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

Version 1.0

July 29, 2021

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Custodian: Susan Slavney

Mars 2020

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Tables and Figures

Document Change Log

Version	Change	Date	Affected portion
0.9	Pre-peer-review version	January 26, 2021	All
1.0	Peer review version	February 4, 2021	Section 1.3, Table 1
1.0	Release 1 version	July 29, 2021	Sections 1.3, 3.4.1, Table 5, Appendix B

TBD Items

Item	Section(s)	Responsibility
Update reference to Mars 2020 Archive Plan	1.3, Applicable Documents	Nicole Spanovich
Update Mars 2020 mission description after landing (change to past tense)	1.5 Mars 2020 Mission	Susan Slavney

Acronyms and Abbreviations

Acronym/Abbreviation	Meaning
ASCII	American Standard Code for Information Interchange
EDR	Experiment Data Record
FSW	Flight Software
GDS	Ground Data System
HTML	HyperText Markup Language
IDS	Instrument Data System
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)
PIXL	Planetary Instrument for X-ray Lithochemistry
RCE	Rover Compute Element
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
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Archive – A place in which public records or historical documents are preserved; also the material preserved, often used in plural.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 PIXL 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 PIXL 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 PIXL EDR Data Product SIS [7], the Mars 2020 PIXL RDR Data Product SIS [8], and the Mars 2020 Camera SIS [9].

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: PIXL Instrument Experiment Data Record (EDR) Data Products for Non-Imaging Components, JPL D-99963, July 27, 2021.

[8] Mars 2020 Software Interface Specification Planetary Instrument for X-ray Lithochemistry (PIXL) Reduced Data Products, JPL D-105236, July 29, 2021.

[9] Mars 2020 Software Interface Specification Camera Instrument Data Products, JPL D-99960, December 21, 2020.

[10] Farley, K.A., et al. (2020), Mars 2020 Mission Overview, Space Sci. Rev. 216:142, doi:10.1007/s11214-020-00762-y.

[11] Allwood, A.C., et al. (2020), PIXL: Planetary Instrument for X-Ray Lithochemistry, Space Sci. Rev. 216:134, doi:10.1007/s11214-020-00767-7.

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 have passed 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 is scheduled to place 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 [10].

1.6 PIXL Description

PIXL (Planetary Instrument for X-ray Lithochemistry) is a microfocus X-ray fluorescence instrument that measures elemental chemistry at sub-millimeter scales. This is achieved by focusing an X-ray beam to a small spot ~ 150 mm, scanning the surface with this beam, and then measuring the induced X-ray fluorescence. Since PIXL also contains a micro-context camera (MCC) it correlates sub-mm scale geochemistry with surface texture.

PIXL is mounted on the rover's robotic arm, allowing it to be placed in close proximity to the surface of selected science targets. For additional precision in placement, and to correct for drift in the robotic arm positioning, PIXL's mounting to the arm includes an articulated hexapod system, allowing PIXL's position in space to be finely adjusted.

In addition to the PIXL Sensor Assembly mounted on the robotic arm, the instrument includes its own electronics system with an instrument computer and memory module, mounted inside the rover body. PIXL is also furnished with a calibration target, mounted externally to the rover in reach of the arm.

PIXL observations consist of a suite of X-ray fluorescence measurements, context images, and metadata. The XRF measurements can be executed in a variety of geometries depending on target type and available observation time, and are accompanied by a set of images documenting the target and its position relative to the instrument.

Details of the PIXL instrument may be found in the PIXL instrument paper [11].

