

Mars Exploration Rover (MER)

Software Interface Specification

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Mars Exploration Rover (MER) Project

APXS Reduced Data Record (RDR) Software Interface Specification (SIS)

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Jet Propulsion Laboratory
California Institute of Technology

CHANGE LOG

DATE	SECTIONS CHANGED	REASON FOR CHANGE	REVISION
10/31/03	All	First draft	Draft
2/18/05	All	Second draft	Draft
3/23/05	Cover page	Initial Release sent out for signature	Draft
3/23/05	Table 3 was removed	Table 3. "APXS Peak Area and Elemental Concentration Column Definitions" is no longer relevant, so this table was removed.	Draft
3/31/05	3.1	Added two sentences: The maximal number of recorded spectra is 12. Spectra taken from previous samples are removed.	Initial Release
3/31/05	Table 2	Deleted the word "Summed" from Table 2 title.	Initial Release
3/31/05	Table A.1	Removed the word "Summed" from the Table title.	Initial Release
3/31/05	Cover page	Changed PDS Central Node Data Engineer to PDS Geosciences Node Lead for one of the signatories	Initial Release

TBD ITEMS

SECTION	DESCRIPTION

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ACRONYMS

APXS	Alpha Particle X-ray Spectrometer
ASCII	American Standard Code for Information Interchange
CODMAC	Committee on Data Management and Computation
EDR	Experiment Data Record
ISO	International Standards Organization
JPL	Jet Propulsion Laboratory
MER	Mars Exploration Rover
NASA	National Aeronautics and Space Administration
ODL	Object Description Language
OSS	Operations Storage Server
PDS	Planetary Data System
RDR	Reduced Data Record
SIS	Software Interface Specification
SOWG	Science Operations Working Group
STG	Science Theme Group
TBD	To Be Determined

1. INTRODUCTION

1.1 Purpose and Scope

The purpose of this data product SIS is to provide users of the MER APXS reduced data product with a description of the product and a description of how it was generated, including data sources and destinations. The product is an ASCII table of results derived from the MER APXS Experiment Data Record (EDR) products. The RDR product includes x-ray count spectra as a function of channel number.

This SIS is intended to provide enough information to enable users to read and understand this data product. The users for whom this SIS is intended are the scientists who will analyze the data, including those associated with the MER Project and those in the general planetary science community.

1.2 Contents

This data product SIS describes how the APXS RDR product is generated, formatted, labeled, and uniquely identified. The document discusses standards used in generating the products and software that may be used to access the product. The product is described in sufficient detail to enable a user to read the product. Finally, an example of the PDS label is provided, along with definitions for the label keywords.

1.3 Applicable Documents and Constraints

This Data Product SIS is responsive to the following MER documents:

1. Mars Exploration Program Data Management Plan, R. E. Arvidson, S. Slavney, and S. Nelson, Rev. 3, March 20, 2002.
2. Mars Exploration Rover Project Archive Generation, Validation and Transfer Plan, Rev. A, R. E. Arvidson and S. Slavney, JPL D-19658, September 29, 2003.
3. MER Project APXS EDR SIS, E. Guinness, JPL D-22848, Version 2.0, June 13, 2003.

This SIS is also consistent with the following Planetary Data System documents:

4. Planetary Data System Data Preparation Workbook, Version 3.1, JPL D-7669, Part 1, February 1, 1995.
5. Planetary Data System Data Standards Reference, Version 3.5, JPL D-7669, Part 2, October, 15, 2002
6. Planetary Science Data Dictionary Document, JPL D-7116, August 28, 2002.

The reader is referred to the following documents for additional information:

7. R. Rieder et al., The New Athena Alpha Particle X-Ray Spectrometer (APXS) for the Mars Exploration Rovers, JGR Planets *108*(E12), 8066, doi:10.1029/2003JE002150, 2003.

Finally, this SIS is meant to be consistent with the contract negotiated between the MER Project and the Athena Principal Investigator in which reduced data records and documentation are explicitly defined as deliverable products.

1.4 Relationships with Other Interfaces

Changes to the APXS EDR data product and the SIS that describes the EDR product [3] could affect the APXS RDR data product and/or this SIS. In addition, changes to the processing tools used to generate the APXS RDR data product could affect both the data product and this SIS.

2. DATA PRODUCT CHARACTERISTICS AND ENVIRONMENT

2.1 Data Product Overview

The APXS RDR data product is an ASCII formatted table. Each ASCII table has an associated detached PDS label, also formatted as ASCII. The APXS RDR product contains the x-ray count data as a function of channel number.

2.2 Data Processing

2.2.1 Data Processing Level

This SIS uses the Committee On Data Management And Computation (CODMAC) data level numbering system to describe the processing level of the APXS RDR data products. These data products are considered CODMAC "Level 2" ["Edited Data"]. Refer to Table 1 for a summary of the CODMAC and NASA data processing levels.

Table 1. Processing Levels for Science Data Sets

NASA	CODMAC	Description
Packet data	Raw - Level 1	Telemetry data stream as received at the ground station, with science and engineering data embedded.
Level-0	Edited - Level 2	Instrument science data (e.g., raw voltages, counts) at full resolution, time ordered, with duplicates and transmission errors removed.
Level 1-A	Calibrated - Level 3	Level 0 data that have been located in space and may have been transformed (e.g., calibrated, rearranged) in a reversible manner and packaged with needed ancillary and auxiliary data (e.g., radiances with the calibration equations applied).
Level 1-B	Resampled - Level 4	Irreversibly transformed (e.g., resampled, remapped, calibrated) values of the instrument measurements (e.g., radiances, magnetic field strength).
Level 1-C	Derived – Level 5	Level 1A or 1B data that have been resampled and mapped onto uniform space-time grids. The data are calibrated (i.e., radiometrically corrected) and may have additional corrections applied (e.g., terrain correction).
Level 2	Derived – Level 5	Geophysical parameters, generally derived from Level 1 data, and located in space and time commensurate with instrument location, pointing, and sampling.

NASA	CODMAC	Description
Level 3	Derived – Level 5	Geophysical parameters mapped onto uniform space-time grids.

2.2.2 Data Product Generation

The APXS RDR data products are produced by APXS instrument team members from the Max Planck Institute for Chemistry (Mainz, Germany) using software tools developed by the APXS team. To generate an APXS RDR product, the x-ray data are extracted from the binary EDR file and converted to an ASCII format. APXS EDR files always contain twelve spectra even if less than twelve new measurements are acquired for a target. Thus, an EDR file may contain spectra for more than one target. In the APXS RDR product any spectra from earlier targets are removed from the product so that each RDR contains data for a single target. No other processing is done on the data.

2.2.3 Data Flow

APXS RDR data products are generated from binary EDR files that are transferred from the OSS to the APXS team workstations. After a science validation period, the APXS RDR data products are transferred to the PDS for final validation and archiving in accordance with the MER archive plan [2].

2.2.4 Labeling and Identification

A file naming scheme has been adapted for the MER image and non-image data products. The file naming scheme adheres to the ISO Level II 27.3 filename convention to be compliant with PDS standards.

