Mars 2020
RIMFAX
PDS Archive Bundle
Software Interface Specification (SIS)

Version 2.0

July 22, 2021

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Mars 2020

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Document Change Log

Version	Change	Date	Affected portion
0.9	Pre-peer-review version	October 28, 2020	All
1.0	Post-peer-review version	December 22, 2020	
2.0	Revised to include RDR products; updated PDS version to 1.15.0.0	January 27, 2021	1.3, Table 5, 3.4
2.0	Revised to change RDR file naming scheme and SIS to “Calibrated”	April 5, 2021	3.4.3
2.0	Updated PDS version to 1.16.0.0. Updated Archive Plan reference. Updated LID examples. Updated versions of PDS4 dictionaries.	July 22, 2021	1.3, 3.4.1, Table 5

TBD Items

Item	Section(s)	Responsibility

Acronyms and Abbreviations

Acronym/Abbreviation	Meaning
ASCII	American Standard Code for Information Interchange
CDR	Calibrated Data Record
EDR	Experiment Data Record
FITS	Flexible Image Transport System
FSW	Flight Software
GDS	Ground Data System
GIF	Graphics Interchange Format
GPR	Ground Penetrating Radar
HiRISE	High Resolution Imaging Science Experiment (on the Mars Reconnaissance Orbiter mission)
HTML	HyperText Markup Language
IDS	Instrument Data System
JPEG	Joint Photographic Experts Group
JPL	Jet Propulsion Laboratory
LID	Logical Identifier
LIDVID	Versioned Logical Identifier (logical identifier with version identifier)
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
NSSDCA	National Space Science Data Coordinated Archive
PDS	Planetary Data System (the organization)
PDS4	Planetary Data System Version 4 (the archive standard)
PNG	Portable Network Graphics
RCE	Rover Compute Element
RDR	Reduced Data Record
RIMFAX	Radar Imager for Mars subsurFace eXperiment
RX	Receiver
SCLK	Spacecraft Clock

SFDU	Standard Format Data Unit
SIS	Software Interface Specification
Sol	Mars solar day
SPICE	Spacecraft, Planet, Instrument, C-matrix, Events kernels
TBD	To Be Determined/Defined
TBPB	To Be Provided By
TIFF	Tagged Image File Format
TX	Transmitter
UTC	Coordinated Universal Time
VICAR	Video Image Communication and Retrieval
VID	Version Identifier
XML	Extensible Markup Language

Glossary

Many of these definitions are taken from Appendix A of the PDS4 (Planetary Data System Version 4) Concepts Document, pds.nasa.gov/pds4/doc/concepts. The reader is referred to that document for more information.

Archive – A place in which public records or historical documents are preserved; also the material preserved, often used in plural. The term may be capitalized when referring to all of PDS holdings (i.e., the PDS Archive).

Basic Product – The simplest product in PDS4; one or more data objects (and their description objects), which constitute (typically) a single observation, document, etc. The only PDS4 products that are *not* basic products are collection and bundle products.

Bundle – A list of related collections. For example, a bundle could list a collection of raw data obtained by an instrument during its mission lifetime, a collection of the calibration products associated with the instrument, and a collection of all documentation relevant to the first two collections.

Class – The set of attributes (including a name and identifier) which describes an item defined in the PDS Information Model. A class is generic, i.e., a template from which individual items may be constructed.

Collection – A list of closely related basic products of a single type (e.g. observational data, browse files, documents, etc.). A collection is itself a product (because it is simply a list, with its label), but it is not a *basic* product.

Data Object – A generic term for an object that is described by a description object. Data objects include both digital and non-digital objects.

Description Object – An object that describes another object. As appropriate, it will have structural and descriptive components. In PDS4 a 'description object' is a digital object, such as a string of bits with a predefined structure.

Digital Object – An object which consists of electronically stored (digital) data.

Identifier – A unique character string by which a product, object, or other entity may be identified and located. Identifiers can be global, in which case they are unique across all of PDS (and its federation partners). A local identifier must be unique within a label.

Label – The aggregation of one or more description objects such that the aggregation describes a single PDS product. In the PDS4 implementation, labels are constructed using XML (eXtensible Markup Language).

Logical Identifier (**LID**) – An identifier that identifies the set of all versions of a product.

Versioned Logical Identifier (LIDVID) – The concatenation of a logical identifier with a version identifier, providing a unique identifier for each version of product.

