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

Version 3.0

March 22, 2022

Prepared by: Susan Slavney

Custodian: Susan Slavney

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Custodian:

Susan Slavney PDS Geosciences Node, Washington University in St. Louis	<date>

Approved:

Dorothea Delapp Mars 2020 SuperCam Team, Los Alamos National Laboratory	<date>
Deborah Padgett Mars 2020 Instrument Data Services, Jet Propulsion Laboratory	<date>

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Document Change Log

Version	Change	Date	Affected portion
0.9	Pre-peer-review version	September 23, 2020	All
1.0	Post-EDR-peer review version	December 13, 2020	All
1.0	Pre-RDR peer review version	March 17, 2021	All
1.0	Post-RDR peer review version Updated Applicable Documents. Updated LID examples. Updated Table 6, PDS Dictionaries.	July 22, 2021	1.3, 3.4.1,Table 6
1.0	Changed subdirectory names from solnnnn to sol_nnnnn	August 13, 2021	Appendix B
2.0	Added new collection	November 22, 2021	Table 3 and Appendix A
3.0	Revised description of calibration collection directory structure	March 22, 2022	Appendix B

TBD Items

Item	Section(s)	Responsibility

Acronyms and Abbreviations

Acronym/Abbreviation	Meaning
ASCII	American Standard Code for Information Interchange
EDR	Experiment Data Record
FITS	Flexible Image Transport System
FSW	Flight Software
GDS	Ground Data System
GIF	Graphics Interchange Format
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
RDR	Reduced Data Record
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
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. Examples of digital objects are data tables, images, and documents.

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.

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 SuperCam 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 SuperCam raw and derived products. For details about these products, including how the instrument acquires data and how the data are processed, see the Mars 2020 SuperCam Data Product SIS [7].

1.3 Applicable Documents and References

[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 Rover Mission (M2020) Software Interface Specification, SuperCam Instrument Experiment Data Record (EDR) Data Products for Non-Imaging Components, JPL D-99966.

[8] SuperCam PDS User Guide, version 1.0, March 10, 2021 (preliminary, to be updated).

[9] Definition of the Flexible Image Transport System (FITS), Version 4.0, August 13, 2018, https://fits.gsfc.nasa.gov/fits_standard.html.

[10] WAVE Audio File Format, Library of Congress Digital Formats Web site, March 9, 2017, https://loc.gov/preservation/digital/formats/fdd/fdd000001.shtml.

[11] Maurice, S., R. C. Wiens, P. Bernardi, et al., The SuperCam Instrument Suite on the NASA Mars 2020 Rover: Science Objectives and Mast-Unit Description, Space Sci. Rev., Mars 2020 special issue, submitted.

[12] Wiens, R. C., S. Maurice, S. H. Robinson, et al., The SuperCam Instrument Suite on the NASA Mars 2020 Rover: Body Unit and Combined System Tests, Space Sci. Rev., Mars 2020 special issue, submitted.

[13] Manrique, J. A., G. Lopez-Reyes, A. Cousin, et al., SuperCam Calibration Targets: Design and Development, Space Sci. Rev., Mars 2020 special issue, submitted.

[14]Maurice, S., R.C. Wiens, et al., The ChemCam instrument suite on the Mars Science Laboratory (MSL) Rover: Science objectives and mast unit description, Space Sci. Rev. doi:10.1007/s11214-012-9912-2, 2012.

[15]Wiens, R.C., S. Maurice, et al., The ChemCam instrument suite on the Mars Science Laboratory (MSL) Rover: Body unit and combined system tests, Space Sci. Rev. doi:10.1007/s11214-012-9902-4, 2012.

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.

1.6 SuperCam Description

SuperCam is an integrated multi-sensor remote-sensing instrument carried aboard the Mars 2020 rover. It implements four spectroscopic techniques to remotely measure properties of materials on Mars. These include:

- Laser-induced breakdown spectroscopy (LIBS)
- Raman spectroscopy
- Time-resolved fluorescence spectroscopy
- Passive spectroscopy - Visible and Infrared spectrometer (VIS IR)

SuperCam also includes a telescopic color context camera, the Remote Micro-Imager (RMI), which is principally used to document the sites of remote spectroscopy measurements. Finally, the instrument also includes a microphone, which is used primarily to measure the pressure wave produced by the generation of plasma at a LIBS target.