Each MER EDR or RDR data product can be uniquely identified by incorporating into the product filename the Rover Mission identifier, the Instrument identifier, the Starting Spacecraft Clock count (SCLK) of the event, the data Product Type, the Site location, the rover Position within the site, the Sequence number, the camera “Eye”, the spectral Filter, the product Creator identifier and a Version number. For non-camera data, several fields do not apply.

Each APXS RDR has a detached PDS label associated with the APXS data file. The file naming scheme for the APXS RDR data products is formed by:

<rover><inst><sclk><prod><site><pos><seq><eye><filt><who><ver>.<ext>

where,

rover = (1 integer) MER rover mission identifier. Valid values are “1” (MER-1), “2” (MER-2), “3” (SIM-1) or “4” (SIM-2)

inst = (1 alpha character) MER science instrument identifier.

Valid values for MER instruments:

“A” - APXS

“B” - Mössbauer

“T” - Mini-TES

“D” - RAT (“D” for Drill)

Valid values for MER camera instruments not described in this SIS:

- “P” - Pancam
- “N” - Navcam
- “F” - Front Hazcam
- “R” - Rear Hazcam
- “M” - Microscopic Imager
- “E” - EDLcam

sclk = (9 integers) Starting Spacecraft Clock time.

prod = (3 alpha characters) Product type. Indicates the product to be an EDR or one of several types of Non-projected RDRs. All product types that begin with “E” denote a type of EDR, while all other product types denote a type of Non-projected RDR.

Valid values for MER non-camera instrument products:

Data Product	Value
APXS/Mini-TES/MB/RAT Detailed Report EDR	“EDR”
RAT Anomaly Report	“EAR”
RAT Parameters	“EDP”
Mini-TES Spectra Emissivity Image Cube	“EMS”
Mini-TES Mineral Abundance Image or Map	“MIN”
Mini-TES Data Cube (general)	“QUB”
APXS X-ray Spectra	“XRC”
Mini-TES Temperature and Thermal Inertia Map	“TTH”

Valid values for MER camera EDR instrument data products not described in this SIS:

Data Product	Non-linearized	CAHV-linearized
Full frame EDR	“EFF”	“FFL”
Sub-frame EDR	“ESF”	“SFL”
Downsampled EDR	“EDN”	“DNL”
Thumbnail EDR	“ETH”	“THN”
Row Summation EDR	“ERS”	n/a
Column Summation EDR	“ECS”	n/a
Reference Pixels EDR	“ERP”	n/a
Histogram EDR	“EHG”	n/a

site = (2 alphanumeric) Site location count. Use of both integers and alphas allows for a total range of 0 thru 1295. A value greater than 1295 is denoted by “##” (2 pound signs), requiring the user to extract actual value from label.

The valid values, in their progression, are as follows:

- Range 0 thru 99 - “00”, “01”, “02” ... “99”
- Range 100 thru 1035 - “A0”, “A1” ... “A9”, “AA”, “AB” ... “AZ”, “B0”, “B1” ... “ZZ”
- Range 1036 thru 1295 - “0A”, “0B” ... “0Z”, “1A”, “1B” ... “9Z”
- Range 1296 or greater - “##” (2 pound signs)

Example value is “AK” for value of 120..

pos = (2 alphanumeric) Position-within-Site count. Use of both integers and alphas allows for a total range of 0 thru 1295. A value greater than 1295 is denoted by “##” (2 pound signs), requiring the user to extract actual value from label.

The valid values, in their progression, are as follows:

Range 0 thru 99 - "00", "01", "02" ... "99"
 Range 100 thru 1035 - "A0", "A1" ... "A9", "AA", "AB" ... "AZ", "B0", "B1" ... "ZZ"
 Range 1036 thru 1295 - "0A", "0B" ... "0Z", "1A", "1B" ... "9Z"
 Range 1296 or greater - "##" (2 pound signs)

Example value is "AK" for value of 120..

seq = (1 alpha character plus 4 integers) Sequence Number. Denotes a group of related commands used as keys for the Ops processing.

Valid values for character (position 1) in field:

"C" - Cruise

"P" - PMA instr. (Pancam, Navcam, MTES, MI)

"D" - IDD & RAT

"R" - Rover Driving

"E" - Engineering

"S" - Submaster

"F" - Flight Software (Seq rejected)

"T" - Test

"G" - (heating)

"W" - Seq. triggered by a commun. Window

"K" - (spare)

"X" - Contingency

"M" - Master (Surface only)

"Y" - (spare)

"N" - In-Situ instr. (APXS, MB)

"Z" - SCM Seq's

Valid values for integers (positions 2 thru 5) in field:

0001 thru **4095** - Valid Sequence number, commanded by Ground

Needs "F" in character position (Camera only):

1000 - Commanded by NAV

2000 - Commanded by SAPP

3000 - Commanded by Fault protection

4000 - Commanded by EDL

Example value is "N0268".

eye = (1 alpha character) Camera eye. Valid values are:

"L" - Left camera eye

"M" - Monoscopic (one camera eye)

"R" - Right camera eye

"N" - Not Applicable (non-image data)

"B" - Both left and right camera eyes

filt = (1 integer) Filter number, with a valid range of **0-8** (0 = "no filter" or "N/A").

who = (1 alpha character) Product creator indicator. Valid values are as follows, though others may be added in the future:

"A" - Arizona State University
"C" - Cornell University
"F" - USGS at Flagstaff
"J" - Johannes Gutenberg Univ. (Germany)
"M" - OPGS (MIPL) at JPL
"N" - NASA Ames Research Center
"P" - Max Planck Institute (Germany)
"S" - SOAS at JPL
"U" - University of Arizona
"V" - SSV Team (E. De Jong) at JPL
"X" - Other

ver = (1 alphanumeric) Version identifier providing uniqueness for book keeping.

The valid values, in their progression, are as follows:

Range 1 thru 9 - "1", "2", ... "9"

Range 10 thru 35 - "A", "B", ... "Z"

Example value is "E" for value of 14.

ext = (3 alpha characters) PDS product type extension.

Valid values for MER non-camera instrument products:

"QUB" - Mini-TES Data Cube

"DAT" - APXS spectra, Mössbauer spectra, RAT binary data

"CSV" - APXS table data, Mössbauer table data

"LBL" - Detached PDS labels for APXS and Mössbauer data

Valid values for MER camera instrument products not described in this SIS:

"IMG" - Camera image EDR and all camera image Non-projected RDRs

"JPG" - Camera image CAHV'd RDRs scaled and JPEG compress (no PDS label)

"pfb" - Camera ASD Terrain RDR (no PDS label)

"VST" - Camera VST Terrain RDR (no PDS label)

Example:

- a) 1A123456789XRC0103N0062N0P1.CSV Rover MER-1, APXS instrument, Spectra, Site 01, Position 03, Seq N0062, produced by MPI, product version 1.