Metadata – Data about data. For example, a 'description object' contains information (metadata) about an 'object.'

Object – A single instance of a class defined in the PDS Information Model.

PDS Information Model – The set of rules governing the structure and content of PDS metadata. While the Information Model (IM) has been implemented in XML for PDS4, the model itself is implementation independent.

Product – One or more labeled objects (digital, non-digital, or both) grouped together and having a single PDS-unique identifier. In the PDS4 implementation, if a product consists of multiple objects, their descriptions are combined into a single XML label. Although it may be possible to locate individual objects within PDS (and to find specific bit strings within digital objects), PDS4 defines 'products' to be the smallest granular unit of addressable data within its complete holdings.

RCE (Rover Compute Element) – One of the two redundant flight computers on Mars 2020. Either RCE (A or B) may be active at any given time.

Registry – A data base that provides services for sharing content and metadata.

XML schema – The definition of an XML document, specifying required and optional XML elements, their order, and parent-child relationships.

XML Schematron – A set of rules used to validate an XML document.

Version Identifier (VID) – Consist of major and minor components separated by a "." (M.n), which identify a specific version of a product.

1 Overview

1.1 Purpose and Scope

This Software Interface Specification (SIS) describes the format and content of the Mars 2020 RIMFAX Planetary Data System (PDS) data archive bundle in which data products, documentation, and supporting material are stored. This document is intended for the scientists who will analyze the data, including those associated with the project and those in the general planetary science community.

1.2 Contents

This SIS describes the organization, identification, and labeling of Mars 2020 RIMFAX raw and calibrated products. For details about these products, including how the instrument acquires data and how the data are processed, see the Mars 2020 RIMFAX Experiment Data Record (EDR) Data Product SIS [7] and RIMFAX Calibrated Data Record (CDR) Data Product SIS [8].

1.3 Applicable Documents

[1] PDS4 Concepts Document, version 1.16.0.0, April 21, 2021, https://pds.nasa.gov/datastandards/documents/concepts/.

[2] Planetary Data System Standards Reference, version 1.16.0.0, April 21, 2021, https://pds.nasa.gov/datastandards/documents/sr/.

[3] Planetary Data System Data Provider's Handbook, version 1.16.0.0, April 21, 2021, https://pds.nasa.gov/datastandards/documents/dph/.

[4] PDS4 Common Data Dictionary, Abridged, version 1.16.0.0, April 2021, https://pds.nasa.gov/datastandards/documents/dd/.

[5] PDS4 Information Model Specification, version 1.16.0.0, April 2021, https://pds.nasa.gov/datastandards/documents/im/.

[6] Mars 2020 Project Archive Generation, Validation and Transfer Plan, JPL D-95520.

[7] Mars 2020 (M2020) Software Interface Specification: RIMFAX Experiment Data Record (EDR) Data Products, JPL D-99964, October 7, 2020.

[8] Mars 2020 Radar Imager for Mars' subsurFace eXperiment (RIMFAX) PDS Archive Calibrated Data Software Interface Specification, March 23, 2021.

[9] Farley, K.A., Williford, K.H., Stack, K.M. et al. Mars 2020 Mission Overview. Space Sci Rev 216, 142 (2020), https://doi.org/10.1007/s11214-020-00762-y.

[10] Hamran, SE., Paige, D.A., Amundsen, H.E.F. et al. Radar Imager for Mars' Subsurface Experiment—RIMFAX. Space Sci Rev 216, 128 (2020), https://doi.org/10.1007/s11214-020-00740-4.

PDS4 is the name of the current PDS archive standard, described in Documents [1] through [5]. The PDS4 Information Model and Documents [1] through [5] are subject to periodic revision. The most recent versions may be found at https://pds.nasa.gov/datastandards/documents/. The PDS4 products specified in this SIS have been designed based on the versions current at the time, which are those listed above. Data products will be archived using the version of the PDS Information Model that is current at the time the products are submitted to peer review. Peer-reviewed products do not need to be revised to incorporate subsequent changes in the Information Model.

1.4 Audience

This SIS is intended to be used both by the instrument team in generating the archive and by data users wishing to understand the format and content of the archive. Typically, these individuals would include scientists, data analysts, and software engineers.

