Archive Volume Software Interface Specification (SIS)

For

Mini-RF Advanced Technologies – Forerunner (Mini-SAR) Payload Operations Center
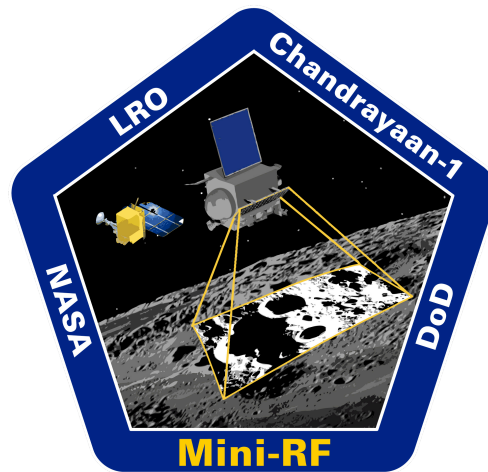
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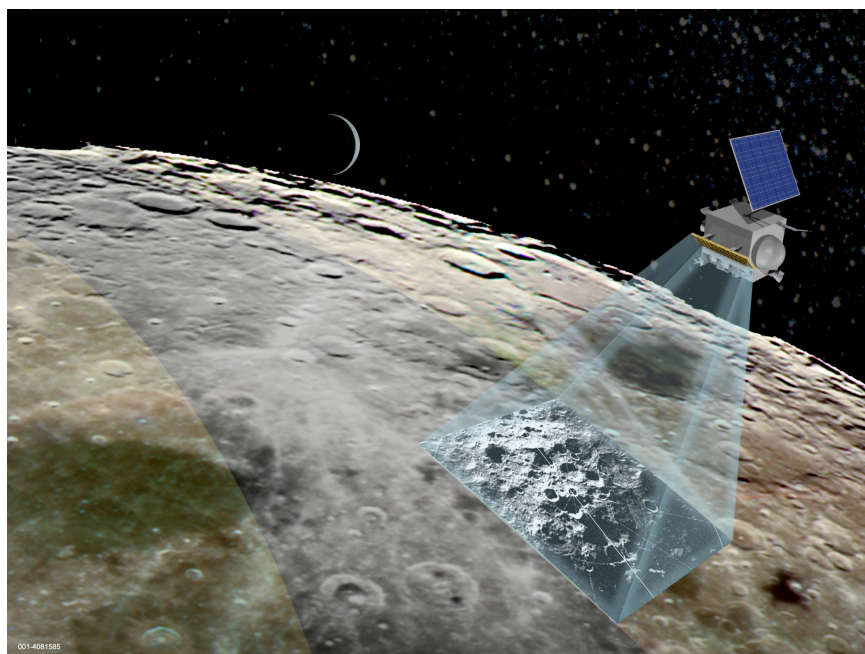Ms. Helene Winters   Date
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RECORD OF CHANGES

CHANGE NO.	DATE	TITLE OR BRIEF DESCRIPTION	ENTERED BY
0	31 May 2007	Initial Release	Mike Reid
1	11 April 2008	Revision for CDR Peer Review	Mike Reid
2	08 April 2009	Added mention of the Sandia 3-D Map and Topography level 3 products to section 2.2.2. Added new Data Set IDs for the Sandia products to section 1.1. Changed the front cover logo from NAWK to Mini-RF.	Mike Reid
3	02 Oct 2009	Removed references to derived scatterometry products. Added and updated information on SPICE kernels. Modified signature list to reflect changes in the project management. Added Zero[th]-Order Mini-RF Calibration document to DOCUMENT directory.	Mike Reid
4	13 Nov 2009	Updated for calibration documents, Arecibo calibration data and orbit number files.	Mike Reid
5	16 Aug 2010	Major updates relating to calibration files, naming convention, and others. Removed references to scatterometry products.	Mike Reid
6	20 Jan 2011	Modified SPICE directory structure; added EXTRAS/UNPROC subdirectory; miscellaneous editorial modifications based on reviewer comments.	Mike Reid

Table of Contents

1. Introduction

1.1. Purpose and Scope

This Software Interface Specification (SIS) is intended to be used by those who wish to understand the format and content of the Forerunner instrument data archive. Typically, these individuals would be software engineers, data analysts, or planetary scientists. The Mini-RF Forerunner instrument, also called "Mini-SAR," is a NASA synthetic aperture radar that flew on the Indian Space Research Organisation's (ISRO) Chandrayaan-1 lunar orbiting spacecraft. NASA flies a similar instrument on the Lunar Reconnaissance Orbiter (LRO) spacecraft. Although the level-1 and level-2 data, polar mosaics, and most other archived products from these two instruments are nearly identical in their format and information content, this document only describes the data archive for the Forerunner (Mini-SAR) instrument.

The Forerunner data archive was originally intended to include products generated by the Forerunner instrument while in scatterometry mode; however, no scientifically useable scatterometry data were collected due to the premature end of the Chandrayaan-1 mission in August 2009.

The specifications in this document apply to all Forerunner standard product archive volumes that are generated by the Mini-RF Project. Identifying keywords are given below in Table 1.

The data sets included on these archive volumes have the following Planetary Data System data set IDs for the raw data, level-1 SAR, level-2 SAR, level-3 SAR mosaics, and SPICE kernels respectively:

- CH1-ORB-L-MRFFR-1-PDR-V1.0

- CH1-ORB-L-MRFFR-4-CDR-V1.0

- CH1-ORB-L-MRFFR-5-CDR-MAP-V1.0

- CH1-ORB-L-MRFFR-5-CDR-MOSAIC-V1.0

- CH1-ORB-L-SPICE-6-V1.0

Keyword	Value
MISSION_NAME	"CHANDRAYAAN-1"
MISSION_ID	CH1
INSTRUMENT_HOST_NAME	"CHANDRAYAAN-1 ORBITER"
INSTRUMENT_HOST_ID	"CH1-ORB"
INSTRUMENT_NAME	"MINI-RF FORERUNNER"
INSTRUMENT_ID	MRFFR

Table 1 Values of mission and instrument identifying key words. Note that the instrument is also known as "Miniature Synthetic Aperture Radar (MiniSAR)."