Details of the SuperCam instrument suite may be found in Section 2 of the SuperCam Data Product SIS [7]. SuperCam builds on the experience of the ChemCam instrument on the Mars Science Laboratory rover. ChemCam has very much the same overall architecture and operation scheme but includes only the LIBS and RMI components [14] [15].

2 SuperCam Data Products

2.1 Data Product Overview

Mars 2020 SuperCam data products in this bundle consist of raw, calibrated, and derived data. Table 1 shows a summary of all SuperCam data product types. Data file formats are covered in Section 4 of this document. See the SuperCam Data Product SIS [7] for details.

Table 1 All SuperCam Data Product Types

Product Name	Product Type (3-character code in filename)	Processing Level	Description	PDS Bundle and Collection, with prefix urn:nasa:pds:	PDS Data Type
LIBS EDR	EL*	raw	Raw LIBS spectra	mars2020_supercam: data_raw_spectra	Table_Binary
VIS EDR	EP0, EP1, EP3, EP9	raw	Raw VISIR spectra	mars2020_supercam: data_raw_spectra	Table_Binary
IR EDR	EP2, EP4	raw	Raw IR spectra	mars2020_supercam: data_raw_spectra	Table_Binary
Raman EDR	ER*	raw	Raw Raman spectra	mars2020_supercam: data_raw_spectra	Table_Binary
TRLS EDR	ET*	raw	Raw Time-resolved luminescence spectra	mars2020_supercam: data_raw_spectra	Table_Binary
RMI EDR	EDR , EF*	raw	RMI raw images	mars2020_supercam: data_raw_rmi	Array_2D_Image
MIC EDR	EA*	raw	Raw acoustic recording	mars2020_supercam: data_raw_audio	Table_Binary
LIBS RDR	CL*	calibrated	LIBS spectra calibrated with wavelength calibration	mars2020_supercam: data_calibrated_spectra	Table_Binary
VIS RDR	CP0, CP1, CP3	calibrated	VIS spectra calibrated	mars2020_supercam: data_calibrated_spectra	Table_Binary
IR RDR	CP2, CP4	calibrated	IR spectra calibrated	mars2020_supercam: data_calibrated_spectra	Table_Binary
Raman RDR	CR*	calibrated	Raman spectra calibrated with wavelength calibration	mars2020_supercam: data_calibrated_spectra	Table_Binary
TRLS RDR	CT*	calibrated	TRLS spectra calibrated with wavelength calibration	mars2020_supercam: data_calibrated_spectra	Table_Binary

RMI RDR	CI*	calibrated	RMI Partially radiometrically corrected images	mars2020_supercam: data_radcal_rmi	Array_2D_Image
MIC RDR	CA*	calibrated	MIC acoustic time series calibrated in Pascal	mars2020_supercam: data_calibrated_audio	Table_Binary
LIBS RDR	n/a	derived	LIBS element abundances	mars2020_supercam: data_derived_spectra	Table_Delimited
VIS RDR	n/a	derived	Ratio of VIS data to the SCCT_White cal target taken under similar conditions	mars2020_supercam: data_derived_spectra	Table_Delimited
IR RDR	n/a	derived	Ratio of IR data to the SCCT_White cal target taken under similar conditions	mars2020_supercam: data_derived_spectra	Table_Delimited
Raman RDR	n/a	derived	Table of features with columns for likely mineral identifications and possible mineral identifications	mars2020_supercam: data_derived_spectra	Table_Delimited
TRLS RDR	n/a	derived	Table of features with columns for likely mineral identifications and possible mineral identifications	mars2020_supercam: data_derived_spectra	Table_Delimited
RMI Mosaic RDR	n/a	derived	RMI mosaics from individual RMI RDR products, position of observations noted	mars2020_supercam: data_special_rmi	Array_2D_Image
RMI Mastcam Mosaic RDR	n/a	derived	Mastcam images with the outlines of the RMI image overlaid	mars2020_supercam: data_special_rmi	Array_2D_Image
MIC RDR	CA*	calibrated	MP4 audio recordings supplementary to data_calibrated_audio products (WAV files)	mars2020_supercam: data_calibrated_audio	Encoded_Audio
Master target	n/a	derived	SuperCam master spreadsheet with information about all targets	mars2020_supercam: data_observation_log	Table_Delimited
Libs Spectral library	n/a	calibrated	Laboratory data used for LIBS RDR	mars2020_supercam: calibration_supercam	Table_Delimited

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.