1.5 Mars 2020 Mission

The Mars 2020 spacecraft launched in July of 2020 and placed the Perseverance Rover on the surface of Mars in Jezero Crater on February 18, 2021. The goal of the mission is to seek signs of life and to collect rock and soil samples for a future return to Earth. The rover will explore the landing site and acquire imaging, spectroscopy, and other measurements to characterize Martian soils, rocks, atmosphere, and other aspects of the environment. The rover carries seven scientific instruments and a sample acquisition and caching system. The various payload elements will be used as an integrated suite of tools to characterize the local geology, to study particular rock and soil targets, to characterize the local environment, and to acquire and cache selected rock and soil samples. The prime mission for the rover is expected to be 836 sols (approximately 2.5 Earth years), with the possibility of an extended mission of unknown duration after that. For additional information see the Mars 2020 mission paper [9].

1.6 RIMFAX Description

RIMFAX is a ground penetrating radar (GPR) that uses a single antenna to transmit (via a transmitter, TX) and receive (via a receiver, RX) electromagnetic waves over a range of frequencies (150 to 1200 MHz) into/from the surface. The instrument can be operated in either active (TX and RX) or passive (RX-only) modes. Transmitted waves propagate downward until they are reflected back by the surface and shallow interfaces in the subsurface geologic structure across which discontinuities in permittivity (i.e., storage of electrical energy in an electric field) exist.

Each passive or active measurement taken across the frequency range, or bandwidth, is known as a “sounding”. A sounding is a time series of the reflected power received by the radar where the time of each sample is related to the position in the subsurface where the reflected power originated. The RIMFAX instrument paper [10] describes this relationship. When measurements are made while the rover (and RIMFAX) is stationary with respect to the surface, successive soundings build a time series that describes how the dielectric properties of the surface/subsurface evolve for a single location over a given period. When the rover (and RIMFAX) moves along a traverse path, successive soundings provide the dielectric structure of the surface/subsurface as a function of location. The 2-D display of these soundings according to their acquisition location is an image known as a radargram.

Details of the RIMFAX instrument may be found in the RIMFAX Experiment Data Record (EDR) Data Product SIS [7], the RIMFAX Calibrated Data Record (CDR) Data Product SIS [8], and the RIMFAX instrument paper [10].

2 RIMFAX Data Products

2.1 Data Product Overview

Mars 2020 RIMFAX data products in this bundle consist of raw and calibrated data. Table 1 shows a summary of all RIMFAX product types. Data file formats are covered in Section 4 of this document. See the EDR Data Product SIS [7] and the Calibrated (RDR) Data Product SIS [8] for details.

Table 1 All RIMFAX Data Product Types

Product Name	RIMFAX Product Type	Processing Level	PDS4 Bundle and Collection, with prefix urn:nasa:pds	Description	PDS Data Type and File Name Extension
GPR Measurements in Frequency Domain	EDR	raw	mars2020_rimfax: data_raw	Depacketized, time sequenced GPR raw science data and metadata in the frequency domain	Table_Binary, .DAT
GPR Measurements Metadata File	EDM	raw	mars2020_rimfax: data_raw	Metadata accompanying EDR science data	Table_Delimited, .CSV
Housekeeping Data	EHK	raw	mars2020_rimfax: data_hk	Depacketized, time sequenced housekeeping data	Table_Delimited, .CSV
Housekeeping Data Metadata File	EHM	raw	mars2020_rimfax: data_hk	Metadata accompanying EHK housekeeping data	Table_Delimited, .CSV
CDR	CDR	calibrated	mars2020_rimfax: data_calibrated	Calibrated GPR data for each measurement and select HK data. Active sounding data are in time domain; Passive radiometry data remain in frequency domain	Table_Delimited, .CSV
Browse Radargram	n/a	browse	mars2020_rimfax: browse_radargram	Browse image for the calibrated time-domain radar data with the surface vertically shifted to incorporate topography	Encoded_Image, .PNG
EDR SIS	n/a	document	mars2020_rimfax: document	Description of EDR contents and format	Document, .PDF
CDR SIS	n/a	document	mars2020_rimfax: document	Description of CDR contents and format	Document, .PDF
Bundle SIS	n/a	document	mars2020_rimfax: document	Description of mars2020_rimfax bundle organization	Document, .PDF
Calibrated Data Catalog	n/a	document	mars2020_rimfax: document	A table of selected information from and about the calibrated data products	Table_Delimited, CSV

2.2 Data Processing Levels

Data processing levels mentioned in this SIS refer to the PDS4 processing levels described in Table 2. The lowest processing level archived in PDS is "raw" as described in the table.

