	Value	Interpretation
0		**Horizontal Polarization Digital to Analog Data Processor**
	0	Horizontal Polarization Digital to Analog Data Processor is On
	1	Horizontal Polarization Digital to Analog Data Processor is Off
1		**Vertical Polarization Digital to Analog Data Processor**
	0	Vertical Polarization Digital to Analog Data Processor is On
	1	Vertical Polarization Digital to Analog Data Processor is Off
2		**Matched load data**
	0	Contents of this record are not matched load data
	1	Contents of this record are matched load data
3		**Correlated Noise Source (CNS)**
	0	The CNS was not active when these data were acquired
	1	The CNS was active when these data were acquired
4		**Canned data**

Bits	Value	Interpretation
	0	Contents of this record are not canned data
	1	Contents of this record are canned data
5		**Nominal Canned Data Values**
	0	The set of canned data samples in the current antenna revolution have nominal values.
	1	The set of canned data samples in the current antenna revolution do not have nominal values.
6		**Undefined**
7		**Cross Polarization Flag**
	0	Cross polarized data are h-pol transmitted, v-pol received
	1	Cross polarized data are v-pol transmitted, h-pol received

Type: Uint8

Group: High Resolution Data

Shape: HiRes_Array

Units: n/a

4.6.115 pri_counter

A sequential counter of the Pulse Repetition Intervals (PRI) recorded for the current antenna revolution.

pri_counter is a one-dimensional array. Each element corresponds to each Pulse Repetition Interval (PRI) that is represented in the High Resolution Data in the Radar Level 1A Product.

Type: Uint16

Group: High Resolution Data

Shape: HiRes_Array

Valid_min: 1

Valid_max: 24000

Units: n/a

4.6.116 rev_hires

rev_hires matches the value of the *revolution_counter* in the Revolution Data Group that corresponds to the antenna revolution when the corresponding high resolution data element was acquired.

rev_hires is a one-dimensional array. Each element corresponds to each Pulse Repetition Interval (PRI) that is represented in the High Resolution Data in the Radar Level 1A Product.

Type:	Uint16
Group:	High Resolution Data
Shape:	HiRes_Array
Valid_min:	0
Valid_max:	65535
Units:	counts

4.6.117 rev_segment_hires

The index of the segment within the current revolution when the corresponding high resolution data element was acquired.

rev_segment hires is a one-dimensional array. Each element corresponds to each Pulse Repetition Interval (PRI) that is represented in the High Resolution Data in the Radar Level 1A Product.

Type:	Uint8
Group:	High Resolution Data
Shape:	HiRes_Array
Valid_min:	0
Valid_max:	15
Units:	n/a

4.6.118 num_hires_blocks

The number of high resolution blocks required to represent all of the data in the corresponding PRI. The number of blocks is determined the instrument pulse rate. Since the number of high resolution blocks can change within a half orbit, this value is critical information for any software that reads the contents of the high resolution data block.

num_hires_blocks is a one-dimensional array. Each element corresponds to each Pulse Repetition Interval (PRI) that is represented in the High Resolution Data in the Radar Level 1A Product.

Type:	Uint8
Group:	High Resolution Data
Shape:	HiRes_Array
Valid_min:	9
Valid_max:	13
Units:	n/a

4.6.119 num_lastblock_samples

The number of valid data samples in the last block of the high resolution data for the corresponding PRI. In most cases, the last block of data for each PRI does not contain a full set of valid samples. The radar instrument does not block out the samples that are invalid in the telemetry. Thus, the user needs to know precisely where to stop collecting valid data within the last block.

num_lastblock_samples is a one-dimensional array. Each element corresponds to each Pulse Repetition Interval (PRI) that is represented in the High Resolution Data in the Radar Level 1A Product.