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 SuperCam Archive Organization

This section describes the organization of the SuperCam archive according to the PDS4 Information Model [5]. In general, PDS archives are organized as bundles, collections, and products. This concept is illustrated briefly by a schematic in Appendix A, and explained more fully in the PDS Concepts Document [1].

3.1 The SuperCam Bundle

The highest level of organization for a PDS archive is the bundle. A bundle is a set of one or more related collections which may be of different types. A collection is a set of one or more related basic products which are typically all of the same type. Bundles and collections are logical structures, not necessarily tied to any physical directory structure or organization.

The complete SuperCam archive is organized into one bundle. The bundle's PDS Logical Identifier (LID) is **urn:nasa:pds:mars2020_supercam**.

3.2 SuperCam Collections

The SuperCam bundle includes the collections of data products and documents listed in Table 3.

Table 3 Collections in the SuperCam Bundle

Collection Logical Identifier	Collection Type	Contents
urn:nasa:pds:mars2020_supercam:data_raw_spectra	Data	Raw (EDR) LIBS, VIS, IR, Raman, and TRLS data products
urn:nasa:pds:mars2020_supercam:data_raw_rmi	Data	Raw (EDR) RMI image data products
urn:nasa:pds:mars2020_supercam:data_raw_audio	Data	Raw (EDR) audio data products
urn:nasa:pds:mars2020_supercam:data_calibrated_spectra	Data	Calibrated (RDR) LIBS, VIS, IR, Raman, and TRLS data products
urn:nasa:pds:mars2020_supercam:data_radcal_rmi	Data	Calibrated (RDR) RMI image data products
urn:nasa:pds:mars2020_supercam:data_calibrated_audio	Data	Calibrated (RDR) audio data products
urn:nasa:pds:mars2020_supercam:data_derived_spectra	Data	Derived (RDR) LIBS, VIS, IR, Raman, and TRLS data products
urn:nasa:pds:mars2020_supercam:data_special_rmi	Data	RMI image mosaics and Mastcam-Z images with RMI image outlines
urn:nasa:pds:mars2020_supercam:data_observation_log	Data	Master spreadsheet with information about all observation targets
urn:nasa:pds:mars2020_supercam:calibration_supercam	Data	Libs Spectral library used for LIBS calibration
urn:nasa:pds:mars2020_supercam:document	Document	Documentation, including this SIS and the Data Product SIS

3.3 SuperCam Data Organization

The SuperCam bundle is organized as a single directory tree with a subdirectory for each collection. Most data subdirectories are further subdivided by sol (Mars day). The calibration_supercam collection is divided into subdirectories based on distance from the LIBS laser to the calibration target. See Appendix B for a diagram of the full directory structure of the bundle.

3.4 SuperCam Product Identification and Naming

A SuperCam data product consists of one or more digital objects in one file, accompanied by a 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.

In addition to data products the archive includes a collection of document products, which also have PDS labels. The document collection includes the SuperCam EDR and RDR Data Product SIS, the SuperCam User Guide, and the SuperCam Bundle SIS (this document).

Finally, the collections and the bundle themselves are 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_supercam.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_spectra** collection is the file **collection_data_raw_spectra.xml** in the directory **data_raw_spectra**. Each collection has an inventory table that lists the products in the collection, e.g. **collection_data_raw_spectra_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_supercam**

  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_supercam:data_raw_spectra**

  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_supercam:data_calibrated_spectra:scam_0298_0625316527_850_cl1_scam15219_gypbass_near_____01p00

The product LID must be unique across the collection. For SuperCam RDR data products, the product LID is the same as the lowercased data file name without the extension. For SuperCam EDR data products, the product LID is the same as the lowercased data file name with the extension. For SuperCam RDR 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 SuperCam 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 SuperCam EDR products the minor version is always "0". Thus the complete VID for all SuperCam 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 SuperCam 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 SuperCam data product LIDVID for version 1.0 of the product:

urn:nasa:pds:mars2020_supercam:data_calibrated_spectra:scam_0298_0625316527_850_cl1_scam15219_gypbass_near_____01p00::1.0

3.4.2 Secondary Members of a Collection

A PDS product may belong to more than one collection. It is a primary member of the collection named in the product LID. The same product LID may be listed as a secondary member in the inventory of other collections. The product's files are not duplicated in the other collections; there is only one physical copy of the product in PDS.