2 PIXL Data Products

2.1 Data Product Overview

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

Table 1 All PIXL Data Product Types

Product Name	PIXL Product Type	Processing Level	PDS4 Bundle and Collection, with prefix urn:nasa:pds:	Description	PDS Data Type and File Name Extension
HK FRAME EDR	E08	raw	mars2020_pixl: data_raw_ancillary	Engineering data at the time of each X-ray measurement in raw DNs and converted engineering units	Table_Delimited, CSV
SCAN LOG EDR	E34	raw	mars2020_pixl: data_raw_ancillary	Scan Log that gives the actual (drift-corrected) hexapod coordinates for each hexapod movement	Table_Binary, .DAT
HISTOGRAM NORMAL A EDR	ENA	raw	mars2020_pixl: data_raw_spectroscopy	Regular histogram at nominal dwell time from X-ray detector A	Table_Delimited, CSV
HISTOGRAM NORMAL B EDR	ENB	raw	mars2020_pixl: data_raw_spectroscopy	Regular histogram at nominal dwell time from X-ray detector B	Table_Delimited, CSV
HISTOGRAM DWELL A EDR	EDA	raw	mars2020_pixl: data_raw_spectroscopy	Regular histogram at longer dwell time from X-ray detector A	Table_Delimited, CSV
HISTOGRAM DWELL B EDR	EDB	raw	mars2020_pixl: data_raw_spectroscopy	Regular histogram at longer dwell time from X-ray detector B	Table_Delimited, CSV
PSEUDOINTENSITY NORMAL EDR	EPN	raw	mars2020_pixl: data_raw_spectroscopy	Pseudointensity Data for each nominal-dwell X-ray histogram calculated onboard (32 pseudointensity entries of summed spectral data representing approximate peak locations)	Table_Delimited, CSV
PSEUDOINTENSITY DWELL EDR	EPD	raw	mars2020_pixl: data_raw_spectroscopy	Pseudointensity Data for each longer-dwell X-ray histogram calculated onboard (32 pseudointensity entries of summed spectral data representing approximate peak locations)	Table_Delimited, CSV
HISTOGRAM MAX VALUE A EDR	EMA	raw	mars2020_pixl: data_raw_spectroscopy	Max Value Histogram from Detector A (see definition under RDRs below)	Table_Delimited, CSV
HISTOGRAM MAX VALUE B EDR	EMB	raw	mars2020_pixl: data_raw_spectroscopy	Max Value Histogram from Detector B	Table_Delimited, CSV
HISTOGRAM BULK SUM A EDR	EBA	raw	mars2020_pixl: data_raw_spectroscopy	Bulk Sum Histogram from Detector A (see definition under RDRs below)	Table_Delimited, CSV

Product Name	PIXL Product Type	Processing Level	PDS4 Bundle and Collection, with prefix urn:nasa:pds:	Description	PDS Data Type and File Name Extension
HISTOGRAM BULK SUM B EDR	EBB	raw	mars2020_pixl: data_raw_spectroscopy	Bulk Sum Histogram from Detector B	Table_Delimited, CSV
MCC OLM TRN ESTIMATE EDR	ESO	raw	mars2020_pixl: data_raw_ancillary	Autonomous Translation Relative Navigation data from the MCC (used for thermal drift correction)	Table_Delimited, CSV
MCC SLI ESTIMATES EDR	ESF	raw	mars2020_pixl: data_raw_ancillary	Distance and plane solutions derived from the SLI measurements.	Table_Delimited, CSV
MCC JPEG IMAGE EDR	EDR	raw	mars2020_imgops: data_mcc_imgops mars2020_pixl: data_imaging (secondary members*)	JPEG compressed context image converted to Array_2D_Image	Array_2D_Image, .IMG
MCC RAW BIT-MAP IMAGE EDR	EDR	raw	mars2020_imgops: data_mcc_imgops mars2020_pixl: data_imaging (secondary members*)	Uncompressed MCC images (raw bitmaps)	Array_2D_Image, .IMG
MCC CONTEXT IMAGE RDR	RCI	partially processed	mars2020_imgops: data_mcc_imgops mars2020_pixl: data_ processed (secondary members*)	MCC Image context image (black-and-white image of target rock) with geometric and radiometric corrections applied	Array_2D_Image, .IMG
MCC CONTEXT IMAGE WITH MARKUP RDR	RCM	calibrated	mars2020_pixl: data_ processed	Markup on MCC context image showing calculated X-ray measurement locations	Product_Ancillary, .TIF
ENGINEERING VALUE HOUSEKEEPING FRAME	R08	calibrated	mars2020_pixl: data_processed	A subset of PIXL housekeeping engineering and state-of-health metadata derived from the E08 housekeeping data product, converted to physical units	Table_Delimited, CSV
LOCALIZED FULL SPECTRA RDR	RFS	calibrated	mars2020_pixl: data_processed	XRF spectrum for each measured location on the target with energy calibration and spatial location	Table_Delimited, CSV
DRIFT CORRECTED X_RAY BEAM LOCATIONS RDR	RXL	calibrated	mars2020_pixl: data_processed	Location of each X-ray measurement in spatial coordinates and pixel location in context image, corrected for thermal drift of robotic arm position or other unexpected motion	Table_Delimited, CSV
BULK SUMMED SPECTRUM RDR	RBS	calibrated	mars2020_pixl: data_processed	Bulk Sum Spectrum (one for each target, all PIXL point spectra for this target summed) with energy calibration	Table_Delimited, MSA
MAX VALUE SPECTRUM RDR	RMS	calibrated	mars2020_pixl: data_processed	Max Value Spectrum (maximum measured value for each channel in the set of spectra for this target) with energy calibration	Table_Delimited, MSA