Type:	Uint8
Group:	High Resolution Data
Shape:	HiRes_Array
Valid_min:	0
Valid_max:	32
Units:	n/a

4.6.120 mantissa

A set of mantissas for all of the samples acquired within a given PRI. The mantissas appear in blocks. Each block contains 32 four bit I and Q component mantissas for each the two co-pol channels and one cross-pol channel. Corresponding I and Q components of the same sample appear in the same byte. The I component occupies the lower order bits. The Q component occupies the higher order bits. Element *num_hires_blocks* in the High Resolution Data specifies the number of blocks required to specify all of the samples for a given PRI. Element *num_lastblock_samples* specifies the number of good samples in the final block for each PRI.

mantissa is a four-dimensional array. The slowest moving index represents each Pulse Repetition Interval (PRI) that is represented in the High Resolution Data in the Radar Level 1A Product. The second dimension index represents the number of blocks required to represent a complete PRI. The third dimension index represents the three channels. Table 25 provides the meaning of the third dimension index. The fourth and fastest moving dimension represents each of the samples in each telemetry block.

Table 25: Interpretation of Third Dimension Index

Third Dimension Index Value	Third Dimension Index Interpretation
0	Corresponding values represent the HH co-pol channel.
1	Corresponding values represent a cross-pol channel. The Cross Polarization bit in the *high_res_status_flag* indicates which cross-pol channel is being downlinked.
2	Corresponding values represent the VV co-pol channel.

Type: Uint8

Group: High Resolution Data

Shape: HiRes_HiResBlock_Channel_BlockSize_Array

Valid_min: 0

Valid_max: 255

Units: n/a

4.6.121 exponent

A set of exponents for all of the samples acquired within a given PRI. The exponents appear in blocks. Each block contains 3 five-bit exponents. The three exponents represent both co-pol channels and one cross-pol channel. Each exponent is stored in a single byte. The exponent value occupies the five lower order bits in each byte. Element *num_hires_blocks* in the High Resolution Data specifies the number of blocks required to specify all of the samples for a given PRI. Element *num_lastblock_samples* specifies the number of good samples in the final block for each PRI.

exponent is a three-dimensional array. The slowest moving index represents each Pulse Repetition Interval (PRI) that is represented in the High Resolution Data in the Radar Level 1A Product. The second dimension index represents the number of blocks required to represent a complete PRI. The third dimension index represents the three channels. Table 26 provides the meaning of each third dimension index.

Table 26: Interpretation of Third Dimension Index

Third Dimension Index Value	Third Dimension Index Interpretation
0	Corresponding values represent the HH co-pol channel.
1	Corresponding values represent a cross-pol channel. The Cross Polarization bit in the *high_res_status_flag* indicates which cross-pol channel is being downlinked.
2	Corresponding values represent the VV co-pol channel.

Type: Uint8

Group: High Resolution Data

Shape: HiRes_HiResBlock_Channel_Array

Valid_min: 0

Valid_max: 31

Units: n/a

4.6.122 antenna_scan_angle

The angle between the projection of electrical boresight vector in the X-Y plane of the instrument fixed coordinate system and the X-axis of the same coordinate system. The instrument fixed X axis approximates the direction of spacecraft motion.

antenna_scan_angle is a one-dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product.

Type: Float32

Group: Spacecraft Data

Shape: SpacecraftData_Array

Valid_min: 0

Valid_max: 359.999

Units: degrees

4.6.123 antenna_look_angle

The angle defined by the electrical boresight vector and to the spacecraft nadir vector.

Antenna_look_angle is a one-dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product.

Type: Float32

Group: Spacecraft Data

Shape: SpacecraftData_Array

Valid_min: 0

Valid_max: 180

Units: degrees

4.6.124 sc_nadir_angle

The angle defined by the spacecraft geodetic nadir vector and the negative Z axis of the instrument fixed coordinate system.

sc_nadir_angle is a one-dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product.

Type: Float32

Group: Spacecraft Data

Shape: SpacecraftData_Array

Valid_min: 0

Valid_max: 180

Units: degrees

4.6.125 pitch

The interpolated angular rotation of the spacecraft body about the Y axis of the Instrument Fixed Frame (INSF) relative to the SRF after a 180 degree roll is performed. The Y axis of the SRF is normal to the spacecraft orbital plane.