SuperCam RMI images are primary members of the collection **urn:nasa:pds:mars2020_imgops:data_rmi_imgops**. The mars2020_imgops bundle contains collections of image products from all cameras on Mars 2020 instruments. The SuperCam RMI images are also secondary members of the collection **urn:nasa:pds:mars2020_supercam:data_raw_rmi**.

3.4.3 EDR File Naming Convention

Figure 1 and Table 4 illustrate the file naming convention for SuperCam EDR data products. This convention is used for most Mars 2020 data files, and some fields do not apply to SuperCam. More details about this naming convention are found in section 6.1 of the SuperCam Data Product SIS [7].

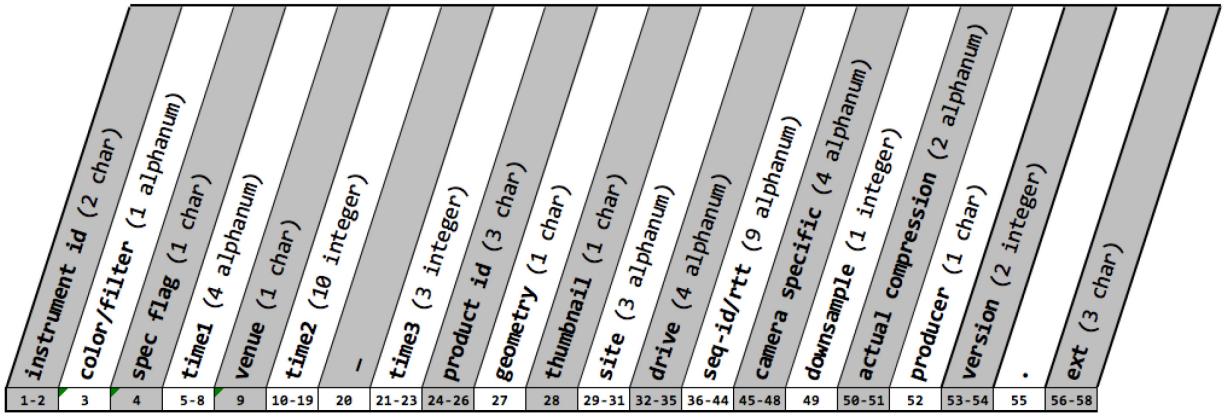


Figure 1 Mars 2020 File Naming Scheme

Table 4 SuperCam EDR File Name Components

Characters	Contents	Description
1-2	Instrument	LR for RMI EDR's and LS for all other EDRs
3	ColorFilter	Underscore for non-image products; color or filter flag for images. See Table 7-1 in the SuperCam Data Product SIS.
4	Special Processing Flag	Indicates off-nominal or special processing; underscore for SuperCam EDRs
5-8	Primary Timestamp:	Sol number for surface data; other values for cruise and test data. See Table 4-2 in the SuperCam Data Product SIS.
9	Venue	Source of telemetry used to create the data product; underscore for flight product, other characters for various testbeds. See Table 4-2 in the SuperCam Data Product SIS.
10-19	Secondary Timestamp:	10-digit Spacecraft Clock Count (SCLK) in seconds for surface, cruise, and some test data products
20	Underscore for readability	Always set to "_"
21-23	Tertiary Timestamp	Milliseconds of the Spacecraft Clock Count
24-26	Product Type	ECM: RMI image ELx : LIBS spectrum ERx : Raman spectrum ETx : TRLS spectrum EP0, EP1 : VIS spectrum EP2 : IR spectrum EAx : Audio recording ESH : State of health product See Table 4-2 in the SuperCam Data Product SIS [7] for values of "x" and other details
27	Geometry	Geometry linearization for image products; may be additional product type character for non-images. See Table 7-1 in SuperCam EDR SIS
28	Thumbnail	N=non thumbnail image, T=thumbnail image, underscore for non-image products.
29-31	Site	Rover location
32-35	Drive	Drive count (position within a Site location) from the Rover Motion Counter where the data was acquired