Product Name	PIXL Product Type	Processing Level	PDS4 Bundle and Collection, with prefix urn:nasa:pds:	Description	PDS Data Type and File Name Extension
BULK QUANTITATIVE MEASUREMENT RDR	RBQ	derived	mars2020_pixl: data_processed	Quantification (element weight percents) for bulk sum spectrum	Table_Delimited, CSV
PSEUDOINTENSITY RDR	RPM	calibrated	mars2020_pixl: data_processed	Pseudointensity values (as computed onboard) with measurement locations in spatial coordinates	Table_Delimited, CSV
ROCK COMPONENT SUMS RDR	RCS	derived	mars2020_pixl: data_processed	Rock Component Sum (if components can be identified and associated in spectrum maps), including summed spectrum, net intensities, and quantification	Table_Delimited, CSV
CALIBRATION RDR	n/a	derived	mars2020_pixl: document	Elemental and geometric calibration package	Document, .PDF
EDR SIS	n/a	document	mars2020_pixl: document	Description of EDR contents and format	Document, .PDF
RDR SIS	n/a	document	mars2020_pixl: document	Description of RDR contents and format	Document, .PDF
Bundle SIS	n/a	document	mars2020_pixl: document	Description of mars2020_pixl bundle organization	Document, .PDF

* “Secondary members” indicates that some or all members of the collection are primary members of another collection. Every product is a primary member of exactly one collection, and is physically resident at the location of that collection. A product may be a secondary member of another collection, meaning its Logical Identifier is listed in that collection’s inventory, but it is not physically copied there.

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 PIXL Archive Organization

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

3.1 The PIXL 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 types. A collection is a set of one or more related basic products that are typically all of the same 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 one or more objects (e.g., a table of data, an image, or a document) described by a label.

The complete PIXL archive is organized into one bundle. The bundle's PDS Logical Identifier (LID) is **urn:nasa:pds:mars2020_pixl.**