Under nominal conditions, the absolute value of the pitch should be very small. The number may appear abnormally large during spacecraft maneuvers or when the mission is recording a cold sky calibration.

Pitch is a one-dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product.

Type:	Float32
Group:	Spacecraft Data
Shape:	SpacecraftData_Array
Valid_min:	-3.0
Valid_max:	3.0
Units:	degrees

4.6.126 roll

The interpolated angular rotation of the spacecraft body about the X axis of the Instrument Fixed Frame (INSF) coordinate system after a 180 degree roll is performed. The X axis of the SRF approximates the direction of spacecraft motion.

Under nominal conditions, the absolute value of the roll should be very small. The number may appear abnormally large during spacecraft maneuvers or when the mission is recording a cold sky calibration.

Roll is a one-dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product.

Type:	Float32
Group:	Spacecraft Data
Shape:	SpacecraftData_Array
Valid_min:	-3.0
Valid_max:	3.0
Units:	degrees

4.6.127 sc_alongtrack_velocity

The interpolated instantaneous velocity of the SMAP spacecraft that is tangent to the spacecraft path within the orbital plane.

sc_alongtrack_velocity is a one-dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product.

Type:	Float32
Group:	Spacecraft Data
Shape:	SpacecraftData_Array
Valid_min:	-8000
Valid_max:	8000
Units:	meters/second

4.6.128 sc_data_time

The representative time for each set of data elements in the Spacecraft Data Group. Time values are counts of International System (SI) seconds based on the J2000 epoch in Ephemeris Time (ET). Time counts in the J2000 epoch are equivalent to the number of Standard International (SI) compatible seconds since 11:58:55.816 on January 1, 2000 UTC.

sc_data_time is a one-dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product.

Type:	Float64
Group:	Spacecraft Data
Shape:	SpacecraftData_Array
Valid_min:	0
Valid_max:	946000000
Units:	seconds

4.6.129 sc_data_time_utc

The representative time for each set of data elements in the Spacecraft Data Group. Each element of the *sc_data_time_utc* array records the same time instant as the element with matching index in the *sc_data_time* array. The *sc_data_time_utc* appears as an easily interpretable character string, while the *sc_data_time* contains the count of Standard International (SI) compatible seconds since 11:58:55.816 on January 1, 2000 UTC.

The format of the *sc_data_time_utc* is YYYY-MM-DDThh:mm:ss.dddZ, where YYYY represents the calendar year, MM represents the month of the year and DD represents the day of the month. The character 'T' demarcates the date from the time. hh represents the hour in twenty-four hour time, mm represents the minutes, ss represents the seconds, and ddd represents thousandths of a second. The character 'Z' designates Greenwich Mean Time. All numerical fields must occupy the allotted space. If any numerical value does not require the allotted space to represent the appropriate number, the field that specifies the number must contain leading zeroes.

sc_data_time_utc is a one-dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product.

Type:	FixLenStr
String Length:	24 characters
Group:	Spacecraft Data
Shape:	SpacecraftData_Array
Valid_min:	'2014-10-31T00:00:00.000Z'
Valid_max:	'2030-12-31T23:59:60.999Z'
Units:	n/a

4.6.130 sc_geodetic_alt_ellipsoid

The interpolated geodetic altitude of the spacecraft above the Earth's reference ellipsoid.

sc_geodetic_alt_ellipsoid is a one-dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product.

Type:	Float32
Group:	Spacecraft Data
Shape:	SpacecraftData_Array
Valid_min:	650000
Valid_max:	750000
Units:	meters

4.6.131 sc_mode_flag

Bit flags that indicate operational conditions for each record that appears in the Spacecraft Data Group.

sc_mode_flag is a one dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product. Elements with matching array indices represent the same record.