1.2. Content Overview

This SIS describes the format, content, and generation of the Forerunner Archive. Section 2, *Archive Volume Contents*, describes the structure of the archive volumes and the contents of each file. Section 3, *Archive Volume Format*, describes the file formats used on the archive volumes. Section 4, *Archive Volume Generation*, describes the procedure for transferring data products to the archive and data volumes. Finally, Section 5, *Support Staff and Cognizant Persons*, lists the individuals responsible for generating the archive volumes. All data products are produced and assembled by the Mini-RF Payload Operations Center (POC) located at The Johns Hopkins University Applied Physics Laboratory (JHU/APL) located in Laurel, Maryland.

1.3. Applicable Documents and Constraints

This Archive Volume SIS is intended to be consistent with the following documents:

1. Chandrayaan-1 Project Mini-SAR Instrument Team Data Management and Archive Plan, The Johns Hopkins University Applied Physics Laboratory, May 30, 2006.

2. PDS Data Product Software Interface Specification (SIS) For Mini-RF Advanced Technologies – Forerunner (Mini-SAR) Payload Operations Center, Mini-RF Program. MRF-4008.

3. *Planetary Data System Standards Reference*, NASA/JPL, February 27, 2009, Version 3.8. JPL D-7669, Part-2. Available from http://pds.jpl.nasa.gov/documents/sr/index.html. [Accessed: January 26, 2010].

4. *Planetary Data System Archive Preparation Guide,* August 29, 2006, Version 1.1, JPL D-31224, NASA/JPL. Available from http://pds.jpl.nasa.gov/documents/apg/index.html. [Accessed: May 8, 2007].

5. Chandrayaan-1 Mini-RF Science Team and PDS Geosciences Node Interface Control Document (ICD).

6. *SPICE Archive Preparation Guide*, September 1, 2010. JPL/NAIF. Available from ftp://naif.jpl.nasa.gov/pub/naif/pds/doc/archiving_guide/. [Accessed: December 2, 2010].

1.4. Relationships with Other Interfaces

This Archive Volume SIS could be affected by changes to the design of the Forerunner standard data products. See the data product SIS (MRF-4008) [section 1.3].

2. Archive Volume Contents

This section describes the contents of the Forerunner Archive volumes, including the file names, file contents, file types, and organization responsible for providing the files. All products are included in a single archive volume (Volume ID: **CH1MRF_0XXX**).

The data products consist of binary images, non-image binary data, supporting data in free-formatted text files, spreadsheet (comma-separated values) text files, and "CONI" text. CONI is a human and machine-readable structured text format developed by Vexcel® corporation and is the standard parameter file format for their SAR processors. We include these parameter files with the products as metadata.
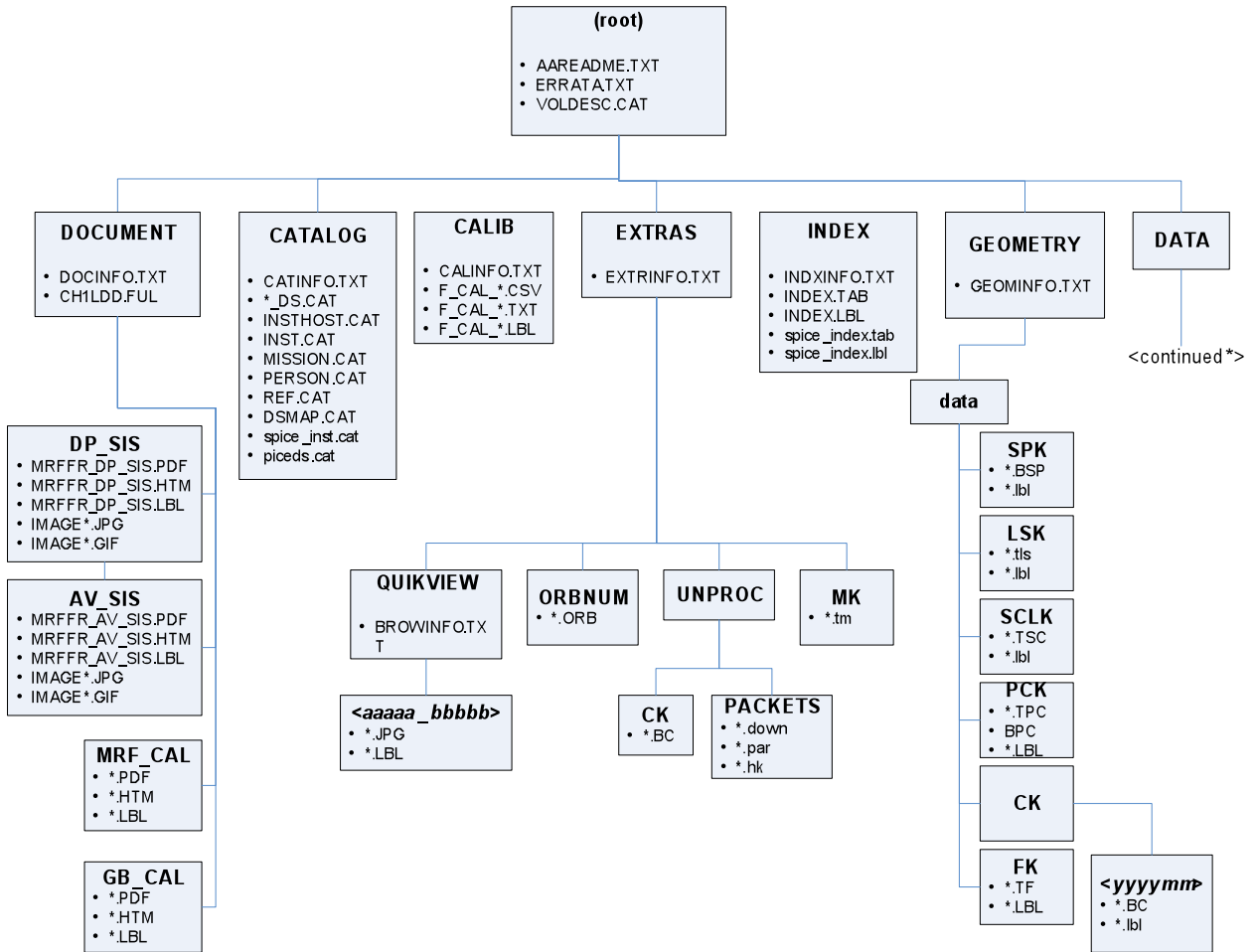
(root)
- AAREADME.TXT
- ERRATA.TXT
- VOLDESC.CAT