2.3 Standards Used in Generating Data Products

2.3.1 PDS Standards

The APXS RDR data products comply with Planetary Data System standards for file formats and labels, as specified in the PDS Standards Reference [5] and the Planetary Science Data Dictionary Document [6].

2.3.2 Time Standards

PDS labels for APXS RDR data products use keywords containing time values, such as start time and stop time. Each time value standard is defined according to the keyword definition. See Appendix B.

2.3.3 Data Storage Conventions

APXS RDR data products and detached PDS label files are stored as ASCII text. Each line or record in the files is terminated with a two-character sequence of carriage return (<CR>, ASCII 13) and line feed (<LF>, ASCII 10) to comply with PDS standards [5]. This line terminator sequence will allow the data files and labels to be easily read on most computers, which recognize either the carriage return, the line feed, or the <CR>/<LF> sequence as an ASCII record terminator.

2.4 Data Validation

Validation of APXS RDR data product labels includes checking for correct PDS syntax, for accepted standard values of keywords, and for internal consistency of label items.

3. DETAILED DATA PRODUCT SPECIFICATIONS

3.1 Data Format Description

Each APXS RDR data file is a comma delimited ASCII text table with variable length columns. The number of columns in the file is dependent on the number of spectra collected for a target. The maximal number of recorded spectra is 12. Spectra taken from previous samples are removed. There are 512 rows in each RDR file. Each row is terminated with a carriage return and line feed character. Table 2 contains the column definitions for the APXS RDR data product.

Table 2. APXS Spectra Column Definitions

Column Number	Name	Data Type	Description
1	APXS X-ray channel	Integer	X-ray channel number
2 ... max 13	X-ray counts	Integer	Counts of the x-ray channel for each subspectrum

3.2 PDS Label Description

Each APXS RDR data product has a detached PDS label, which is stored as ASCII text. The PDS label is object-oriented with keywords for product identification, along with the data object definition. The data object definition within the label contains descriptive information needed to interpret or process the data. The PDS spreadsheet object is used to describe the format of the APXS RDR product.

PDS labels are written in Object Description Language (ODL) [5]. PDS label statements have the form of "keyword = value". Each label statement is terminated with a carriage return character (ASCII 13) and a line feed character (ASCII 10) sequence to allow the label to be read by many operating systems. Pointer statements with the following format are used to indicate the location of data objects in the data product:

^object = location

where the caret character (^, also called a pointer) is followed by the name of the specific data object. For detached PDS labels, location is the name of the file that contains data object and optionally the starting record number of the data object within the file or byte offset from the start of the file.

Appendix A lists an example PDS label for an APXS RDR.

4. APPLICABLE SOFTWARE

4.1 Applicable PDS Software Tools

PDS-labeled tables can be viewed with the program NASAView, developed by the PDS. NASAView is available in versions that run on SUN/SOLARIS, Windows, and LINUX operating systems. NASAView can be obtained from the PDS web site <http://pdsproto.jpl.nasa.gov/Distribution/license.html>.

APPENDIX A - SAMPLE APXS RDR LABEL

A.1. PDS Label for Spectra

```

PDS_VERSION_ID                = PDS3

/* FILE DATA ELEMENTS */

RECORD_TYPE                   = STREAM
FILE_RECORDS                  = 512
^SPREADSHEET                  = "1A136253888XRC1500N1419N0P1.CSV"

/* IDENTIFICATION DATA ELEMENTS */

DATA_SET_ID                   = "MER1-M-APXS-2-XRAYSPEC-SCI-V1.0"
PRODUCT_ID                    = "1A136253888XRC1500N1419N0P1"
SOURCE_PRODUCT_ID             = "1A136253888EDR1500N1419N0M1"
PRODUCT_TYPE                  = APXS_XRC
RELEASE_ID                    = "0003"
ROVER_MOTION_COUNTER          = (15, 0, 60, 293, 0)
ROVER_MOTION_COUNTER_NAME     = (SITE, DRIVE, IDD, PMA, HGA)
COMMAND_SEQUENCE_NUMBER       = 1
INSTRUMENT_HOST_ID           = MER1
INSTRUMENT_HOST_NAME         = "MARS EXPLORATION ROVER 1"
INSTRUMENT_ID                 = APXS
INSTRUMENT_TYPE               = SPECTROMETER
LOCAL_TRUE_SOLAR_TIME         = "04:48:44"
MAGNET_ID                     = "NULL"
MISSION_NAME                   = "MARS EXPLORATION ROVER"
MISSION_PHASE_NAME            = "EXTENDED MISSION"
OBSERVATION_ID                = "1594032128"
PLANET_DAY_NUMBER             = 91
PRODUCER_INSTITUTION_NAME     = "MAX PLANCK INSTITUTE"
PRODUCT_CREATION_TIME         = 2005-01-08T17:34:42
SEQUENCE_ID                   = n1419
SEQUENCE_VERSION_ID           = "0"
SPACECRAFT_CLOCK_CNT_PARTITION = 1
SPACECRAFT_CLOCK_START_COUNT  = "136235628.238"
SPACECRAFT_CLOCK_STOP_COUNT   = "136253888.207"
START_TIME                    = 2004-04-26T07:13:11.516
STOP_TIME                     = 2004-04-26T12:17:31.552
TARGET_NAME                   = MARS
TARGET_TYPE                   = PLANET

/* TELEMETRY DATA ELEMENTS */

APPLICATION_PROCESS_ID         = 32
APPLICATION_PROCESS_NAME       = APXS
APPLICATION_PROCESS_SUBTYPE_ID = 0
EARTH_RECEIVED_START_TIME     = 2004-04-26T20:01:29.476
EARTH_RECEIVED_STOP_TIME      = 2004-04-26T20:01:34.254
EXPECTED_PACKETS              = "N/A"
PACKET_MAP_MASK               = "N/A"
RECEIVED_PACKETS              = "N/A"
SAMPLING_COUNT                = 0

```

```

SPICE_FILE_NAME           = "chronos.mer"
TELEMETRY_FORMAT_ID      = SPT
TELEMETRY_PROVIDER_ID    = "SSW MER_DP"
TELEMETRY_SOURCE_NAME    = "032_000_n1419-000-0001_001_0136253888-
053.dat"
TELEMETRY_SOURCE_TYPE    = "DATA PRODUCT"
TLM_INST_DATA_HEADER_ID  = 3

```

```

/* ROVER STATE */
/* COORDINATE SYSTEM STATE: ROVER */

```

```

GROUP                     = ROVER_COORDINATE_SYSTEM
COORDINATE_SYSTEM_NAME   = ROVER_FRAME
COORDINATE_SYSTEM_INDEX  = (15, 0, 60, 293, 0)
COORDINATE_SYSTEM_INDEX_NAME = (SITE, DRIVE, IDD, PMA, HGA)
ORIGIN_OFFSET_VECTOR     = (0.00000, 0.00000, 0.00000)
ORIGIN_ROTATION_QUATERNION = (0.999886, 0.0131920, 0.00737100,
                              -0.000377824)
POSITIVE_AZIMUTH_DIRECTION = CLOCKWISE
POSITIVE_ELEVATION_DIRECTION = UP
QUATERNION_MEASUREMENT_METHOD = COARSE
REFERENCE_COORD_SYSTEM_NAME = SITE_FRAME
REFERENCE_COORD_SYSTEM_INDEX = 15
END_GROUP                 = ROVER_COORDINATE_SYSTEM