36-44	Sequence ID/ Round Trip Tracking	Identifies sequence-ID or Round-Trip Tracking token. Other vaules for test data.
45-48	Instrument-specific	For SuperCam, "_###", where ### is the point number from the Command Arguments data product object for non-image data, or the observation counter for RMI data (see the SuperCam EDR SIS [7]). Other values for test data.
49	Downsample	For SuperCam RMI data, a downsample resolution identifier; for non-image data, an underscore
50-51	Compression	For SuperCam RMI data, a compression type identifier; for non-image data, two underscores
52	Producer	Identifier of the institution/team that created this product
53-54	Version	Product version number
55	Separator	Separator for filename and extension, always “.”
56-59	File name extension	"FITS", "IMG"

The following are examples of SuperCam EDR data product file names.

LIBS: `LS__C298T0625302894_968EL1__0010044scam15219_0001LUJ01.FITS`
Raman: `LS__C293T0624868150_145ER0__0010094scam15218_0001LUJ01.FITS`
IR: `LS__C298T0625300815_526EP2__0010044scam15225_0001LUJ01.FITS`
RMI: `LRE_D008T0631779418_508ECM_N0010000XXXX00000_0010LUJ00.IMG`

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

3.4.4 RDR File Naming Convention

The SuperCam RDR file name uses some of the same elements as the EDR file name along with some additional elements.

Table 5 SuperCam RDR File Name Components

Characters	Contents	Description
1-4	Instrument	SCAM
5	_	Underscore for readability
6-9	Sol number	Sol (Martian day)
10	_	Underscore for readability
11-20	SCLK	Spacecraft clock count, whole number of seconds
21	_	Underscore for readability
22-24	SCLK fraction	Spacecraft clock count, fractional seconds
25	_	Underscore for readability
26-28	Product Type	Rxx: RMI image RLx : LIBS spectrum RRx : Raman spectrum RTx : TRLS spectrum RP0, EP1 : VIS spectrum RP2 : IR spectrum RAx : Audio recording RSH : State of health product See Section 6.1 in the SuperCam User Guide [8] for values of "x" and other details

29	_	Underscore for readability
30-38	Sequence	Sequence number
39	_	Underscore for readability
40-59	Target name	Name of target of observation, padded with underscores if needed
60	_	Underscore for readability
61-62	Point number	Point number in raster, or 01 for single point
63	Producer	P for Principal Investigator
64-65	Version	Version number
66-70	Extension	.fits

3.5 PDS4 Labels and Other 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. See Appendix A for more information about XML files and software to read them.

Some SuperCam data files have Object Definition Language (ODL) labels embedded at the beginning of the data file. These labels are created by Mars 2020 Instrument Data Services (IDS) during product generation. They are ASCII text labels in a KEYWORD = VALUE format, and they look similar to PDS3 labels, although they are not strictly compliant with that previous PDS standard. The PDS4 XML label includes all the metadata from the ODL label that is relevant to the archive product.

In addition to ODL labels, image data files generated by IDS have embedded VICAR labels. The PDS4 XML label includes all the metadata from the VICAR label that is relevant to the archive product.

Details about the contents of ODL and VICAR labels may be found in the SuperCam Data Product SIS [7].

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 6 lists the data dictionaries used in SuperCam labels.

Table 6 PDS4 Dictionaries Used In SuperCam 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
Display Information Discipline Dictionary	PDS4_DISP_1G00_1500.*	PDS Cartography and Imaging Sciences Node
Image Discipline Dictionary	PDS4_IMG_1G00_1860.*	PDS Cartography and Imaging Sciences Node
Mission Surface Discipline Dictionary	PDS4_MSN_SURFACE_1G00_1220.*	PDS Cartography and Imaging Sciences Node
***Version numbers may change.**		

4 SuperCam Product Formats

This section describes the formats of data and document product types in the SuperCam bundle.