DOCUMENT
- DOCINFO.TXT
- CH1LDD.FUL

CATALOG
- CATINFO.TXT
- *_DS.CAT
- INSTHOST.CAT
- INST.CAT
- MISSION.CAT
- PERSON.CAT
- REF.CAT
- DSMAP.CAT
- spice_inst.cat
- piceds.cat

CALIB
- CALINFO.TXT
- F_CAL_*.CSV
- F_CAL_*.TXT
- F_CAL_*.LBL

EXTRAS
- EXTRINFO.TXT

INDEX
- INDXINFO.TXT
- INDEX.TAB
- INDEX.LBL
- spice_index.tab
- spice_index.lbl

GEOMETRY
- GEOMINFO.TXT

DATA

<continued *>

DP_SIS
- MRFFR_DP_SIS.PDF
- MRFFR_DP_SIS.HTM
- MRFFR_DP_SIS.LBL
- IMAGE*.JPG
- IMAGE*.GIF

AV_SIS
- MRFFR_AV_SIS.PDF
- MRFFR_AV_SIS.HTM
- MRFFR_AV_SIS.LBL
- IMAGE*.JPG
- IMAGE*.GIF

MRF_CAL
- *.PDF
- *.HTM
- *.LBL

GB_CAL
- *.PDF
- *.HTM
- *.LBL

data

QUIKVIEW
- BROWINFO.TXT

ORBNUM
- *.ORB

UNPROC

MK
- *.tm

<aaaaa_bbbbb>
- *.JPG
- *.LBL

CK
- *.BC

PACKETS
- *.down
- *.par
- *.hk

SPK
- *.BSP
- *.lbl

LSK
- *.tls
- *.lbl

SCLK
- *.TSC
- *.lbl

PCK
- *.TPC
- BPC
- *.LBL

CK

FK
- *.TF
- *.LBL

<yyyymm>
- *.BC
- *.lbl

Figure 1 The root directory of the archive and its immediate subdirectories. *The DATA subdirectory is given in Figure 2.

2.1. Root Directory Contents

Files in the root directory include an overview of the archive, a description of the volume for the PDS Catalog, and a list of errata or comments about the archive. The following files are contained in the Root Directory.

File Name	File Contents	Provided By
AAREADME.TXT	Volume content and format information with an attached PDS label. This file also contains a description of publicly available software, which was used in generating the products and which might be useful in analyzing them.	POC

ERRATA.TXT	A cumulative listing of comments and updates concerning all archive volumes published to date	POC
VOLDESC.CAT	A description of the contents of this volume in a PDS format readable by both humans and computers	POC

Table 2 Root directory contents.

2.2. Data (DATA) Directory Contents and Naming

The Data Directory contains the delivered science data products. Under the **DATA** directory is the SAR subdirectory. The SAR directory is further divided into a single subdirectory for the level-3 mosaic products and multiple subdirectories for the lower-level products

The subdirectories for the lower-level products are named based on the number of the orbit during which the original raw data were collected. The directory naming scheme contains two five-digit natural numbers separated by an underscore. The first number *aaaaa* is the number of the first orbit and the second number *bbbbb* is the number of the last orbit represented in the directory. In other words, a directory named "00402_00578" contains all data collected in orbits 402 through 578. The orbit numbers given in the directory names are padded with leading zeroes. The investigator who creates the product set will determine the number of orbits represented in a given directory. There are multiple directories of this type.

Within each orbit-numbers directory, there is a subdirectory for the raw data and each level of science data processing up to, but not including the level-3 mosaics. The level-3 SAR products reside in a separate **MOSAICS** directory at the same level as the orbit-number directories because the mosaic products are constructed from data acquired during multiple orbits and are therefore not associated with one particular orbit. The data product SIS document [ref. sec. 1.3] describes the naming convention for the files that reside within these subdirectories.
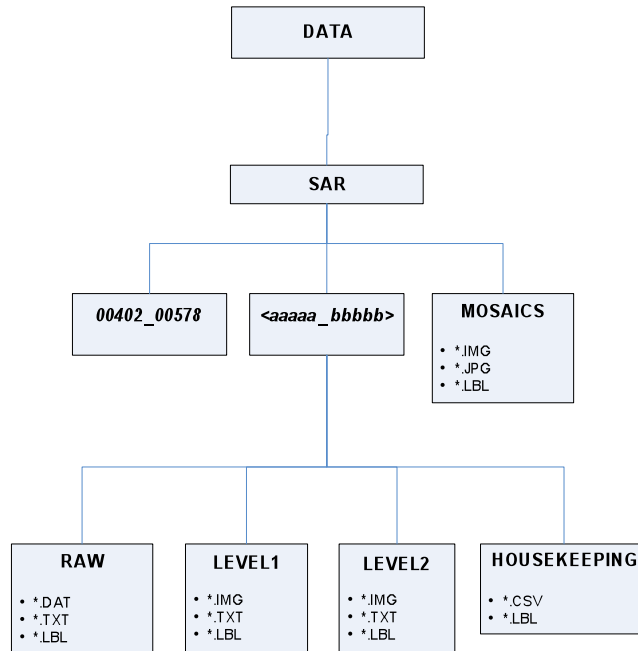
Figure 2 The DATA subdirectory (under root) and its subdirectories. The subdirectories titled "00402_00578" are examples of what the orbit-associated product directories following the aaaaa_bbbbb naming format would look like. The example directory 00402_00578 would contain the data collected during orbits 402 through 478.