```

```

/* ARTICULATION DEVICE STATE: INSTRUMENT DEPLOYMENT DEVICE AT THE START */

```

```

GROUP                     = START_IDD_ARTICULATION_STATE
ARTICULATION_DEVICE_ID    = IDD
ARTICULATION_DEVICE_NAME  = "INSTRUMENT DEPLOYMENT DEVICE"
ARTICULATION_DEVICE_ANGLE = (0.302038 <rad>, -0.0282162 <rad>,
                              1.29951 <rad>, 0.185468 <rad>,
                              3.15076 <rad>, 0.302252 <rad>,
                              -0.0320500 <rad>, 1.28262 <rad>,
                              0.227287 <rad>, 3.03184 <rad>)
ARTICULATION_DEVICE_ANGLE_NAME = ("JOINT 1 AZIMUTH-ENCODER",
                                   "JOINT 2 ELEVATION-ENCODER",
                                   "JOINT 3 ELBOW-ENCODER",
                                   "JOINT 4 WRIST-ENCODER",
                                   "JOINT 5 TURRET-ENCODER",
                                   "JOINT 1 AZIMUTH-POTENTIOMETER",
                                   "JOINT 2 ELEVATION-POTENTIOMETER",
                                   "JOINT 3 ELBOW-POTENTIOMETER",
                                   "JOINT 4 WRIST-POTENTIOMETER",
                                   "JOINT 5 TURRET-POTENTIOMETER")
ARTICULATION_DEVICE_MODE  = GUARDED
ARTICULATION_DEVICE_TEMP  = (1.00000e+30 <degC>, -46.8465 <degC>)
ARTICULATION_DEVICE_TEMP_NAME = ("AZIMUTH JOINT 1", "TURRET JOINT 5")
ARTICULATION_DEV_VECTOR   = (-0.0147503, 0.0263754, 0.999543)
ARTICULATION_DEV_VECTOR_NAME = GRAVITY
CONTACT_SENSOR_STATE      = ("NO CONTACT", "NO CONTACT", CONTACT,
                              CONTACT, "NO CONTACT", "NO CONTACT",
                              OPEN, "NO CONTACT")
CONTACT_SENSOR_STATE_NAME = ("MI SWITCH 1", "MI SWITCH 2",
                              "RAT SWITCH 1", "RAT SWITCH 2",
                              "MB SWITCH 1", "MB SWITCH 2",

```

```

"APXS DOOR SWITCH", "APXS CONTACT
SWITCH" )
  ARTICULATION_DEV_INSTRUMENT_ID = APXS
END_GROUP = START_IDD_ARTICULATION_STATE

/* COORDINATE SYSTEM STATE: INSTRUMENT DEPLOYMENT DEVICE AT THE START */

GROUP = START_IDD_COORDINATE_SYSTEM
  COORDINATE_SYSTEM_NAME = APXS_FRAME
  COORDINATE_SYSTEM_INDEX = (15, 0, 60, 293, 0)
  COORDINATE_SYSTEM_INDEX_NAME = (SITE, DRIVE, IDD, PMA, HGA)
  ORIGIN_OFFSET_VECTOR = (1.10661, 0.113606, 0.290757)
  ORIGIN_ROTATION_QUATERNION = (0.591676, 0.0280522, 0.0437475,
                                0.804499)
  POSITIVE_AZIMUTH_DIRECTION = CLOCKWISE
  POSITIVE_ELEVATION_DIRECTION = DOWN
  REFERENCE_COORD_SYSTEM_NAME = ROVER_FRAME
  REFERENCE_COORD_SYSTEM_INDEX = (15, 0, 60, 293, 0)
END_GROUP = START_IDD_COORDINATE_SYSTEM

/* ARTICULATION DEVICE STATE: INSTRUMENT DEPLOYMENT DEVICE AT END */

GROUP = STOP_IDD_ARTICULATION_STATE
  ARTICULATION_DEVICE_ID = IDD
  ARTICULATION_DEVICE_NAME = "INSTRUMENT DEPLOYMENT DEVICE"
  ARTICULATION_DEVICE_ANGLE = (0.302038 <rad>, -0.0282162 <rad>,
                                1.29951 <rad>, 0.185468 <rad>,
                                3.15076 <rad>, 0.302537 <rad>,
                                -0.0318107 <rad>, 1.28402 <rad>,
                                0.228956 <rad>, 3.03244 <rad>)
  ARTICULATION_DEVICE_ANGLE_NAME = ("JOINT 1 AZIMUTH-ENCODER",
                                     "JOINT 2 ELEVATION-ENCODER",
                                     "JOINT 3 ELBOW-ENCODER",
                                     "JOINT 4 WRIST-ENCODER",
                                     "JOINT 5 TURRET-ENCODER",
                                     "JOINT 1 AZIMUTH-POTENTIOMETER",
                                     "JOINT 2 ELEVATION-POTENTIOMETER",
                                     "JOINT 3 ELBOW-POTENTIOMETER",
                                     "JOINT 4 WRIST-POTENTIOMETER",
                                     "JOINT 5 TURRET-POTENTIOMETER")
  ARTICULATION_DEVICE_MODE = "FREE SPACE"
  ARTICULATION_DEVICE_TEMP = (1.00000e+30 <degC>, -37.4815 <degC>)
  ARTICULATION_DEVICE_TEMP_NAME = ("AZIMUTH JOINT 1", "TURRET JOINT 5")
  ARTICULATION_DEV_VECTOR = (-0.0147503, 0.0263754, 0.999543)
  ARTICULATION_DEV_VECTOR_NAME = GRAVITY
  CONTACT_SENSOR_STATE = ("NO CONTACT", "NO CONTACT", CONTACT,
                           CONTACT, "NO CONTACT", "NO CONTACT",
                           OPEN, "NO CONTACT")
  CONTACT_SENSOR_STATE_NAME = ("MI SWITCH 1", "MI SWITCH 2",
                                "RAT SWITCH 1", "RAT SWITCH 2",
                                "MB SWITCH 1", "MB SWITCH 2",
                                "APXS DOOR SWITCH", "APXS CONTACT
SWITCH" )
  ARTICULATION_DEV_INSTRUMENT_ID = APXS
END_GROUP = STOP_IDD_ARTICULATION_STATE

/* COORDINATE SYSTEM STATE: INSTRUMENT DEPLOYMENT DEVICE AT END */