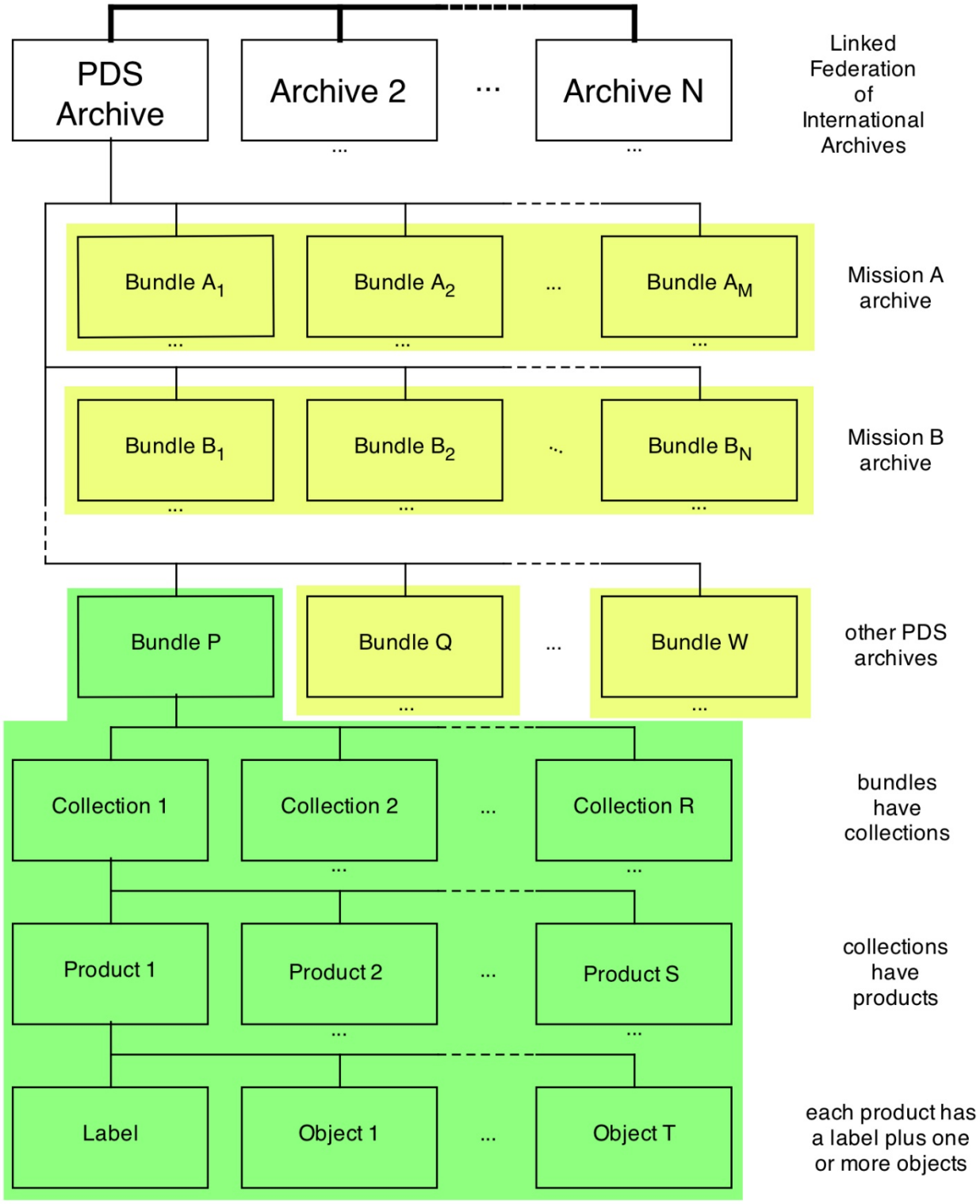

Figure 1 PDS bundles, collections, and products.

3.2 PIXL Collections

The PIXL bundle includes the following collections of data products and documents.

Table 3 Collections in the PIXL Bundle

Collection Logical Identifier	Collection Type	Contents
urn:nasa:pds:mars2020_pixl:data_raw_spectroscopy	Data	Raw (EDR) non-image science data products
urn:nasa:pds:mars2020_pixl:data_raw_ancillary	Data	Raw (EDR) non-image ancillary data products
urn:nasa:pds:mars2020_pixl:data_imaging	Data	Image data products from the MCC camera
urn:nasa:pds:mars2020_pixl:data_processed	Data	Partially processed, calibrated, and derived (RDR) data products
urn:nasa:pds:mars2020_pixl:document	Document	Documentation, including this SIS and the EDR and RDR Data Product SISes

3.3 PIXL Data Organization

The PIXL bundle is organized as a single directory tree with a subdirectory for each collection. Data subdirectories are further subdivided by sol (Mars day). See Appendix B for a diagram of the full directory structure of the bundle.