2.2.1. The SAR (**SAR**) Subdirectory

As the name implies, the **SAR** directory contains the science data collected by the Forerunner instrument while operating in SAR mode. The orbit number subdirectories within this directory contain raw, level-1, and level 2 products. They do not contain level 0 products, as these are not archived at the PDS. The mosaic (**MOSAICS**) subdirectory contains the level-3 SAR mosaics.

Subdirectory Name	Directory Contents	Provided By
<aaaaa_bbbbb>/RAW	The raw data directory contains the Packetized Data Records (PDR) or "raw" data. These data are unprocessed CCSDS packets received from ISRO. They are provided to the PDS in "safed" form and are accompanied by minimal PDS labels. No formatting is done on them.	POC
<aaaaa_bbbbb>/HOUSEKEEPING	Housekeeping data associated with the collection period.	POC
<aaaaa_bbbbb>/LEVEL1	The level-1 SAR science data products including PDS labels. These contain processed binary data products and ancillary data in spreadsheet (CSV) and structured text files. This directory contains the original image file produced by the level-1 SAR processor, 4 Stokes parameter files, 3 derived parameter files (SSP, OSP, CPR) and ancillary data files.	POC

<aaaaa_bbbbb>/LEVEL2	The level-2 SAR science data products including PDS labels. These contain processed binary data products and ancillary data in spreadsheet (CSV) and structured text files. This directory contains the original image file produced by the level-2 SAR processor, 4 Stokes parameter files, 3 derived parameter files (SSP, OSP, CPR) and ancillary data files.	POC
MOSAICS	The level-3 (mosaic) SAR science data products including PDS labels.	POC

Table 3 A description of the contents of the numbered orbit subdirectories within the SAR directory. *<aaaaa_bbbbb>* indicates the number of the first orbit represented in the directory *aaaaa* and the number of the last orbit represented in the directory *bbbbb*.

2.3. Index Directory Contents

Files in the Index Directory are provided to help the user locate products on this archive volume and on previously released volumes in the archive. The following files are contained in the Index Directory.

File Name	File Contents	Provided By
INDXINFO.TXT	A description of the contents of this directory	POC
INDEX.TAB	Index file for the Mini-SAR science products (not including SPICE kernels). See *Table 5* below for a description of this file.	POC
INDEX.LBL	A detached PDS label that describes INDEX.TAB	POC
spice_index.tab	Index file for the SPICE kernels in the GEOMETRY directory	POC
spice_index.lbl	A detached PDS label that describes spice_index.tab	POC

Table 4 The contents of the INDEX directory. This contains index files for both the general archive and the SPICE kernels.

Column	Format	Length (bytes)	Example
VOLUME_ID	CHARACTER	14	"CH1MRF_1001"
DATA_SET_ID	CHARACTER	35	"CH1-ORB-L-MRFFR-5-CDR-MAP-V1.0"
PRODUCT_ID	CHARACTER	31	"FSB_04579_2CD_OKU_87S092_V1.IMG"
PRODUCT_VERSION_ID	CHARACTER	15	"1.0"
FILE_SPECIFICATION_NAME	CHARACTER	90	"CH1MRF_0XXX/DATA/SAR/00000_00499/LEVEL1/FSB_04579_2CD_OKU_87S092_V1.IMG.LBL"
PRODUCT_CREATION_TIME	TIME	25	2008-01-06T16:33
START_TIME	TIME	28	2007-11-01T19:03:13.462
STOP_TIME	TIME	28	2007-11-01T19:04:28.380
SPACECRAFT_CLOCK_START_COUNT	CHARACTER	30	"1/1234567890.54321"
SPACECRAFT_CLOCK_STOP_COUNT	CHARACTER	30	"1/1234568890.12345"
ORBIT_NUMBER	CHARACTER	7	"0310"

Table 5 The contents and format of the general archive INDEX.TAB file. Each record in the table will be composed of these fields and there will be one record for every product file in the archive. The spice_index.tab file follows the standard NAIF format.

2.4. Document Directory Contents

The Document Directory contains documentation to help the user understand and use the archive data. The following files are contained in the Document Directory. Files linked to the HTML (*.HTM) version of the documents will be stored in subdirectories of the same name as the document (without the file suffix). Each document is stored in its own subdirectory.