In general Mars 2020 archives employ the abbreviation RDR for Reduced Data Record, referring to data products at any level of processing beyond the raw data. The term CDR for Calibrated Data Record refers specifically to one category of RDRs, that is, data products that have been calibrated.

Table 2 Data Processing Level Definitions

PDS4 processing level	PDS4 processing level description
Raw	Original data from an experiment. If compression, reformatting, packetization, or other translation has been applied to facilitate data transmission or storage, those processes are reversed so that the archived data are in a PDS approved archive format. Often called EDRs (Experimental Data Records).
Partially Processed	Data that have been processed beyond the raw stage but which have not yet reached calibrated status. These and more highly processed products are often called RDRs (Reduced Data Records).
Calibrated	Data converted to physical units, which makes values independent of the experiment.
Derived	Results that have been distilled from one or more calibrated data products (for example, maps, gravity or magnetic fields, or ring particle size distributions). Supplementary data, such as calibration tables or tables of viewing geometry, used to interpret observational data should also be classified as 'derived' data if not easily matched to one of the other three categories.

3 RIMFAX Archive Organization

This section describes the organization of the RIMFAX archive according to the PDS4 Information Model [5].

3.1 The RIMFAX Bundle

The highest level of organization for a PDS archive is the bundle. A bundle is a set of one or more related collections that may be of different collection types. A collection is a set of one or more related basic products that are typically all of the same product type. Bundles and collections are logical structures, not necessarily tied to any physical directory structure or organization. Figure 1 illustrates the relationships among bundles, collections, and products. A product consists of a file containing one or more digital objects (e.g., a table of data, an image, or a document) described by an accompanying label file.

The complete RIMFAX archive is organized into one bundle. The bundle's PDS Logical Identifier (LID) is **urn:nasa:pds:mars2020_rimfax**.

3.2 RIMFAX Collections

The RIMFAX bundle includes the following collections of data products and document products. The document collection includes the RIMFAX EDR Data Product Software Interface Specification (SIS) [7], the RIMFAX Calibrated (CDR) Data Product Software Interface Specification [8], and the RIMFAX Bundle Software Interface Specification (this document).

Table 3 Collections in the RIMFAX Bundle

Collection Logical Identifier	Collection Type	Contents
urn:nasa:pds:mars2020_rimfax:data_raw	Data	Raw (EDR) science data products
urn:nasa:pds:mars2020_rimfax:data_hk	Data	Raw (EDR) housekeeping data products
urn:nasa:pds:mars2020_rimfax:data_calibrated	Data	Calibrated (CDR) data products
urn:nasa:pds:mars2020_rimfax:browse_radargram	Browse	Browse images of radargrams compiled for select calibrated data products
urn:nasa:pds:mars2020_rimfax:document	Document	Documentation, including this SIS and the EDR and CDR Data Product SISes

3.3 RIMFAX Data Organization

The RIMFAX bundle is organized as a single directory tree with a subdirectory for each collection. Raw Data and HK Data subdirectories are further subdivided by sol (Mars day); the Calibrated Data subdirectory is subdivided by Earth year, e.g. 2021. See Appendix B for a diagram of the full directory structure of the bundle.

3.4 RIMFAX Product Identification and Naming

A RIMFAX data product consists of a file composed of one or more digital objects (e.g., a table of data, an image, or a document), accompanied by a PDS label file. Document files in document products and browse files in browse products also contain a respective PDS label file. The PDS label provides identification and other metadata for the data file. The PDS label typically has the same name as the file it describes, except that it has the extension ".xml". See section 3.5 for more information about PDS labels.

The collections and the bundle themselves are also considered products in PDS, and therefore have their own labels. The bundle label is in the root directory of the archive and is named **bundle_rimfax.xml**. The label for a collection is found in the directory for the collection, and is named **collection_<something>.xml**. For example, the label for the **data_raw** collection is the file **collection_data_raw.xml** in the directory **data_raw**. Each collection has an inventory table that lists the products in the collection, e.g. **collection_data_raw_inventory.csv**.

3.4.1 Logical Identifiers

Every product in PDS is assigned a Logical Identifier (LID) that allows it to be uniquely identified across the system. Each product also has a Version Identifier (VID) that allows different versions of a specific product to be referenced uniquely. A product's LID and VID are defined as separate attributes in the product label. For convenience they may be combined in a single string called a LIDVID, with two colons between the LID and the VID. If a particular version of a product is desired, the LIDVID should be used; otherwise the LID alone should be used with the understanding that it refers to the latest version of the product.