3.4 PIXL Product Identification and Naming

A PIXL data product consists of one or more digital objects in one file, accompanied by a PDS label file. A table of data is an example of a digital object. 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 bundle includes a collection of document products, which also have PDS labels. The document collection includes the PIXL EDR Data Product Software Interface Specification (SIS), the PIXL RDR Data Product SIS, and the PIXL 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_pixl.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_spectroscopy** collection is the file **collection_data_raw_spectroscopy.xml** in the directory **data_raw_spectroscopy**. Each collection has an inventory table that lists the products in the collection, e.g. **collection_data_raw_spectroscopy_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. Example LIDs are given in the following section.

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_pixl**

  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_pixl:data_processed**

  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_pixl:data_data_processed:pe__0089_0674838381_000r08__00400480349312030003___j01

- The product ID must be unique across the collection. For PIXL data products, the product ID 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. 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. The PDS Standards Reference [2] prescribes rules for incrementing major and minor components.

Example of a complete LIDVID for a PIXL data product, version 1.0:
urn:nasa:pds:mars2020_pixl:data_data_processed:pe__0089_0674838381_000r08__00400480349312030003___j01::1.0

3.4.2 File Naming Convention

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

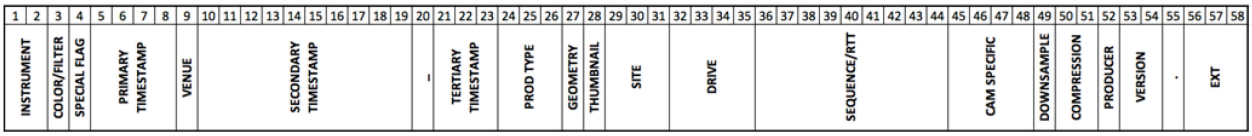

Figure 2 Mars 2020 File Naming Scheme

Table 4 PIXL File Name Components

Characters	Contents	Description
1-2	Instrument	PS: PIXL Spectroscopy PE: PIXL Engineering PC: PIXL Camera
3	Configuration	"_" for PIXL spectroscopy and engineering
4	Special Processing Flag	"_" (none for PIXL)
5-8	Sol	Sol number for flight surface data; see EDR SIS for other uses
9	Mission venue	"_" for Flight Mode
10-19	Spacecraft Clock Count (SCLK)	10-integer spacecraft clock count in seconds
20	Underscore	Always "_" for readability
21-23	Fractional SCLK	3-digit spacecraft clock count fractional seconds
24-26	Product Type	See PIXL Product Type in Table 1
27	Geometry	"_" indicates raw (non-linearized) geometry "L" indicates product has been linearized with nominal stereo partner "A" indicates product has been linearized with actual stereo partner "T" indicates product has had trapezoidal correction applied
28	Thumbnail	"_" for non-image products "T": Product is a thumbnail image "N": Product is not a thumbnail image
29-31	Site	Site identifier from Rover Motion Counter
32-35	Drive	Drive identifier (position within a site location)
36-44	Round-Trip Tracking token	Unique identifier for tracking activities (only in PIXL filenames)
45-48	Camera-specific identifier	4-digit PIXL Motion Counter (only in PIXL filenames)
49	Downsample resolution	"_" for non-image data products For image products: Resolution = 2^n x 2^n