File Name	File Contents	Provided By
DOCINFO.TXT	A description of the contents of this directory	POC
DP_SIS/MRFFR_DP_SIS.HTM	The Data Product SIS as an HTML document (this will actually be a set of files containing both HTML text and images).	POC
DP_SIS/MRFFR_DP_SIS.PDF	The Data Product SIS as a PDF file	POC
DP_SIS/MRFFR_DP_SIS.LBL	A PDS detached label that describes both MRFFR_DP_SIS.HTM and MRFFR_DP_SIS.PDF	POC

AV_SIS/MRFFR_AV_SIS.HTM	The Archive Volume SIS (this document) as an HTML document (this will actually be a set of files containing both HTML text and images).	POC
AV_SIS/MRFFR_AV_SIS.PDF	The Archive Volume SIS (this document) as a PDF file	POC
AV_SIS/MRFFR_AV_SIS.LBL	A PDS detached label that describes both MRFFR_AV_SIS.HTM and MRFFR_AV_SIS.PDF.	POC
GB_CAL/MRFFR_GB_CALIB_JENSEN2009.PDF	Document describing the Feb. 28 and March 1, 2009 calibrations performed using data acquired at the Green Bank Radio Telescope.	POC
GB_CAL/MRFFR_GB_CALIB_JENSEN2009.HTM	Document describing the Feb. 28 and March 1, 2009 calibrations performed using data acquired at the Green Bank Radio Telescope in HTML format.	POC
GB_CAL/MRFFR_GB_CALIB_JENSEN2009.LBL	A PDS detached label that describes both MRFFR_GB_CALIB.PDF and MRFFR_GB_CALIB.HTM.	POC
MRF_CAL/MRF_CAL_MCKERRACHER_ET_AL2010.PDF	Document describing the overall Mini-RF instrument calibration in PDF format.	POC
MRF_CAL/MRF_CAL_MCKERRACHER_ET_AL2010.HTM	Document describing the overall Mini-RF instrument calibration in PDF format.	POC
MRF_CAL/MRF_CAL_MCKERRACHER_ET_AL2010.LBL	A PDS detached label that describes both the PDF and HTM versions of the Mini-RF overall calibration document.	POC
CH1_LDD.FULL	A local data dictionary that contains the definitions of mission-specific PDS keywords.	PDS

Table 6 The contents of the Document directory.

2.5. Catalog Directory Contents

The files in the Catalog Directory provide a top-level understanding of the mission, spacecraft, instruments, and data sets. The files in this directory are coordinated with the PDS data engineer, who is responsible for loading them into the PDS catalog. The following files are found in the Catalog Directory:

File Name	File Contents	Provided By
CATINFO.TXT	A description of the contents of this directory	POC
*_DS.CAT	Data set information for the PDS catalog (one file per data set). The file name will reflect the DATA_SET_ID, but will comply with PDS file naming standards. It will be composed of the DATA_SET_ID minus the "CH1-ORB-L-" prefix, all dashes and periods replaced with underscores, and _DS.CAT appended to the end. For example, the catalog file for the data set *CH1-ORB-L-MRFFR-4-CDR-V1.0* would be named **MRFFR_4_CDR_V1_0_DS.CAT**.	POC

INSTHOST.CAT	Instrument host (i.e., spacecraft) information for the PDS catalog	M3 Project
INST.CAT	Instrument information for the PDS catalog	POC
spice_inst.cat	"Instrument" information relating to SPICE kernels	NAIF
MISSION.CAT	Mission information for the PDS catalog	M3 Project
PERSON.CAT	Personnel information for the PDS catalog (Team and PDS personnel responsible for generating the archive)	POC
REF.CAT	References mentioned in other *.CAT files	POC
DSMAP.CAT	Contains the map projection equations for the level-2 products.	POC

Table 7 The contents of the Catalog directory.

2.6. EXTRAS Directory

This directory contains the JPEG browse images associated with the data products, the orbit number files, and the processing parameter file. Files in this directory do not have PDS labels associated with them.

2.6.1. QUIKVIEW Subdirectory Contents

The QUIKVIEW subdirectory contains reduced-size, easily viewed versions of data products to be used to help identify products of interest. These are JPEG-compressed images in standard JFIF format. Browse images are provided for level-2 circular polarization ratio and Stokes 1 parameter products only. Beneath the QUIKVIEW subdirectory, there will be multiple subdirectories organized and named by orbit number. These subdirectories will contain the browse images associated with the given orbits. The subdirectory naming scheme contains two five-digit natural numbers separated by an underscore. The first number *aaaaa* is the number of the first orbit and the second number *bbbbb* is the number of the last orbit represented in the directory. In other words, a directory named "00402_00578" contains all browse images associated with orbits 402 through 578. The orbit numbers given in the subdirectory names are padded with leading zeroes. There will be one of these subdirectories for each corresponding level-2 data directory.

2.6.2. ORBNUM Subdirectory Contents

The ORBNUM subdirectory contains orbit number files. These provide associations between orbit numbers and times. They are stored in subdirectories named by year and month. There is one orbit number file for each day. The subdirectory naming scheme is of the form *yyyyMM* where *yyyy* is the year and *MM* the month of the year when the orbit began.

2.6.3. MK Subdirectory Contents

This directory contains the SPICE metakernel. The metakernel lists in order the other kernels that are to be loaded when using Mini-SAR data. All of the other SPICE-related files reside in the GEOMETRY directory. In accordance with NAIF standards, the metakernel resides in the archive EXTRAS directory.

2.6.4. UNPROC Subdirectory Contents

This directory contains unprocessed raw data files and unused attitude (CK) kernels. It contains two subdirectories, PACKETS which contain unprocessed raw data files that were deemed unusable, and CK which contains CKs that cover part of the time that these raw files were collected. The data in the UNPROC directory have been determined to be not scientifically useful and are included in the archive only for completeness.

File Name	File Contents	Provided By
EXTRINFO.TXT	A description of the contents of this directory	POC
ORBNUM/<*yyyyMM*>/LRO_ORBNUM_*yyyymmdd_vv*.ORB	File containing the times and geometric information associated with the beginnings of orbits.	POC
QUIKVIEW/<*aaaaa_bbbbb*>/	A set of JPEG browse images of the level-2 ST1 and CPR product files stored in orbit-based subdirectories.	POC
PROCESSING_PARMS.TXT	A text file containing a set of parameters used in processing the science data products.	POC
MK/	The SPICE metakernel file.	POC
UNPROC/PACKETS UNPROC/CK	Contains unprocessed data that have been determined to be unusable.	POC

Table 8 The contents of the Extras directory.