```

```

GROUP = STOP_IDD_COORDINATE_SYSTEM
COORDINATE_SYSTEM_NAME = APXS_FRAME
COORDINATE_SYSTEM_INDEX = (15, 0, 60, 293, 0)
COORDINATE_SYSTEM_INDEX_NAME = (SITE, DRIVE, IDD, PMA, HGA)
ORIGIN_OFFSET_VECTOR = (1.10661, 0.113606, 0.290757)
ORIGIN_ROTATION_QUATERNION = (0.591676, 0.0280522, 0.0437475,
                                0.804499)
POSITIVE_AZIMUTH_DIRECTION = CLOCKWISE
POSITIVE_ELEVATION_DIRECTION = DOWN
REFERENCE_COORD_SYSTEM_NAME = ROVER_FRAME
REFERENCE_COORD_SYSTEM_INDEX = (15, 0, 60, 293, 0)
END_GROUP = STOP_IDD_COORDINATE_SYSTEM

OBJECT = SPREADSHEET
INTERCHANGE_FORMAT = ASCII
ROWS = 512
FIELDS = 7
ROW_BYTES = 132
FIELD_DELIMITER = "COMMA"
DESCRIPTION = "APXS x-ray spectra in counts as a
function
of channel number. The number of spectra in the file (maximum of 12)
depends on the length of the integration. Channel 1 contains the lifetime
for the spectrum in units of 10 seconds. Channel 2 is the unique id for
the spectrum. The value increments by one after every cycle start.
Channels 3 and 4 contain the temperature correction gain multiplier and
linear term, respectively. The measured x-ray data start with channel 5.
The last channel, number 512, contains the number of x-rays with energies
greater than full scale."

OBJECT = FIELD
NAME = "CHANNEL_NUMBER"
FIELD_NUMBER = 1
DATA_TYPE = ASCII_INTEGER
BYTES = 10
DESCRIPTION = "Channel number representing a given
energy level."
END_OBJECT = FIELD

OBJECT = FIELD
NAME = "SPECTRA_01"
FIELD_NUMBER = 2
DATA_TYPE = ASCII_INTEGER
BYTES = 10
DESCRIPTION = "Number of x-rays detected per channel."
END_OBJECT = FIELD

OBJECT = FIELD
NAME = "SPECTRA_02"
FIELD_NUMBER = 3
DATA_TYPE = ASCII_INTEGER
BYTES = 10
DESCRIPTION = "Number of x-rays detected per channel."
END_OBJECT = FIELD

OBJECT = FIELD

```

```
NAME = "SPECTRA_03"
FIELD_NUMBER = 4
DATA_TYPE = ASCII_INTEGER
BYTES = 10
DESCRIPTION = "Number of x-rays detected per channel."
END_OBJECT = FIELD

OBJECT = FIELD
NAME = "SPECTRA_04"
FIELD_NUMBER = 5
DATA_TYPE = ASCII_INTEGER
BYTES = 10
DESCRIPTION = "Number of x-rays detected per channel."
END_OBJECT = FIELD

OBJECT = FIELD
NAME = "SPECTRA_05"
FIELD_NUMBER = 6
DATA_TYPE = ASCII_INTEGER
BYTES = 10
DESCRIPTION = "Number of x-rays detected per channel."
END_OBJECT = FIELD

OBJECT = FIELD
NAME = "SPECTRA_06"
FIELD_NUMBER = 7
DATA_TYPE = ASCII_INTEGER
BYTES = 10
DESCRIPTION = "Number of x-rays detected per channel."
END_OBJECT = FIELD
END_OBJECT = SPREADSHEET
END
```

APPENDIX B – LABEL KEYWORD DEFINITIONS

Note see the Planetary Science Data Dictionary [6] for the definitions of keywords within the spreadsheet and column objects.

Keyword Name	Definition	Type	Units	Valid Values	<ul style="list-style-type: none"> • Location in PDS Label • Source
APPLICATION_PROCESS_ID	Identifies the source/process which created the data.	Integer		(see APPLICATION_PROCESS_NAME)	<p>LOCATION TELEMETRY (Class)</p> <p>SOURCE CCSDS:Primary:APID</p>
APPLICATION_PROCESS_NAME	Provides the name associated with the source/process which created the data.	String (256)		APID NAME 21 "PANCAM LEFT" 22 "PANCAM RIGHT" 23 "NAVCAM LEFT" 24 "NAVCAM RIGHT" 25 "HAZCAM LEFT FRONT" 26 "HAZCAM RIGHT FRONT" 27 "HAZCAM LEFT REAR" 28 "HAZCAM RIGHT REAR" 29 "MI" 30 "DESCENT IMAGER" 31 "MINITES" 32 "APXS" 33 "MB" 34 "RAT"	<p>LOCATION TELEMETRY (Class)</p> <p>SOURCE Table Lookup CCSDS:Primary:APID</p>
APPLICATION_PROCESS_SUBTYPE_ID	Identifies the source/subprocess that created the data.	Integer		0 APXS SCIENCE DATA	<p>LOCATION TELEMETRY (Class)</p> <p>SOURCE CCSDS:Primary:subtype</p>

Keyword Name	Definition	Type	Units	Valid Values	<ul style="list-style-type: none"> ● Location in PDS Label ● Source
ARTICULATION_DEVICE_ANGLE	<p>Provides the value of an angle between two parts or segments of an articulated device.</p> <p>MER uses radians. The PDS default unit for this keyword is degrees, so the <rad> tag is required for MER data.</p>	Float array[10]	radians (<rad> unit tag required)		<p>LOCATION a) START_IDD_ARTICULATION_STATE (Group) b) STOP_IDD_ARTICULATION_STATE (Group)</p> <p>SOURCE Group Dependent a) IDPH:bgn->idd.q_enc[5] IDPH:bgn->idd.q_pot[5] c) IDPH:end->idd.q_enc[5] IDPH:end->idd.q_pot[5]</p>
ARTICULATION_DEVICE_ANGLE_NAME	<p>Provides the formal name that identifies each of the values used in ARTICULATION_DEVICE_ANGLE.</p>	String array[10]		("JOINT 1 AZIMUTH-ENCODER", "JOINT 2 ELEVATION-ENCODER", "JOINT 3 ELBOW-ENCODER", "JOINT 4 WRIST-ENCODER", "JOINT 5 TURRET-ENCODER", "JOINT 1 AZIMUTH-POTENTIOMETER", "JOINT 2 ELEVATION-POTENTIOMETER", "JOINT 3 ELBOW-POTENTIOMETER", "JOINT 4 WRIST-POTENTIOMETER", "JOINT 5 TURRET-POTENTIOMETER")	<p>LOCATION a) START_IDD_ARTICULATION_STATE (Group) b) STOP_IDD_ARTICULATION_STATE (Group)</p> <p>SOURCE Static Values</p>
ARTICULATION_DEVICE_ID	<p>Specifies the abbreviated ID of the articulation device described by the containing group. An articulation device is anything that can move independently of the spacecraft to which it is attached, e.g. mast heads, wheel bogies, arms, etc.</p>	string		IDD	<p>LOCATION a) START_IDD_ARTICULATION_STATE (Group) b) STOP_IDD_ARTICULATION_STATE (Group)</p> <p>SOURCE Static Values</p>