Table 27 specifies the meaning of individual bits in the *sc_mode_flag*:

Table 27: The sc_mode_flag

Bits	Value	Interpretation
0		**Instrument viewing mode**
	0	Spacecraft antenna is positioned so that the SMAP instrument views locations on the Earth's surface.
	1	Spacecraft antenna is positioned so that the SMAP instrument does not view the Earth. SMAP spacecraft is either in maneuver, running a cold sky calibration for the radiometer or in a transition state.
1		**Ephemeris Usage Flag**
	0	Processing employed reconstructed ephemeris
	1	Processing employed predicted ephemeris
2-15		**Undefined**

Type: Uint16

Group: Spacecraft Data

Shape: SpacecraftData_Array

Units: n/a

4.6.132 sc_nadir_lat

The interpolated geodetic latitude of the spacecraft's ground track position.

sc_nadir_lat is a one-dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product.

Type: Float32

Group: Spacecraft Data

Shape: SpacecraftData_Array

Valid_min: -90

Valid_max: 90

Units: degrees_north

4.6.133 sc_nadir_lon

The interpolated longitude of the spacecraft's ground track position.

sc_nadir_lon is a one-dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product.

Type: Float32

Group: Spacecraft Data

Shape: SpacecraftData_Array

Valid_min: -180

Valid_max: 179.999

Units: degrees_east

4.6.134 declination

The declination of the antenna boresight vector.

declination is a one-dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product.

Type: Float32

Group: Spacecraft Data

Shape: SpacecraftData_Array

Valid_min: -90.0

Valid_max: 90.0

Units: degrees

4.6.135 right_ascension

The right ascension of the antenna boresight vector.

right_ascension is a one-dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product.

Type: Float32

Group: Spacecraft Data

Shape: SpacecraftData_Array

Valid_min: 0.0

Valid_max: 359.999

Units: degrees

4.6.136 sc_qual_flag

Bit flags that indicate the quality of spacecraft position and orientation, or antenna azimuth data for each record that appears in the Spacecraft Data Group.

sc_qual_flag is a one dimensional array. Every record in the Spacecraft Data Group represents each 0.1 second in the time period covered by the Level 1A Product. Elements with matching array indices represent the same record.

Table 28 specifies the meaning of individual bits in the *sc_qual_flag*:

Table 28: The sc_qual_flag

Bits	Value	Interpretation
0		**Ephemeris Quality**
	0	Quality and frequency of the ephemeris data is within acceptable range.
	1	Quality or frequency of the ephemeris data may not be adequate to yield a sufficiently accurate measure of spacecraft location to meet mission geolocation requirements.
1		**Attitude Quality**
	0	Quality and frequency of the attitude data is within acceptable range.
	1	Quality or frequency of the attitude data may not be adequate to interpolate a sufficiently accurate measure of spacecraft attitude to meet mission requirements.
2		**Antenna Azimuth Quality**
	0	Quality and frequency of the antenna azimuth data is within acceptable range.
	1	Quality or frequency of the antenna azimuth data may not be adequate to yield a sufficiently accurate antenna

Bits	Value	Interpretation
		azimuth measure to meet mission geolocation requirements.
3-15		**Undefined**

Type: Uint16

Group: Spacecraft Data

Shape: SpacecraftData_Array

Units: n/a

4.6.137 sc_radial_velocity

The interpolated velocity of the SMAP spacecraft in the direction of the vector that runs from the instantaneous spacecraft position to the center of the Earth.

sc_radial_velocity is a one-dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product.

Type: Float32

Group: Spacecraft Data

Shape: SpacecraftData_Array

Valid_min: -8000

Valid_max: 8000

Units: meters/second

4.6.138 x_pos

The interpolated X component of spacecraft position in the Earth Centered Rotating (ECR) coordinate system.

X_pos is a one-dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product.

Type: Float32

Group: Spacecraft Data

Shape: SpacecraftData_Array

Valid_min: -9999999

Valid_max: 9999999

Units: meters

4.6.139 x_vel

The interpolated X component of spacecraft velocity in the Earth Centered Rotating (ECR) coordinate system.

X_vel is a one-dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product.