LIDs and VIDs are assigned by PDS and are formed according to the conventions described in the following sections. More information on LIDs and VIDs may be found in Section 6D of the PDS Standards Reference [2] and in Chapter 5 of the Data Providers' Handbook [3].

3.4.1.1 LID Formation

LIDs take the form of a Uniform Resource Name (URN). LIDs are restricted to ASCII lower case letters, digits, dash, underscore, and period. Colons are used to separate prescribed components of the LID. Within one of these prescribed components, the dash, underscore, or period may be used as separators. LIDs are limited in length to 255 characters.

Mars 2020 LIDs are formed according to the following conventions:

- Bundle LIDs are formed by appending a bundle-specific ID to the PDS base ID:

  urn:nasa:pds:<bundle ID>

  Example: **urn:nasa:pds:mars2020_rimfax**

  The bundle ID must be unique across all bundles archived with the PDS.

- Collection LIDs are formed by appending a collection-specific ID to the collection's parent bundle LID:

  urn:nasa:pds:<bundle ID>:<collection ID>

  Example: **urn:nasa:pds:mars2020_rimfax:data_calibrated**

  The collection ID must be unique across the bundle. Collection IDs correspond to the collection type (e.g. "browse", "data", "document", etc.). Additional descriptive information may be appended to the collection type (e.g. "data_raw", "data_calibrated", etc.).

- Basic product LIDs are formed by appending a product-specific ID to the product's collection LID:

  urn:nasa:pds:<bundle ID>:<collection ID>:<product ID>

  Example: **urn:nasa:pds:mars2020_rimfax: data_calibrated:rimfax_calibrated_0081**