Keyword Name	Definition	Type	Units	Valid Values	<ul style="list-style-type: none"> Location in PDS Label Source
ARTICULATION_DEVICE_MODE	<p>Indicates the deployment state (i.e., physical configuration) of an articulation device at the time of data acquisition.</p> <p>For MER, this is the mode of the last move:</p> <p>“FREE SPACE” – IDD arm was moved where there was no contact with a target expected.</p> <p>“GUARDED” – IDD arm was moved where contact with the target was expected.</p> <p>“RETRACTING” – IDD arm was moved where an instrument is removed from a target.</p> <p>“PRELOAD” – IDD arm stays in contact with the target and applies force or over-travel on an instrument.</p>	String		<p><u>IDD</u></p> <p>0=“FREE SPACE”, 1=“GUARDED”, 2=“RETRACTING”, 3=“PRELOAD”</p>	<p>LOCATION</p> <p>a) START_IDD_ARTICULATION_STATE (Group) b) STOP_IDD_ARTICULATION_STATE (Group)</p> <p>SOURCE</p> <p>Group Dependent; Table Lookup a) IDPH:bgn->idd.idd_mode b) IDPH:end->idd.idd_mode</p>
ARTICULATION_DEVICE_NAME	<p>Specifies the common name of the articulation device described by the containing group.</p>	string		<p>“INSTRUMENT DEPLOYMENT DEVICE”</p>	<p>LOCATION</p> <p>a) START_IDD_ARTICULATION_STATE (Group) b) STOP_IDD_ARTICULATION_STATE (Group)</p> <p>SOURCE</p> <p>Static Value</p>
ARTICULATION_DEVICE_TEMP	<p>Provides the temperature, in Celsius, of an articulated device or some part of an articulated device.</p>	Float array[2]	deg C (<degC> unit tag required)	-3.4e38 to 3.4e38	<p>LOCATION</p> <p>a) START_IDD_ARTICULATION_STATE (Group) b) STOP_IDD_ARTICULATION_STATE (Group)</p> <p>SOURCE</p> <p>a) IDPH:bgn->idd.temp[2] b) IDPH:end->idd.temp[2]</p>
ARTICULATION_DEVICE_TEMP_NAME	<p>An array of the formal names identifying each of the values used in ARTICULATION_DEVICE_TEMP.</p>	string array[2]		<p>(“AZIMUTH JOINT 1”, “TURRET JOINT 5”)</p>	<p>LOCATION</p> <p>a) START_IDD_ARTICULATION_STATE (Group) b) STOP_IDD_ARTICULATION_STATE (Group)</p> <p>SOURCE</p> <p>a) Static Value</p>

Keyword Name	Definition	Type	Units	Valid Values	<ul style="list-style-type: none"> Location in PDS Label Source
ARTICULATION_DEV_INSTRUMENT_ID	Provides an abbreviated name or acronym that identifies an instrument mounted on the articulation device.	String(12)		<u>IDD</u> 0 = MI 1 = RAT 2 = MB 3 = APXS	LOCATION a) START_IDD_ARTICULATION_STATE (Group) b) STOP_IDD_ARTICULATION_STATE (Group) SOURCE Table Lookup; a) IDPH:bgn->idd.instrument b) IDPH:end->idd.instrument
ARTICULATION_DEV_VECTOR	Provides the direction and magnitude of an external force acting on the articulation device, in the rover's coordinate system at the time the pose was computed.	Float array[3]			LOCATION a) START_IDD_ARTICULATION_STATE (Group) b) STOP_IDD_ARTICULATION_STATE (Group) SOURCE a) IDPH:bgn->idd.tilt[3] b) IDPH:end->idd.tilt[3]
ARTICULATION_DEV_VECTOR_NAME	Provides the formal name of the vector type of the articulation device.	String		GRAVITY	LOCATION a) START_IDD_ARTICULATION_STATE (Group) b) STOP_IDD_ARTICULATION_STATE (Group) SOURCE Static Value
COMMAND_SEQUENCE_NUMBER	Provides a numeric identifier for a sequence of commands sent to a spacecraft or instrument. For MER, this is the command number that identifies the specific generating command within the specified sequence.	Integer			LOCATION IDENTIFICATION (Class) SOURCE UPTH:ProdCmndId; Command Number
CONTACT_SENSOR_STATE	An array of identifiers for the state of an instrument's or instrument host's contact sensors at a specified time. For MER, "CONTACT" or "NO CONTACT" for most values. For the value corresponding to APXS DOOR SWITCH (entry 7), values are "OPEN" or "CLOSED".	String array[8]		0 = "NO CONTACT" or "CLOSED" 1 = "CONTACT" or "OPEN" "CONTACT" or "NO CONTACT" for all array positions except for position 7, which would be "OPEN" or "CLOSED"	LOCATION a) START_IDD_ARTICULATION_STATE (Group) b) STOP_IDD_ARTICULATION_STATE (Group) SOURCE Lookup Table a) IDPH:bgn->idd.contact (bit map) b) IDPH:end->idd.contact (bit map)

Keyword Name	Definition	Type	Units	Valid Values	<ul style="list-style-type: none"> ● Location in PDS Label ● Source
CONTACT_SENSOR_STATE_NAME	An array of the formal names identifying each of the values used in CONTACT_SENSOR_STATE.	String array[8]		("MI SWITCH 1", "MI SWITCH 2", "RAT SWITCH 1", "RAT SWITCH 2", "MB SWITCH 1", "MB SWITCH 2", "APXS DOOR SWITCH", "APXS CONTACT SWITCH")	<p>LOCATION</p> <p>a) START_IDD_ARTICULATION_STATE (Group)</p> <p>b) STOP_IDD_ARTICULATION_STATE (Group)</p> <p>SOURCE</p> <p>Static Value</p>
COORDINATE_SYSTEM_INDEX	<p>Instance of the coordinate frame in which the values are expressed. This is a group of integers that can be used to record and track the movement of a rover during surface operations.</p> <p>When in a COORDINATE_SYSTEM_STATE group, this keyword identifies which instance of the coordinate frame named by COORDINATE_SYSTEM_NAME is being defined by the group.</p> <p>For MER, the indices are based on the ROVER_MOTION_COUNTER. This counter is incremented each time the rover moves (or may potentially have moved, e.g. due to arm motion). The full counter has values (SITE, DRIVE, IDD, PMA, HGA)</p> <p>Example: COORDINATE_SYSTEM_INDEX = (1,3,2,3,2)</p>	integer array[5]			<p>LOCATION</p> <p>a) START_IDD_COORDINATE_SYSTEM (Group)</p> <p>b) STOP_IDD_COORDINATE_SYSTEM (Group)</p> <p>c) ROVER_COORDINATE_SYSTEM (Group)</p> <p>SOURCE</p> <p>Calculated from IDPH:bgn->rmc and COORDINATE_SYSTEM_NAME</p> <p>Use all 5 elements except if the COORDINATE_SYSTEM_NAME = SITE_FRAME, then only use the first element.</p>
COORDINATE_SYSTEM_INDEX_NAME	An array of the formal names identifying each integer specified in COORDINATE_SYSTEM_INDEX.	String array[6]		(SITE, DRIVE, IDD, PMA, HGA)	<p>LOCATION</p> <p>a) START_IDD_COORDINATE_SYSTEM (Group)</p> <p>b) STOP_IDD_COORDINATE_SYSTEM (Group)</p> <p>c) ROVER_COORDINATE_SYSTEM (Group)</p> <p>SOURCE</p> <p>Static Value; Group Dependant</p> <p>Should match the number of values in the COORDINATE_SYSTEM_INDEX</p>