4.1 Science Data Product Formats

SuperCam science data products are formatted as ASCII text comma-separated value (CSV) tables, binary tables, or two-dimensional image arrays, according to the definitions of these structures in Section 4 of the PDS Standards Reference [2]. The formats are described at length in the SuperCam Data Product SIS [7]. The data products also conform to the FITS 4.0 standard and include FITS header objects [8].

In most cases a single SuperCam data file contains multiple data objects and header objects, all of which are described in the accompanying PDS4 label.

Raw and calibrated SuperCam audio data are recorded as binary tables. A version of the audio recording in a WAVE format file is included in the **data_calibrated_audio** collection [9].

4.2 Document Product Formats

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.

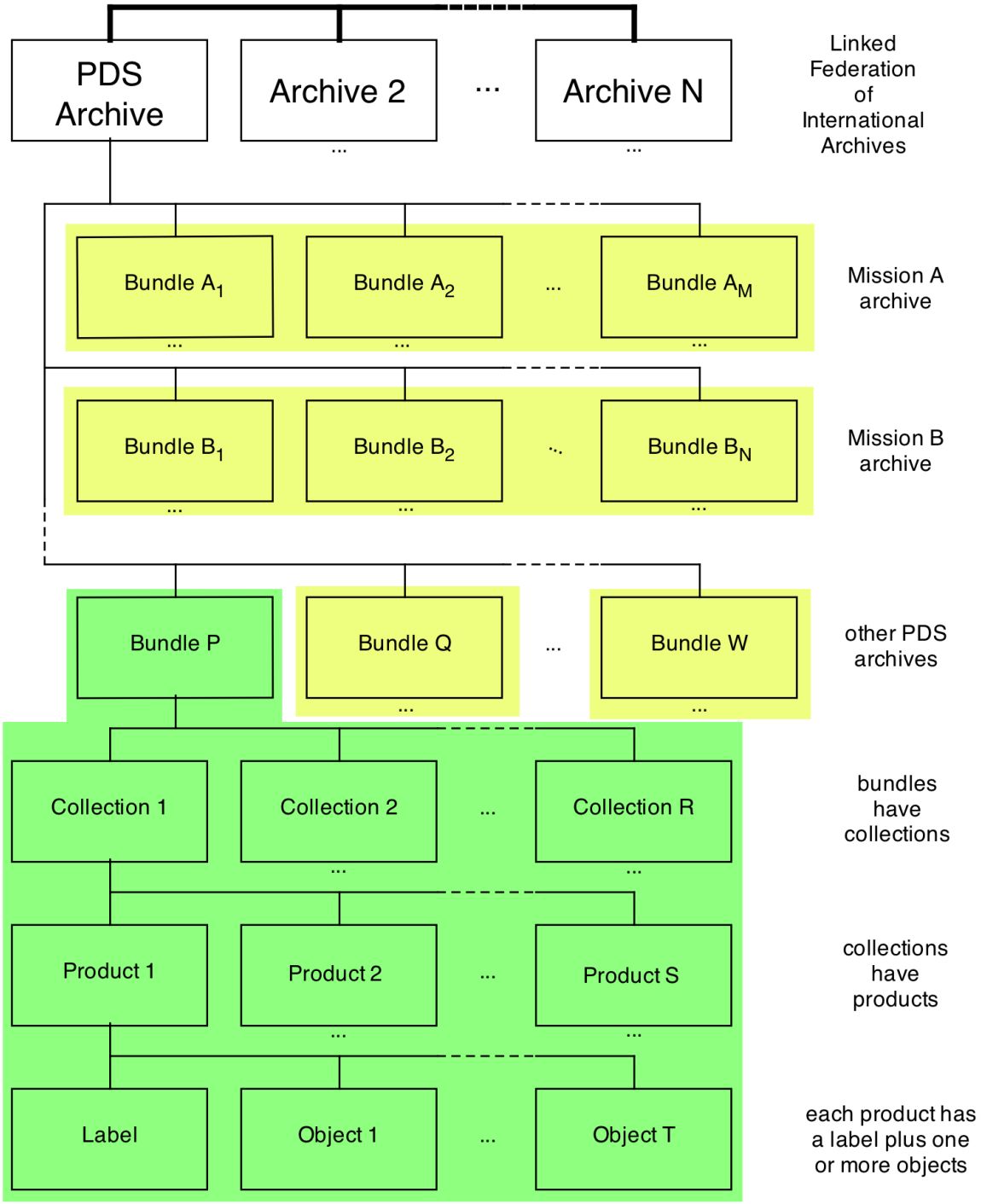
4.3 File Types

Table 7 describes the file types found in the bundle along with suggested software tools for viewing them.