Valid values	Resolution
0	1x1

		1 — 2x2 2 — 4x4 3 — 8x8 … — ...
50-51	Compression	"__" for non-image data products For image products: **Type** / **Valid values** / **Description** JPEG (lossy) / 00 / Thumbnail 01-99 / Jpeg quality level A0 / Jpeg quality level 100 ICER (lossy) / I1, I2, …, I8 / 1 bpp, 2 bpp, …, 8 bpp I9 / Anything higher than 8 bpp Lossless / LI / ICER LL / LOCO LM / Malin LU / Uncompressed
52	Provider	Provider institution ID J: IDS at JPL P: Instrument Principal Investigator Other: Co-investigators as identified at discretion of PI
53-54	Product Version	Product version number. Increments by one whenever a previously generated file with an otherwise identical filename exists. **Values** / **Range** 00, 01, 02 …, 99 / 0 thru 99 A0, A1, …, A9 / 100 thru 109 AA, AB, …, AZ / 110 thru 135 B0, B1, B2 …, B9 / 136 thru 145 BA, BB, …, BZ / 146 thru 171 … / … Z0, Z1, …, Z9 / 1000 thru 1009 ZA, ZB, …, ZZ / 1010 thru 1035 _ _ / Value is out of range
55	Separator	Separator for filename and extension, always "."
56-58	File name extension	"DAT" : Binary table "CSV" : ASCII comma-separated-value text file "IMG" : Image data

The following are examples of PIXL data product file names.

Histogram Normal A EDR	`ps__0077_0637743441_000ena_n00100360009835610195 0__j01.csv`
MCC ROI EDR	`pc__0295_0632909178_000esr_n001000000000045301580__j01.dat`
Localized full spectra RDR	`ps__0139_0654662877_000rfs_n001000000000045300000__j01.csv`
MCC raw image EDR	`pc__0118t0677414812_000edr_n011001800176999100060 75j01.img`

PIXL data file names in the PDS archive are in lowercase characters.

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 PIXL labels.

Table 5 PDS4 Dictionaries Used In PIXL 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

*Versions current at time of first data release

4 PIXL Product Formats

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

4.1 Data Product Formats

PIXL non-image data products are formatted as binary tables or ASCII text comma-separated value (CSV) tables, according to the definitions of these structures in Section 4 of the PDS Standards Reference [2]. The formats are described at length in the PIXL EDR Data Product SIS [7] and the PIXL RDR Data Product SIS [8].

A PIXL non-image data file contains one or more data objects, either a binary table, a CSV table, or multiple CSV tables. Some CSV tables are preceded by a header record.

PIXL image data products are formatted as PDS image (IMG) files. An IMG file is a binary array of values all of the same data type. Image products are described in the Mars 2020 Camera SIS [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.

Appendix A Support Staff and Cognizant Persons

Name	Role	Institution	Email
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Appendix B Bundle Directory Structure

PIXL Bundle Root

```
|--- bundle_pixl.xml
|--- readme.txt
|--- data_raw_ancillary
        |--- collection_data_raw_ancillary.xml
        |--- collection_data_raw_ancillary_inventory.csv
        |--- sol_00001
          . . .
        |--- sol_nnnnn
|--- data_raw_spectroscopy
        |--- collection_data_raw_spectroscopy.xml
        |--- collection_data_raw_spectroscopy_inventory.csv
        |--- sol_00001
          . . .
        |--- sol_nnnnn
|--- data_ imaging
        |--- collection_data_imaging.xml
        |--- collection_data_imaging_inventory.csv
|--- data_processed
        |--- collection_data_processed.xml
        |--- collection_data_processed_inventory.csv
        |--- sol_00001
          . . .
        |--- sol_nnnnn
|--- document
        |--- collection_document.xml
        |--- collection_document_inventory.csv
        |--- pixl_bundle_sis.pdf, .xml
        |--- pixl_edr_sis.pdf, .xml
        |--- pixl_rdr_sis.pdf, .xml
        |--- pixl_release_notes.pdf, .xml
        |--- pixl_user_guide.pdf, .xml
```

The **data_imaging** collection contains PIXL MCC images, which are primary members of the collection **urn:nasa:pds:mars2020_imgops:data_mcc_imgops**. They are listed by their LIDVIDs as secondary members in the file **collection_data_imaging_inventory.csv**. The LIDVIDs may be used to locate the

images in their primary collection, using PDS search tools. In this way the relationship of the MCC images to the PIXL bundle is made explicit, even though the images belong primarily to a different bundle with other Mars 2020 images.