Type: Float32

Group: Spacecraft Data

Shape: SpacecraftData_Array

Valid_min: -8000

Valid_max: 8000

Units: meters/second

4.6.140 yaw

The interpolated angular rotation of the spacecraft body about the Z axis of the Instrument Fixed Frame (INSF) coordinate system after a 180 degree roll is performed. The Z axis of the SRF runs from the center of mass of the spacecraft toward geodetic nadir.

Under nominal conditions, the absolute value of the yaw should be very small. The number may appear abnormally large during spacecraft maneuvers or when the mission is recording a cold sky calibration.

Yaw is a one-dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product.

Type: Float32

Group: Spacecraft Data

Shape: SpacecraftData_Array

Valid_min: -3.0

Valid_max: 3.0

Units: degrees

4.6.141 y_pos

The interpolated Y component of spacecraft position in the Earth Centered Rotating (ECR) coordinate system.

Y_pos is a one-dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product.

Type:	Float32
Group:	Spacecraft Data
Shape:	SpacecraftData_Array
Valid_min:	-9999999
Valid_max:	9999999
Units:	meters

4.6.142 y_vel

The interpolated Y component of spacecraft velocity in the Earth Centered Rotating (ECR) coordinate system.

Y_vel is a one-dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product.

Type:	Float32
Group:	Spacecraft Data
Shape:	SpacecraftData_Array
Valid_min:	-8000
Valid_max:	8000
Units:	meters/second

4.6.143 z_pos

The interpolated Z component of spacecraft position in Earth Centered Rotating (ECR) coordinate system.

Z_pos is a one-dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product.

Type:	Float32
Group:	Spacecraft Data
Shape:	SpacecraftData_Array
Valid_min:	-9999999

Valid_max: 9999999

Units: meters

4.6.144 z_vel

The interpolated Z component of spacecraft velocity in the Earth Centered Rotating (ECR) coordinate system.

Z_vel is a one-dimensional array. Each array element represents each 0.1 second that falls within the time period covered by a Level 1A Radar product.

Type: Float32

Group: Spacecraft Data

Shape: SpacecraftData_Array

Valid_min: -8000

Valid_max: 8000

Units: meters/second

5 APPENDIX A – ACRONYMS AND ABBREVIATIONS

This is the standard Soil Moisture Active Passive (SMAP) Science Data System (SDS) list of acronyms and abbreviations. Not all of these acronyms and abbreviations appear in every SMAP SDS document.

ADT	Algorithm Development Team
AMSR	Advanced Microwave Scanning Radiometer
ANSI	American National Standards Institute
AOS	Acquisition of Signal
APF	Algorithm Parameter File
ARS	Agricultural Research Service
ASF	Alaska Satellite Facility
ATBD	Algorithm Theoretical Basis Document
ATLO	Assembly Test Launch and Operations
BFPQ	Block Floating Point Quantization
BIC	Beam Index Crossing
CARA	Criticality and Risk Assessment
CBE	Current Best Estimate
CCB	Configuration Control Board
CCSDS	Consultative Committee on Space Data Systems
CDR	Critical Design Review
CEOS	Committee on Earth Observing Systems
CF	Climate and Forecast (metadata convention)
CM	Configuration Management
CM	Center of Mass
CNS	Correlated Noise Source
CONUS	Continental United States
COTS	Commercial Off the Shelf
CR	Change Request
DAAC	Distributed Active Archive Center
DB	Database
DBA	Database Administrator
dB	decibels
deg	degrees

deg/sec	degrees per second
deg C	degrees Celsius
DEM	Digital Elevation Model
DFM	Design File Memorandum
DIU	Digital Interface Unit
DN	Data Number
DOORS	Dynamic Object Oriented Requirements
DQC	Data Quality Control
DSK	Digital Skin Kernel
DVD	Digital Versatile Disc
EASE	Equal Area Scalable Earth
ECMWF	European Centre for Medium Range Weather Forecasts
ECHO	EOS Clearing House
ECI	Earth Centered Inertial Coordinate System
ECR	Earth Centered Rotating Coordinate System
ECR	Engineering Change Request
ECS	EOSDIS Core System
EDOS	EOS Data Operations System
EM	Engineering Model
EOS	Earth Observing System
EOSDIS	Earth Observing System Data and Information System
EPO	Education and Public Outreach
ESDIS	Earth Science Data and Information System Project
ESDT	Earth Science Data Type
ESH	EDOS Service Header
ESSP	Earth Science System Pathfinder
ET	Ephemeris TIme
EU	Engineering Units
FOV	Field of View
FRB	Functional Requirements Baseline
FS	Flight System