Keyword Name	Definition	Type	Units	Valid Values	<ul style="list-style-type: none"> ● Location in PDS Label ● Source
COORDINATE_SYSTEM_NAME	<p>Provides the full name of the coordinate system to which the state vectors are referenced.</p> <p>When in a COORDINATE_SYSTEM_STATE group, this keyword provides the full name of the coordinate system being defined by the group. The rest of the keywords in the group describe how this coordinate system is related to some other (the "reference"). Non-unique coordinate systems (such as "SITE" for rover missions), which have multiple instances using the same name, also require COORDINATE_SYSTEM_INDEX to completely identify the coordinate system.</p>	string(30)		ROVER_FRAME, SITE_FRAME, MAST_FRAME, LOCAL_LEVEL_FRAME, <u>IDD only</u> 0=MI_FRAME 1=RAT_FRAME 2=MB_FRAME 3=APXS_FRAME,	<p>LOCATION</p> <p>a) START_IDD_COORDINATE_SYSTEM (Group) b) STOP_IDD_COORDINATE_SYSTEM (Group) c) ROVER_COORDINATE_SYSTEM (Group)</p> <p>SOURCE</p> <p>Group dependant a) one of the IDD only frames based on IDPH:bgn->idd.instrument b) one of the IDD only frames based on IDPH:end->idd.instrument c) ROVER_FRAME</p>
DATA_SET_ID	<p>A unique alphanumeric identifier for a data set or a data product. The DATA_SET_ID value for a given data set or product is constructed according to flight project naming conventions. In most cases the DATA_SET_ID is an abbreviation of the DATA_SET_NAME.</p> <p>In the PDS, the values for both DATA_SET_ID and DATA_SET_NAME are constructed according to standards outlined in the Standards Reference.</p>	string(40)		APXS "MER1-M-APXS-2-EDR-OPS-V1.0", "MER2-M-APXS-2-EDR-OPS-V1.0" "SIM1-M-APXS-2-EDR-V1.0" "SIM2-M-APXS-2-EDR-V1.0"	<p>LOCATION</p> <p>IDENTIFICATION (Class)</p> <p>SOURCE</p> <p>PDS Table Lookup CCSDS:Primary:APID CHDO-82:scft_id</p>
EARTH_RECEIVED_START_TIME	<p>Provides the beginning time at which telemetry was received. This should be represented in UTC system format.</p>	Datetime		YYYY-MM-DDThh:mm:ss[.fff]	<p>LOCATION</p> <p>TELEMETRY (Class)</p> <p>SOURCE</p> <p>Calculated CHDO_82:ert</p>
EARTH_RECEIVED_STOP_TIME	<p>Provides the ending time for receiving telemetry. This should be represented in UTC system format.</p>	Datetime		YYYY-MM-DDThh:mm:ss[.fff]	<p>LOCATION</p> <p>TELEMETRY (Class)</p> <p>SOURCE</p> <p>Calculated CHDO_82:ert</p>

Keyword Name	Definition	Type	Units	Valid Values	<ul style="list-style-type: none"> Location in PDS Label Source
EXPECTED_PACKETS	<p>Provides the total number of telemetry packets that constitute a complete data product, i.e., a data product without missing data.</p> <p>For MER, "Packets" are also referred to as "Parts".</p>	Integer			<p>LOCATION TELEMETRY (Class)</p> <p>SOURCE UPTH:TotalParts</p>
FILE_RECORDS	<p>Indicates the number of physical file records, including both label records and data records. In the PDS the use of FILE_RECORDS along with other file-related data elements is fully described in the Standards Reference.</p>	Integer		5	<p>LOCATION FILE DATA ELEMENT (Class)</p> <p>SOURCE Static Value</p>
INSTRUMENT_HOST_ID	<p>Provides a unique identifier for the host where an instrument is located. This host can be either a spacecraft or an earth base (e.g., and observatory or laboratory on the earth). Thus, INSTRUMENT_HOST_ID can contain values that are either SPACECRAFT_ID values or EARTH_BASE_ID values.</p>	String(6)		<p>SCID Keyword Values</p> <p>253 "MER1"</p> <p>254 "MER2"</p> <p>252 "SIM1"</p> <p>255 "SIM2"</p>	<p>LOCATION IDENTIFICATION (Class)</p> <p>SOURCE Table Lookup CHDO_82:scft_id</p>
INSTRUMENT_HOST_NAME	<p>Provides the full name of the host on which an instrument is based. This host can be either a spacecraft or an earth base. Thus, the INSTRUMENT_HOST_NAME element can contain values that are either SPACECRAFT_NAME values or EARTH_BASE_NAME values.</p> <p>Note that mosaics may contain more than one value in an array.</p>	String		<p>"MARS EXPLORATION ROVER 1"</p> <p>"MARS EXPLORATION ROVER 2"</p> <p>"SIMULATED MARS EXPLORATION ROVER 1"</p> <p>"SIMULATED MARS EXPLORATION ROVER 2"</p>	<p>LOCATION IDENTIFICATION (Class)</p> <p>SOURCE Table Lookup CHDO_82:scft_id</p>
INSTRUMENT_ID	<p>Provides an abbreviated name or acronym that identifies an instrument.</p> <p>INSTRUMENT_ID is not a unique identifier for a given instrument. The associated INSTRUMENT_NAME element provides the full name of the instrument.</p>	string(12)		<p>IDD</p> <p>29 = "MI"</p> <p>34 = "RAT"</p> <p>33 = "MB"</p> <p>32 = "APXS"</p>	<p>LOCATION IDENTIFICATION (Class)</p> <p>SOURCE Table Lookup; CCSDS:Primary:APID</p>
INSTRUMENT_TYPE	<p>Identifies the type of an instrument.</p> <p>Note that mosaics may contain more than one value in an array.</p>	String		"SPECTROMETER"	<p>LOCATION IDENTIFICATION (Class)</p> <p>SOURCE Static Value</p>