2.7. Calibration (CALIB) Directory Contents

The Calib Directory contains calibration files used to process the data products, or calibration data needed to use the data products. The following files are contained in the **CALIB** Directory. There may be multiple versions of each file distinguished by the <*date*> section of the file name. The calibration files are associated with the level-1 products data set (CH1-ORB-L-MRFFR-4-CDR-V*n.n*). See the data product SIS document for the naming conventions applied to these files.

File Name	File Contents	Provided By
CALINFO.TXT	A description of the contents of this directory	POC
ARECIBO/FSA_RPD_200901301917_V01.DAT	Arecibo Radio Telescope calibration file collected on 30 Jan. 2009 at 19:17h UTC.	POC
ARECIBO/FSA_RPD_200901301917_V01.LBL	Parameter file for Arecibo Radio Telescope calibration file collected on 30 Jan. 2009 at 19:17h UTC.	POC
ARECIBO/FSA_RPD_200901301917_V01.LBL	PDS label for Arecibo Radio Telescope calibration file collected on 30 Jan. 2009 at 19:17h UTC.	POC
ARECIBO/FSA_RPD_200901301944_V01.DAT	Arecibo Radio Telescope calibration file collected on 30 Jan. 2009 at 19:44h UTC.	POC

ARECIBO/FSA_RPD_200901301944_V01.LBL	Parameter file for Arecibo Radio Telescope calibration file collected on 30 Jan. 2009 at 19:44h UTC.	POC
ARECIBO/FSA_RPD_200901301944_V01.LBL	PDS label for Arecibo Radio Telescope calibration file collected on 30 Jan. 2009 at 19:44h UTC.	POC
NADIR/FSC_RPD_200901182144_V01.DAT	Nadir calibration file collected on 18 Jan. 2009 at 21:44h UTC.	POC
NADIR/FSC_RPD_200901182144_V01.TXT	Parameter file for the nadir calibration file collected on 18 Jan. 2009 at 21:44h UTC.	POC
NADIR/FSC_RPD_200901182144_V01.LBL	PDS label for the nadir calibration file collected on 18 Jan. 2009 at 21:44h UTC.	POC
NADIR/FSC_RHK_200901182144_V01.CSV	Instrument housekeeping file associated wit the nadir calibration file collected on 18 Jan. 2009 at 21:44h UTC. Text file in CSV format.	POC
NADIR/FSC_RHK_200901182144_V01.LBL	PDS label for the instrument housekeeping file associated wit the nadir calibration file collected on 18 Jan. 2009 at 21:44h UTC.	POC

Table 9 The contents of the Calibration directory.

2.8. GEOMETRY Directory

This directory contains SPICE kernels (CH1-ORB-L-SPICE-6-V1.0) generated by ISRO and the Mini-RF POC for the Chandrayaan-1 mission and delivered to the PDS. These reside in the SPICE subdirectory within the GEOMETRY directory. In accordance with NAIF archiving conventions, both attached and detached PDS labels accompany each kernel. This directory contains subdirectories for each type of delivered kernel. Each subdirectory also contains an *info.txt file. SPICE metakernels are provided in the EXTRAS/MK directory in the archive volume. This volume does not contain instrument (IK) or events (EK) kernels. The SPICE kernels and labels are formatted in accordance with NAIF PDS node standards [see ref. sec. 1.3, item 6] even though, in the case of Forerunner, they are delivered to the Geosciences PDS node.

Per NAIF standards, all text SPICE kernels have Unix-style <LF> end of file markers, not PDS standard PC-style <CR><LF> end of line markers and all binary SPICE kernels are provided in big-endian byte order form.

Subdirectory	Files	Subdirectory Contents
<root>	GEOMINFO.TXT data/	GEOMINFO.TXT describes the contents of this directory. data/ is the subdirectory containing the SPICE kernel subdirectories.
data/ck	*.BC, ckinfo.txt	Attitude and pointing SPICE kernels (CK).
data/fk	*.tf, fkinfo.txt	Frame kernels (FK).
data/lsk	*.tls, lskinfo.txt	The leap seconds kernel (LSK).
data/pck	*.tpc, *.bpc, pckinfo.txt	The planetary constants kernels (PCK).

data/sclk	*.TSC, sclkinfo.txt	The spacecraft clock coefficients kernels.
data/spk	*.BSP, *.bsp, spkinfo.txt	The full mission spacecraft and planetary ephemeris kernels (SPK).

Table 10 The organization of the GEOMETRY directory which contains SPICE kernels and ancillary files. All kernels have associated detached PDS labels (*.lbl) in the same directory. Note that the metakernel resides in the EXTRAS/MK directory.

3. Archive Volume Format

This section describes the format of Forerunner Archive Volumes. Data that comprise the Archive will be formatted in accordance with Planetary Data System specifications [Applicable Documents 4 and 5].   There will be only one archive volume, and its VOLUME_ID is **CH1MRF_0XXX**.

Archive Volumes are delivered to the PDS on a mailable external hard drive.

3.1. File Formats

This section describes file formats for the kinds of files contained on Archive Volumes.

3.1.1. Document File Format

Document files exist in the Root, DATA, DOCUMENT and CATALOG directories. They are ASCII files, which may have attached PDS labels. Lines in a .TXT or .CAT file end with a PDS-standard carriage return character (ASCII 13) and a line feed character (ASCII 10). This allows the files to be readable under various operating systems.