FSW	Flight Software
F/T	Freeze/Thaw
FTP	File Transfer Protocol
GByte	gigabyte
GDS	Ground Data System
GHA	Greenwich Hour Angle
GHz	gigahertz
GLOSIM	Global Simulation
GMAO	Global Modeling and Assimilation Office
GMT	Greenwich Mean Time
GN	Ground Network
GPMC	Governing Program Management Council
GPP	Gross Primary Production
GPS	Global Positioning System
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HDF	Hierarchical Data Format
HK	Housekeeping (telemetry)
Hz	Hertz
HSD	Health and Status Data
ICE	Integrated Control Electronics
ICESat	Ice, Cloud and Land Elevation Satellite
IDL	Interactive Data Language
I&T	Integration and Test
ICD	Interface Control Document
IEEE	Institute of Electrical and Electronics Engineers
IFOV	Instantaneous Field of View
I/O	Input/Output
IOC	In-Orbit Checkout
IRU	Inertial Reference Unit
ISO	International Organization for Standardization
IV&V	Independent Verification and Validation

ITAR	International Traffic in Arms Regulations
I&T	Integration and Test
JPL	Jet Propulsion Laboratory
KHz	kilohertz
km	kilometers
LAN	Local Area Network
LBT	Loopback Trap
LEO	Low Earth Orbit
LEOP	Launch and Early Operations
LOE	Level Of Effort
LOM	Life Of Mission
LOS	Loss of Signal
LSK	Leap Seconds Kernel
LZPF	Level Zero Processing Facility
m	meters
MHz	megahertz
MIT	Massachusetts Institute of Technology
MMR	Monthly Management Review
MOA	Memorandum of Agreement
MOC	Mission Operations Center
MODIS	Moderate Resolution Imaging Spectroradiometer
MOS	Mission Operations System
m/s	meters per second
ms	milliseconds
MS	Mission System
NAIF	Navigation and Ancillary Information Facility
NASA	National Aeronautics and Space Administration
NCEP	National Centers for Environmental Protection
NCP	North Celestial Pole
NCSA	National Center for Supercomputing Applications
NEDT	Noise Equivalent Diode Temperature
NEE	Net Ecosystem Exchange

NEN	Near Earth Network
netCDF	Network Common Data Form
NFS	Network File System/Server
NISN	NASA Integrated Services Network
NRT	Near Real Time
NOAA	National Oceanic and Atmospheric Administration
NSIDC	National Snow and Ice Data Center
NVM	Non-Volatile Memory
NWP	Numerical Weather Product
n/a	not applicable
OCO	Orbiting Carbon Observatory
OEF	Orbit Events File
ORBNUM	Orbit Number File
OODT	Object Oriented Data Technology
ORR	Operational Readiness Review
ORT	Operational Readiness Test
OSSE	Observing System Simulation Experiment
OSTC	One Second Time Command
PALS	Passive and Active L-Band System
PALSAR	Phased Array L-Band Synthetic Aperture Radar
PcK	Planetary Constants Kernel
PDR	Preliminary Design Review
POR	Power On Reset
PPPCS	Pointing, Position, Phasing and Coordinate System
PR	Problem Report
PRF	Pulse Repetition Frequency
PRI	Pulse Repetition Interval
PROM	Programmable Read Only Memory
PSD	Product Specification Document
QA	Quality Assurance
rad	radians
RAM	Random Access Memory