Table 7 SuperCam Bundle File Types

Filename Extension	File type	Description
csv	Comma-Separated Value	Text file containing one or more tables with fields separated by commas. These files may be viewed in a text editor, and may be imported into a spreadsheet program such as Microsoft Excel.
fits	Flexible Image Transport System	An open standard for digital data files formatted as arrays or tables. Several free FITS viewers are available, including https://heasarc.gsfc.nasa.gov/docs/software/ftools/fv/ and https://www.mpe.mpg.de/~ott/QFitsView/.
img	PDS image	Images in PDS IMG format are binary arrays that may be viewed with the PDS4 Viewer (https://sbnwiki.astro.umd.edu/wiki/PDS4_Viewer) and transformed into other formats using the PDS Transform tool (https://nasa-pds.github.io/transform/). A Python library of tools to read PDS4-labeled images and other products is available at https://sbnwiki.astro.umd.edu/wiki/Python_PDS4_Tools/.
pdf	Portable Document Format	Several free PDF viewers are available, including Adobe Acrobat Reader (https://acrobat.adobe.com/us/en/acrobat/pdf-reader.html).
txt	ASCII text	Text files viewable in any text editor and most web browsers.
xml	eXtensible Markup Language	XML is a markup language commonly used to describe data. Every data file and document in the bundle is accompanied by a PDS4 label in an XML file. These XML files conform to the PDS4 Information Model XML schema at https://pds.nasa.gov/pds4/schema/released/. XML files are text files. They are best viewed in an XML-aware editor, and may be used by software that can manipulate XML documents. Some XML editors are Oxygen (https://www.oxygenxml.com/), Notepad++ (https://notepad-plus-plus.org/), Code Browser (https://tibleiz.net/code-browser/), and XmlPad (https://xmlpad-mobile.com/).

Appendix A. PDS Bundles, Collections, and Products



This figure illustrates the organization of PDS archives, including links from PDS to other archive systems. Some missions (A and B) may create multiple bundles. A single bundle may have several collections, each of which has several products comprising a label and one or more objects (green). Other bundles (yellow) would have similar structures. Examples of objects are data tables, images, and documents.

Appendix B. Bundle Directory Structure

```
SuperCam Bundle Root
   |--- data_raw_spectra
           |--- sol_00001
             …
           |--- sol_nnnnn
   |--- data_raw_rmi
           |--- collection inventory only; refers to products in the
                urn:nasa:pds:mars2020_imgops:data_rmi_imgops collection
   |--- data_raw_audio
           |--- sol_00001
             …
           |--- sol_nnnnn
   |--- data_calibrated_spectra
           |--- sol_00001
             …
           |--- sol_nnnnn
   |--- data_radcal_rmi
           |--- sol_00001
             …
           |--- sol_nnnnn
   |--- data_calibrated_audio
           |--- sol_00001
             …
           |--- sol_nnnnn
   |--- data_derived_spectra
   |--- data_special_rmi
   |--- data_observation_log
   |--- calibration_supercam
           |--- 1545mm
                …
           |--- 3006mm
                |--- 2850mm
                     …
                |--- 2855mm
                     …
                |--- 2860mm
```

```
                    …
                |--- 2869mm
                    …
                |--- 3006mm
                    …
            |---4250mm
                …
|--- document
```

Appendix C. Support Staff and Cognizant Persons

Name	Role	Institution	Email
Susan Slavney	PDS Node Representative	Washington University	susan.slavney@wustl.edu
Dorothea DeLapp	SuperCam Team Archive Representative	Los Alamos National Laboratory	ddelapp@lanl.gov
Deborah Padgett	IDS Representative	Jet Propulsion Laboratory	deborah.l.padgett@jpl.nasa.gov
Paolo Pilleri	SuperCam Team	Institut de Recherche en Astrophysique et Planétologie	paolo.pilleri@irap.omp.eu