Documents in the Document directory contain formatting and figures that cannot be rendered as ASCII text. Therefore each document is given in two formats, hypertext and PDF. The hypertext file contains ASCII text plus hypertext markup language (HTML) commands that enable it to be viewed in a web browser such as Mozilla, Apple Safari, or Microsoft Internet Explorer. The web browser automatically incorporates subsidiary files such as images and style sheets referenced by the HTML file into the document. The second format, PDF (Portable Document Format) is a format from Adobe Systems Inc.® that is frequently used for distributing documents. Adobe offers free software, Acrobat Reader, for viewing PDF files.

3.1.2. Tabular File Format

Tabular files (.TAB suffix) exist in the Index directory. Tabular files are ASCII files formatted for direct reading into many database management systems on various computers. All fields are separated by commas, and character fields are enclosed in double quotation marks ("). (Character fields are padded with spaces to keep quotation marks in the same columns of successive records.) Character fields are left justified, and numeric fields are right justified. The "start byte" and "bytes" values listed in the labels do not include the commas between fields or the quotation marks surrounding character fields. The records are of fixed length, and the last two bytes of each record contain the ASCII carriage return and line feed characters. This allows a table to be treated as a fixed length record file on computers that support this file type and as a text file with embedded line delimiters on those that don't.

All tabular files are described by detached PDS labels. The PDS label file has the same name as the data file it describes, with the extension .LBL; for example, the file INDEX.TAB is accompanied by the detached label file INDEX.LBL in the same directory.

3.1.3. Spreadsheet File Format

Ancillary text data are provided in spreadsheet format. A spreadsheet file is a comma-delimited ASCII text file (.CSV suffix). Spreadsheet files are designed to be easily read by third-party spreadsheet software such as Microsoft Excel, Open Office, and others. Unlike Tabular files, spreadsheet files are not of fixed record length and character fields are not padded with spaces and no left or right justification is done. As with all delivered text files, the last two bytes of each record contain the ASCII carriage return and line feed characters.

All spreadsheet files are described by detached PDS labels. The PDS label file has the same name as the data file it describes, with the extension .LBL. The PDS label gives a complete description of every field in the spreadsheet (see *Planetary Data System Standards Reference* [**Error! Reference source not found.**], section A.28).

3.1.4. Raw Format

The raw or Packetized Data Records (PDR) files contain binary and unprocessed CCSDS packet data. These are provided with only minimal PDS labels. The PDS label file has the same name as the data file it describes, with the extension .LBL.

3.1.5. Binary File Format

The RAW data and certain supporting products are provided as binary tables. These products consist of numerical data in big-endian format. They are accompanied by detached full PDS labels.

3.1.6. Mosaic Format

The level-3 mosaics are created using the Integrated Software for Imaging Spectrometers (ISIS) software from the USGS. These are images comprised of calibrated data from multiple orbits. They are single band raw binary images consisting of 32-bit floating point pixels. They are also provided as JPEG images. They are accompanied by detached full PDS labels.

3.1.7. Image Format

The primary level-1 and level-2 science data products as well as some of the supporting data are provided as binary image files. They contain data of both numeric and character types. The data are written in little-endian (PC_REAL) format

All binary files are described by detached PDS labels. The PDS label file has the same name as the data file it describes, with the extension .LBL. The PDS label gives a complete description of every field in the data file.

3.1.8. SPICE Kernels Format

Geometry, ephemeris, and attitude information are provided in SPICE kernels. SPICE kernels can contain either binary or text data.

All SPICE files are described by attached and detached PDS labels. The PDS label file has the same name as the data file it describes, with the extension .lbl. The PDS standards provide a label standard for SPICE kernels (see *Planetary Data System Standards Reference* [1.3], section A.27). This standard will be followed for the Forerunner SPICE kernels.

The SPICE kernels reside in the GEOMETRY directory of this archive.

3.1.9. PDS Label Format

All data files in the archive have PDS labels, either embedded at the beginning of the file or detached in a separate file. For examples of PDS labels for each type of data product, see the Data Product SIS [Applicable Document 3].

A PDS label, whether embedded or detached from its associated file, provides descriptive information about the associated file. The PDS label is an object-oriented structure consisting of sets of 'keyword=value' declarations. The object to which the label refers (e.g. IMAGE, TABLE, etc.) is denoted by a statement of the form:

    ^object = location

in which the carat character (^, also called a pointer in this context) indicates where to find the object. In an embedded label, the location is an integer representing the starting record number of the object (the first record in the file is record 1). In a detached label, the location denotes the name of the file containing the object, along with the starting record or byte number, if there is more than one object in the file. For example:

    ^HEADER = ("F01.IMG",1)

    ^IMAGE = ("F01.IMG",1025 <BYTES>)

indicates that the IMAGE object begins at byte 1025 of the file F01.IMG, in the same directory as the detached label file. Below is a list of the possible formats for the ^object definition.

    ^object   = n

    ^object   = n<BYTES>

    ^object   = "filename.ext"

    ^object   = ("filename.ext",n)

    ^object   = ("[dirlist]filename.ext",n)

    ^object   = ("filename.ext",n<BYTES>)

    ^object   = ("[dirlist]filename.ext",n<BYTES>)

where

    n is the starting record or byte number of the object, counting from the beginning of the file (record 1, byte 1),

    <BYTES> indicates that the number given is in units of bytes,

    filename is the up to 27 character, alphanumeric upper-case file name,

ext is the 3 character upper-case file extension,

dirlist is a period-delimited path-list of parent directories, in upper case, that specifies the object file directory (used only when the object is not in the same directory as the label file). The list begins at the directory level below the root directory of the CD-ROM. '[dirlist]' may be omitted when the object being described is located either in the same directory as the detached label, or in a subdirectory named LABEL that is located in a higher level of the directory tree, typically the CD-ROM root itself.