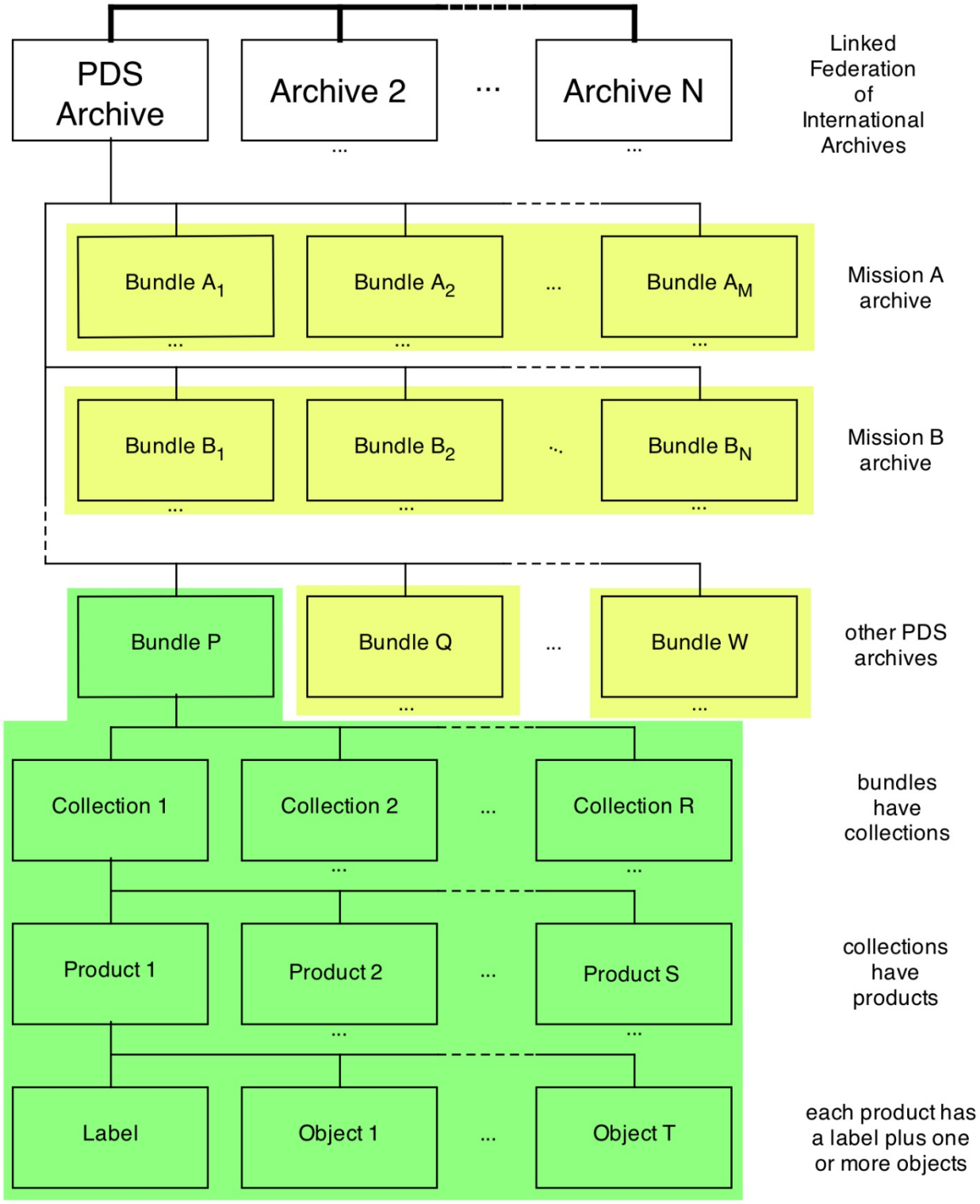

Figure 1 PDS bundles, collections, and products.

The product LID must be unique across the collection. For RIMFAX EDR data products, the product LID is the same as the lowercased data file name with the extension. For RIMFAX CDR data products, the product LID is the same as the lowercased data file name without the extension.

3.4.1.2 VID Formation

Product Version IDs consist of major and minor components separated by a "." (M.n). Both components of the VID are integer values.

For RIMFAX EDRs, the major component is set based on the operations pipeline version ID assigned to the product. This value is extracted from the last two characters of the ops product filename. For RIMFAX EDR products the minor version is always "0". Thus the complete VID for all RIMFAX EDR products is "M.0". As not all internal product versions are released to PDS, "M" does not necessarily begin at 1, and revisions in the PDS archive may skip version numbers. This versioning scheme does not follow the PDS standard for versioning, which requires versions to begin at 1.0 and increment sequentially.

For RIMFAX RDRs, versioning follows the rules in the PDS Standards Reference [2]. The major component is initialized to a value of "1", and the minor component is initialized to a value of "0". The minor component resets to "0" when the major component is incremented.

Example of a complete LIDVID for a RIMFAX EDR data product, version 1.0:

urn:nasa:pds:mars2020_rimfax:data_raw: xm2_d030t0633687556edr0010212n__a_0cr1xxxx00000j01.dat::1.0

Example of a complete LIDVID for a RIMFAX CDR data product, version 1.0:

urn:nasa:pds:mars2020_rimfax:data_calibrated:rimfax_calibrated_0081::1.0

3.4.2 EDR File Naming Convention

Figure 2 and Table 4 illustrate the file naming convention for RIMFAX raw (EDR) data products. This convention is used for most Mars 2020 data files, and some fields do not apply to RIMFAX. More details about this naming convention are found in the RIMFAX EDR Data Product SIS [7].

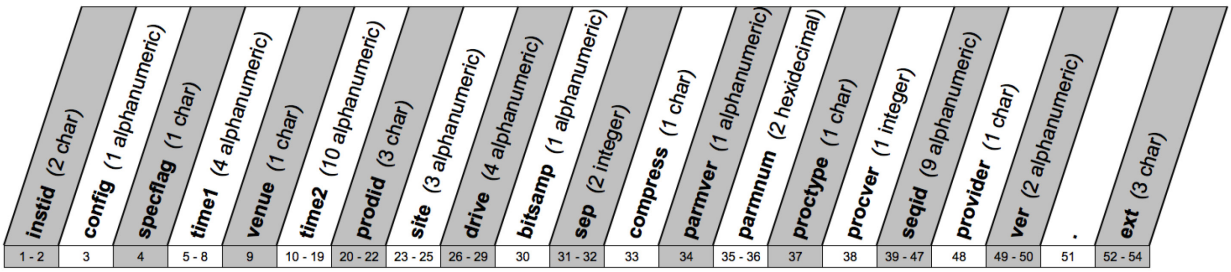

Figure 2 RIMFAX File Naming Scheme

Table 4 RIMFAX Raw (EDR) File Name Components

Characters	Contents	Description
1-2	Instrument	XM: RIMFAX Mobile XS: RIMFAX Stationary