RBA	Reflector Boom Assembly
RBD	Rate Buffered Data
RBE	Radiometer Back End
RDD	Release Description Document
RDE	Radiometer Digital Electronics
RF	Radio Frequency
RFA	Request For Action
RFE	Radiometer Front End
RFI	Radio Frequency Interference
RMS	root mean square
RSS	root sum sqaure
ROM	Read Only Memory
RPM	revolutions per minute
RVI	Radar Vegetation Index
SA	System Administrator
SAR	Synthetic Aperture Radar
S/C	Spacecraft
SCE	Spin Control Electronics
SCLK	Spacecraft Clock
SDP	Software Development Plan
SDS	Science Data System
SDT	Science Definition Team
SI	International System
SITP	System Integration and Test Plan
SMAP	Soil Moisture Active Passive
SMEX	Soil Moisture Experiment
SMOS	Soil Moisture and Ocean Salinity Mission
SMP	Software Management Plan
SNR	signal to noise ratio
SOC	Soil Organic Carbon
SOM	Software Operators Manual
SQA	Software Quality Assurance

SPDM	Science Process and Data Management
SPG	Standards Process Group
SPK	Spacecraft Kernel
SQA	Software Quality Assurance
SPS	Science Production Software
SRF	Science Orbit Reference Frame
SRR	System Requirements Review
SRTM	Shuttle Radar Topography Mission
SSM/I	Special Sensor Microwave/Imager
STP	Software Test Plan
sec	seconds
TAI	International Atomic Time
T_b	Brightness Temperature
TBC	To Be Confirmed
TBD	To Be Determined
TBR	To Be Resolved
TBS	To Be Specified
TCP/IP	Transmission Control Protocol/Internet Protocol
TEC	Total Electron Content
TM	Trademark
TOA	Time of Arrival
TPS	Third Party Software
UML	Unified Modeling Language
U-MT	University of Montana
USDA	United States Department of Agriculture
UTC	Coordinated Universal Time
V&V	Verification and Validation
VWC	Vegetation Water Content

6 APPENDIX B - SMAP Data Product Specification Documents

SMAP Level 1B Radar (L1B_S0_LoRes) Product Specification Document, JPL D-72544 Revision A, July 20, 2015.

SMAP Level 1C_S0_HiRes Product Specification Document, JPL D-72554 Revision A, July 20, 2015.

SMAP Level 1A Radiometer Product Specification Document, JPL D-92340 Revision A, July 20, 2015.

SMAP Level 1B Radiometer (L1B_TB) Product Specification Document, JPL D-92339 Revision A, July 20, 2015.

SMAP Level 1C Radiometer (L1C_TB) Product Specification Document, JPL D-72545, Date (**TBD)**.

SMAP Level 2 Active Soil Moisture (L2_SM_A) Product Specification Document, JPL D-72546, Date (**TBD)**.

SMAP Level 2 Passive Soil Moisture (L2_SM_P) Product Specification Document, JPL D-72547, Date (**TBD)**.

SMAP Level 2 Active/Passive Soil Moisture (L2_SM_AP) Product Specification Document, JPL D-72548, Date (**TBD)**.

SMAP Level 3 Freeze-Thaw (L3_FT_A) Product Specification Document, JPL D-72549, Date (**TBD)**.

SMAP Level 3 Active Soil Moisture (L3_SM_A) Product Specification Document, JPL D-72550, Date (**TBD)**.

SMAP Level 3 Passive Soil Moisture (L3_SM_P) Product Specification Document, JPL D-72551, Date (**TBD)**.

SMAP Level 3 Active/Passive Soil Moisture (L3_SM_AP) Product Specification Document, JPL D-72552, Date (**TBD)**.

SMAP Level 4 Carbon (L4_C) Product Specification Document, Document Identifier (**TBD)**, Date (**TBD)**.

SMAP Level 4 Soil Moisture (L4_SM) Product Specification Document, Document Identifier (**TBD)**, Date (**TBD)**.

7 APPENDIX C – SHAPES IN THE L1A Radar PRODUCT

Table 29 lists all of the Shapes that appear in the L1A Radar Product. The table also lists the rank, the nominal dimensions and the maximum dimensions for each Shape in the L1A Radar Product.