A reference to an external text file would be indicated by the ^TEXT keyword. For example:

^TEXT = ("FILENAME.TXT")

A reference to a separate spreadsheet (CSV) file would be indicated by the ^SPREADSHEET keyword. For example:

^SPREADSHEET = ("F_CAL_PPF_20070011000_01.CSV")

Lines of text in detached labels end with a carriage return character (ASCII 13) and a line feed character (ASCII 10). This allows the files to be readable under various operating systems.

3.1.10. Catalog File Format

Catalog files (suffix .CAT) exist in the Root and Catalog directories. They are text files formatted in an object-oriented structure consisting of sets of 'keyword=value' declarations.

4. Archive Volume Generation

4.1. Data Transfer and Validation Methods

Initially, the entire data archive is produced at the Payload Operations Center (POC) and delivered to the PDS Geosciences node on a detachable hard drive or through electronic transfer. The POC will make multiple deliveries to the PDS. Only new or changed files will be delivered in subsequent deliveries.

4.2. Data Product Sizes and Delivery Rates

The POC will provide the data products to the PDS twelve months after the end of each observation opportunity. It is expected that there will be a single Forerunner delivery to the PDS.

Product	Product Size Per Day	Expected Number of Products for Primary 2-Year Mission	Expected Total Data Volume for Primary Mission
Raw SAR	3.6 GB	356	1,284 GB
Level-1 SAR	270 MB	356	96 GB
Level-2 SAR	590 MB	356	210 GB
Level-3 SAR (mosaic)	N/A	16	4 GB
Ancillary data	5 MB	100	2 GB

Table 11 A summary of the expected sizes and production rates for the Forerunner standard products.

5. Support Staff and Cognizant Persons

Name	Affiliation	Role on Project	Address	e-mail
Dr. Paul Spudis	Lunar And Planetary Institute	Forerunner Principal Investigator	3600 Bay Area Blvd. Houston, TX 77058	spudis@lpi.usra.edu
Dr. D. Ben Bussey	JHU/APL	Mini-RF Science Team Liaison	11100 Johns Hopkins Rd. Laurel, MD 20723	Ben.Bussey@jhuapl.edu
Helene Winters	JHU/APL	Project Manager	11100 Johns Hopkins Rd, Laurel, MD 20723	helene.winters@jhuapl.edu
Mike Reid	JHU/APL	Data Archivist	11100 Johns Hopkins Rd, Laurel, MD 20723	mike.reid@jhuapl.edu
Susan Slavney	PDS Geosciences Node, Washington University in St. Louis	PDS Representative	1 Brookings Drive Campus Box 1169 St. Louis, MO 63130	Susan.Slavney@wustl.edu

Table 12 The list of key personnel on the Forerunner project.

6. Glossary

Archive – An archive consists of one or more data sets along with all the documentation and ancillary information needed to understand and use the data. An archive is a logical construct independent of the medium on which it is stored.

Archive Volume, Archive Volume Set – A volume is a unit of media on which data products are stored; for example, one CD-ROM or DVD-ROM. An *archive volume* is a volume containing all or part of an archive; that is, data products plus documentation and ancillary files. When an archive spans multiple volumes, they are called an *archive volume set*. Usually the documentation and some ancillary files are repeated on each volume of the set, so that a single volume can be used alone.

Catalog Information – Descriptive information about a data set (e.g. mission description, spacecraft description, instrument description), expressed in Object Description Language (ODL) which is suitable for loading into a PDS catalog.

Data Product – A labeled grouping of data resulting from a scientific observation, usually stored in one file. A product label identifies, describes, and defines the structure of the data. An example of a data product is a planetary image, a spectrum table, or a time series table.

Data Set – An accumulation of data products. A data set together with supporting documentation and ancillary files is an archive.

Standard Data Product – A data product generated in a predefined way using well-understood procedures, processed in "pipeline" fashion. Data products that are generated in a nonstandard way are sometimes called *special data products*.

7. Acronyms

APL	(The Johns Hopkins University) Applied Physics Laboratory
ASCII	American Standard Code for Information Interchange
CCSDS	Consultative Committee for Space Data Systems
CK	Camera-matrix (attitude) Kernel
CDR	Calibrated Data Record
DEM	Digital Elevation Model
EK	Events Kernel
FK	Frames Kernel
GSFC	Goddard Space Flight Center
IK	Instrument Kernel
ISIS	Integrated Software for Imaging Spectrometers (USGS software)
ISRO	Indian Space Research Organisation
JFIF	JPEG File Interchange Format (file format for JPEG images)
JHU/APL	The Johns Hopkins University Applied Physics Laboratory
JPEG	Joint Photographic Experts Group (image compression algorithm)
JPL	(NASA) Jet Propulsion Laboratory
LSK	Leap Seconds Kernel
LRO	Lunar Reconnaissance Orbiter
M3	Moon Mineralogy Mapper (NASA instrument on Chandrayaan-1)
NAIF	(NASA/JPL) Navigation and Ancillary Information Facility
NASA	National Aeronautics and Space Administration
ODL	Object Description Language
PCK	Planetary Constants Kernel
PDF	(Adobe) Portable Document Format
PDR	Packetized Data Records
PDS	(NASA) Planetary Data System
POC	Payload Operations Center (at APL)
PVL	Parameter Value Language
SAR	Synthetic Aperture Radar
SCLK	Spacecraft Clock Kernel (SPICE)
SFTP	Secure File Transfer Protocol
SPICE	Spacecraft, Planet, Instrument, C-matrix Events
SPK	Spacecraft and Planet (ephemeris) Kernel

USGS	United States Geological Survey
UTC	Coordinated Universal Time