3	Configuration	1 – RCE side A, Antenna ACTIVE 2 – RCE side A, Calibration Cable ACTIVE 3 – RCE side A, Antenna PASSIVE 4 – RCE side A, Calibration Cable PASSIVE 5 – RCE side B, Antenna ACTIVE 6 – RCE side B, Calibration Cable ACTIVE 7 – RCE side B, Antenna PASSIVE 8 – RCE side B, Calibration Cable PASSIVE
4	Special Processing Flag	Indicates off-nominal or special processing; applicable to RDRs only. See EDR Data Product SIS for details [7].
5-8	Time1	Sol number for flight surface data; see EDR SIS for other uses
9	Venue	Underscore for flight surface data; see EDR SIS for other uses
10-19	Time2	10-integer spacecraft clock count in seconds
20-22	prodid	EDR: GPR sounding measurement sample in frequency domain EDM: GPR sounding measurement sample metadata file EHK: Housekeeping data EHM: Housekeeping data metadata file EFC: Fault Condition EFM: Fault Condition Metadata file
23-25	Site	Site location count from the Rover Motion Counter for the frame wherein the data was collected
26-29	Drive	Drive count (position within a Site location) from the Rover Motion Counter, which may be last drive prior to stationary data collection
30	Bitsamp	N: Normal (16-bit) L: Long (24-bit)
31-32	Separation	RIMFAX separation distance in cm (00 through 99)
33	Compress	Downlink compression performed by RCE (not instrument) A: Lossless "gzip" B: Lossless LOCO C: Lossy at 90% quality D: Lossy at 80% quality ...Z: TBD (as needed)
34	Parmver	Parameter Table Version Number "1","2", … "9" : versions 1 through 9 "A", "B", … "Z" : version 10 through 35 "_" (underscore) : 36 and higher
35-36	Parmnum	Parameter Mode Numbers 00 through FF (hexadecimal)
37	Proctype	Onboard Processing Type R: Raw D: Decimated
38	Procver	Onboard Processing Type Verison "1","2", … "9" : versions 1 through 9 "A", "B", … "Z" : version 10 through 35 "_" (underscore) : 36 and higher
39-47	Seqid	Sequence or Activity or Component Identifier (9 alphanumeric characters). If Sequence ID, composed of a 4-char subfield and a 5-digit numeric subfield representing the

		6-bit "Category" and 14-bit numeric components of the commanded Sequence ID, respectively.
48	Provider	Provider institution ID J: IDS at JPL P: Instrument Principal Investigator Other: Co-investigators as identified at discretion of PI
49-50	Ver	Product version number "01", "02", … "99" : range 1 through 99 "A0", "A1", … "A9" : range 100 through 109 "AA", "AB", … "AZ" : range 110 through 135 "B0", "B1", … "B9" : range 136 through 145 "BA", "BB", … "BZ" : range 146 through 171 "C0", "C1", … "C9" : range 172 through 181 "CA", "CB", … "CZ" : range 182 through 207
51	Separator	Separator for filename and extension, always "."
52-54	File name extension	"DAT" : Binary GPR sounding data "CSV" : ASCII comma-separated-value text file "PNG" : Image data in PNG format

The following are examples of RIMFAX EDR data product file names

EDR	`XM2_D030B0633687556EDR0010212N10A_0CR1RFAX00001J01.DAT`
EDR Metadata	`XM2_D030B0633687556EDM0010212N10A_0CR1RFAX00001J01.CSV`
Housekeeping	`XS4_C118_0428014742EHK0010000N00A_01R1aut_04096J01.CSV`
Housekeeping Metadata	`XS4_C118_0428014742EHM0010000N00A_01R1aut_04096J01.CSV`

RIMFAX EDR data file names are a mix of upper and lower case characters. The corresponding product LIDs are lower case only.

3.4.3 Calibrated File Naming Convention

RIMFAX calibrated data files (also known as Calibrated Data Records, or CDRs) contain one Sol's worth of data, and are named according to the format:

rimfax_calibrated_<SOLNUMBER>.<SUFFIX>

For example:

rimfax_calibrated_0001.csv

rimfax_calibrated_0001.xml

3.5 PDS4 Labels

A typical PDS4 data product consists of a data object (e.g., a table) in one file and an accompanying label in a separate file. A product may have more than one data object in the data file, and it may have more than one data file, but it always has exactly one label in a file by itself.