The naming convention for shape names places the dimension where consecutive indices represent contiguous storage positions last. The naming convention thus conforms to index representation in the C language.

On the other hand, since a large contingent of the SMAP science community programs are in Fortran, index order of arrays in this document conforms to the Fortran standard. Thus, in array dimension representation, the dimension where consecutive indices represent contiguous storage appears first.

Table 29: Shapes in the SMAP L1A Radar Product

Shape	Rank	Nominal Product Dimensions	Maximum Product Dimensions
SpacecraftData_Array	1	(2954)	(2954)
HSD_Array	1	(2954)	(2954)
HSD_HSDFlags_Array	2	(10,2954)	(10,2954)
HSD_HSDSpares_Array	2	(3,2954)	(3,2954)
HSD_HSDVoltSensor_Array	2	(15,2954)	(15,2954)
HSD_HSDTempSensor_Array	2	(32,2954)	(32,2954)
AntennaRev_Array	1	(640)	(720)
AntennaRev_HiResInterval_Array	2	(2,640)	(2,720)
AntennaRev_Segment_Array	2	(16,640)	(16,720)
Trap_Array	1	(10240)	(11520)
LoopBackTrap_LBTSamples_Array	2	(21,10240)	(21,11520)
LoRes_Array	1	(175825)	(175825)
LoRes_PRI_Array	2	(48,175825)	(48,175825)
LoRes_LoResBin_Array	2	(13,175825)	(13,175825)

Shape	Rank	Nominal Product Dimensions	Maximum Product Dimensions
HiRes_Array	1	(3544700)	(8439560)
HiRes_HiResBlock_Channel_BlockSize_Array	4	(32,3,12,3544700)	(32,3,13,8439560)
HiRes_HiResBlock_Channel_Array	3	(3,12,3544700)	(3,13,8439560)

8 APPENDIX D – L1A Radar DIMENSIONS

Table 30 lists all of the Dimensions that are used by data elements in the Level 1A Radar Product. The name of each Dimension matches the name given in the Dimension column below. The table also lists the anticipated nominal value and the maximum value for each dimension that appears in the L1A Radar Product.

Table 30: Dimensions in the SMAP L1A Radar Product

Dimension	Nominal Size	Maximum Size
AntennaRev	640	720
BlockSize	32	32
Channel	3	3
HiRes	3544700	8439560
HiResBlock	12	13
HiResInterval	2	2
HSD	2954	2954
HSDFlags	10	10
HSDSpares	3	3
HSDTempSensor	32	32
HSDVoltSensor	15	15
KpComp	2	3
LBTSamples	21	21
LoopBackTrap	10240	11520
LoRes	175825	175825
LoResBin	13	13
PRI	48	48
Segment	16	16
SpacecraftData	2954	2954

9 APPENDIX E – L1A Radar UNITS

Table 31 lists the Units that are used by the L1A Radar product elements. The SMAP implementation of HDF5 stores unit information for each data element in local metadata. The first column in the Table 31 identifies units that apply to data in the L1A Radar Product. The second column lists the Common Symbol used to represent the unit. The third column lists the matching Label that appears in the local metadata in the L1A Radar Product.

Table 31: Units in the SMAP L1C_S0_HiRes Product

Unit	Common Symbol	Level 1A Radar Label	Typical Use
Counts	Counts	counts	number of elements in a set
Degrees	degrees	degrees	angular measure
degrees Celsius	°C	degrees_Celsius	temperature measure
Dimensionless	n/a		dimensionless quantity
Gigahertz	GHz	GHz	frequency measure
Kelvins	K	K	temperature measure
meters per second	m/s	m/s	velocity measure
Megabytes	MBytes	MBytes	computer storage units
Meters	m	m	distance measure
Kilometers	km	km	distance measure
Percent	%	percent	per hundred
Seconds	s	sec	time measure
revolutions per minute	rpm	rpm	rotational measure
Volts	V	V	electrical potential difference

10 APPENDIX F – Code Examples that Read HDF5 (TBD)