PDS4 labels are ASCII text files written in the eXtensible Markup Language (XML). Typically a label has the same file name as the data file it describes but with the extension ".xml". If the label describes more than one data file, it will have a slightly different file name, but always the extension ".xml". If the data file also happens to be an XML file, its file name extension will be changed to avoid a conflict with the label file name.

Documents are also considered products and have accompanying PDS4 labels.

3.6 PDS4 Data Dictionaries

The structure and content of PDS4 labels conform to the PDS Information Model as embodied by the PDS Common Dictionary [4] and, as needed, additional mission-specific or discipline-specific data dictionaries. PDS dictionaries are written as XML schema and Schematron files, which are maintained at https://pds.nasa.gov/datastandards/dictionaries/. The PDS Data Provider's Handbook explains the use of these schema and Schematron files [3]. In brief, the schema is the XML model that PDS4 labels must follow, and the Schematron is a set of validation rules that are applied to PDS4 labels.

At the beginning of every PDS4 label are statements listing the name and version of the PDS Common Dictionary and any other data dictionaries that are used in the label. The PDS Validate Tool (https://pds.nasa.gov/tools/about/) is used by data providers and by PDS to ensure that the label conforms to the dictionary specifications, and that the label correctly describes the contents of the data file(s).

Table 5 lists the data dictionaries used in RIMFAX labels.

Table 5 PDS4 Dictionaries Used In RIMFAX Labels

Dictionary	File Name	Steward
PDS Common Dictionary	PDS4_PDS_1G00.*	PDS Engineering Node
Mars 2020 Mission Dictionary	PDS4_MARS2020_1G00_1000.*	PDS Geosciences Node
Geometry Discipline Dictionary	PDS4_GEOM_1G00_1930.*	PDS Geosciences Node
Processing Information Discipline Dictionary	PDS4_PROC_1G00_1210.*	PDS Cartography and Imaging Sciences Node
Mission Surface Discipline Dictionary	PDS4_MSN_SURFACE_1G00_1220.*	PDS Cartography and Imaging Sciences Node
***Version numbers of these dictionaries may change.**		

4 RIMFAX Product Formats

This section describes the formats of data, document, and browse product types in the RIMFAX bundle.

4.1 Data Product Formats

RIMFAX raw (EDR) data products are formatted as binary tables (file name extension **.dat**) or ASCII text comma-separated value tables (file name extension **.csv**), according to the definitions of these structures in Section 4 of the PDS Standards Reference [2]. The formats are described at length in the RIMFAX EDR Data Product SIS [7].

RIMFAX calibrated (CDR) data products are formatted as ASCII CSV tables.

A RIMFAX data file contains a single data object, either a binary table or a CSV table. A data file that contains a CSV table also contains a header record.

4.2 Document Product Formats

Most documents in this archive are in Portable Document File (PDF) format, specifically PDF/A (https://www.loc.gov/preservation/digital/formats/fdd/fdd000125.shtml), or in plain ASCII text in cases where no special formatting is required.

The RIMFAX Calibrated Data Catalog document is a CSV table.

4.3 Browse Product Formats

Browse images of radargrams are compiled from traverse sounding data from select calibrated data products, typically of longer rover traverses. These images are in PNG format.

Appendix A Support Staff and Cognizant Persons

Name	Role	Institution	Email
Susan Slavney	PDS Node Representative	Washington University	susan.slavney@wustl.edu
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Mark Sullivan	RIMFAX Representative	UCLA	marks@mars.ucla.edu
Rafael Alanis	IDS Representative	Jet Propulsion Laboratory	rafael.alanis@jpl.nasa.gov

Appendix B Bundle Directory Structure

```
urn-nasa-pds-mars2020_rimfax
   |--- data_raw
           |--- sol_00001
             …
           |--- sol_nnnnn
   |--- data_hk
           |--- sol_00001
             …
           |--- sol_nnnnn
   |--- data_calibrated
           |--- 2021
             …
           |--- yyyy
   |--- browse_radargram
   |
   |--- document
           |--- collection_document.xml
           |--- collection_document_inventory.csv
           |--- rimfax_bundle_sis.pdf, .xml
           |--- rimfax_edr_sis.pdf, .xml
           |--- rimfax_cdr_sis.pdf, .xml
```