Keyword Name	Definition	Type	Units	Valid Values	<ul style="list-style-type: none"> • Location in PDS Label • Source
LOCAL_TRUE_SOLAR_TIME	<p>Local true solar time, or LTST, is one of two types of solar time used to express the time of day at a point on the surface of a planetary body. LTST is measured relative to the true position of the Sun as seen from a point on the planet's surface.</p> <p>The coordinate system used to define LTST has its origin at the center of the planet. Its Z-axis is the north pole vector (or spin axis) of the planet. The X-axis is chosen to point in the direction of the vernal equinox of the planet's orbit. (The vernal or autumnal equinox vectors are found by searching the planetary ephemeris for those times when the vector from the planet's center to the Sun is perpendicular to the planet's north pole vector. The vernal equinox is the time when the Sun appears to rise above the planet's equator.)</p> <p>Positions of points in this frame can be expressed as a radius and areocentric right ascension' and 'declination' angles. The areocentric right ascension angle, or ARA, is measured positive eastward in the equatorial plane from the vernal equinox vector to the intersection of the meridian containing the point with the equator. Similarly, the areocentric declination is the angle between the equatorial plane and the vector to the point. LTST is a function of the difference between the ARAs of the vectors to the Sun and to the point on the planet's surface. Specifically,</p> $LTST = (a(P) - a(TS)) * (24 / 360) + 12$ <p>where, LTST = the local true solar time in true solar hours</p> <p>a(P) = ARA of the point on the planet's surface in deg</p> <p>a(TS) = ARA of the true sun in deg</p>	string(12)		NOTE: Value will be uncalibrated if SPICE kernels are unavailable.	<p><u>LOCATION</u></p> <ul style="list-style-type: none"> •IDENTIFICATION (Class) <p><u>SOURCE</u></p> <ul style="list-style-type: none"> •Calculation: - IDPH:bgn->rover_time.seconds - IDPH:bgn->rover_time.subseconds - SCLK Kernel - Landing- Site kernel - P Kernel

Keyword Name	Definition	Type	Units	Valid Values	<ul style="list-style-type: none"> Location in PDS Label Source
MAGNET_ID	Identifies a magnet instrument that is visible in an image or observation.	String		"N/A", "CAPTURE", "FILTER", "UNK"	<p>LOCATION IDENTIFICATION (Class)</p> <p>SOURCE Calculated via an algorithm using ??????????</p>
MISSION_NAME	Identifies a planetary mission or project. A given planetary mission may be associated with one or more spacecraft.	String		"MARS EXPLORATION ROVER"	<p>LOCATION IDENTIFICATION (Class)</p> <p>SOURCE Static Value</p>
MISSION_PHASE_NAME	Provides the commonly-used identifier of a mission phase.	string(30)		"CRUISE", "EXTENDED MISSION", "PRIMARY MISSION", "ATLO", "ORT1", "ORT2", "ORT3", "ORT4", "TBD"	<p>LOCATION IDENTIFICATION (Class)</p> <p>SOURCE Operator Supplied Parameter</p>
OBSERVATION_ID	Uniquely identifies a scientific observation within a data set. It is set via the data product context ID – which doesn't necessarily map to a specific object – it's just used to group various instrument data sets together via a common keyword.	String			<p>LOCATION IDENTIFICATION (Class)</p> <p>SOURCE IPDH:bgn->context_id</p>
ORIGIN_OFFSET_VECTOR	<p>Specifies the offset from the reference coordinate system's origin to the origin of the coordinate system being defined by the enclosing COORDINATE_SYSTEM_STATE group. In other words, it is the location of the current system's origin as measured in the reference system.</p> <p>For example, in the case of the PMA_COORDINATE_SYSTEM group, ORIGIN_OFFSET_VECTOR describes the rotation of the PMA (camera head) boresight (about the ORIGIN_OFFSET_VECTOR) relative to the Rover frame.</p>	Float array[3]	meters		<p>LOCATION a) START_IDD_COORDINATE_SYSTEM (Group) b) STOP_IDD_COORDINATE_SYSTEM (Group) c) ROVER_COORDINATE_SYSTEM (Group)</p> <p>SOURCE a) IDPH:bgn->idd.pos[3] b) IDPH:end->idd.pos[3] c) IDPH:bgn->pos.v[3]</p>

Keyword Name	Definition	Type	Units	Valid Values	<ul style="list-style-type: none"> ● Location in PDS Label ● Source
ORIGIN_ROTATION_QUATERNION	<p>Provides an array of four values that specify the rotation of the coordinate system being defined by the enclosing COORDINATE_SYSTEM_STATE group, relative to the reference system. This can be expressed as follows: Given a vector expressed in the current frame, multiplication by this quaternion will give the same vector as expressed in the reference frame.</p> <p>Quaternions are expressed as a set of four numbers in the order (s, v1, v2, v3), where $s = \cos(\theta/2)$ $v(n) = \sin(\theta/2) * a(n)$. theta = the angle of rotation a = the (x,y,z) vector around which the rotation occurs.</p> <p>For MER, the value for ORIGIN_ROTATION_QUATERNION that defines a coordinate frame like Rover frame is computed with respect to only the orientations of the frame's axes... regardless of whether POSITIVE_ELEVATION_DIRECTION is declared to be "UP" or "DOWN"</p> <p>For example, in the case of the PMA_COORDINATE_SYSTEM group, ORIGIN_OFFSET_VECTOR describes the rotation of the PMA (camera head) boresight (about the ORIGIN_OFFSET_VECTOR) relative to the Rover frame.</p>	Float array[4]			<p>LOCATION</p> <ul style="list-style-type: none"> a) START_IDD_COORDINATE_SYSTEM (Group) b) STOP_IDD_COORDINATE_SYSTEM (Group) c) ROVER_COORDINATE_SYSTEM (Group) <p>SOURCE</p> <ul style="list-style-type: none"> a) IDPH:bgn->idd.quaternion[4] b) IDPH:end->idd.quaternion[4] c) IDPH:bgn->pos.q[4] <p>Received in (v1, v2, v3, s) order.</p>

Keyword Name	Definition	Type	Units	Valid Values	<ul style="list-style-type: none"> ● Location in PDS Label ● Source
PACKET_MAP_MASK	<p>A binary or hexadecimal number identifying which of a data file's expected packets were actually received. The digits correspond positionally with the relative packet numbers of the data file. The bits are to be read left to right; i.e., the first (left-most) digit of the number corresponds to the first packet of the data file. A bit value of 1 indicates that the packet was received; a value of 0 indicates that it was not received.</p> <p>The number is stored in the PDS radix notation of <radix>#<value>#.</p>	Non-decimal			<p>LOCATION TELEMETRY (Class)</p> <p>SOURCE Calculated UPDTH:PartNumber</p>
PDS_VERSION_ID	<p>Represents the version number of the PDS standards document that is valid when a data product label is created. Values for the PDS_version_id are formed by appending the integer for the latest version number to the letters 'PDS'.</p> <p>Examples: PDS3, PDS4.</p>	String(6)		"PDS3"	<p>LOCATION PDS required</p> <p>SOURCE PDS</p>
PLANET_DAY_NUMBER	<p>Indicates the number of sidereal days (rotation of 360 degrees) elapsed since a reference day (e.g., the day on which a landing vehicle set down).</p>	Integer		NOTE: Value will be uncalibrated if SPICE kernels are not available.	<p>LOCATION IDENTIFICATION (Class)</p> <p>SOURCE Calculated IPDH:bgn->rover_time.seconds IPDH:bgn->rover_time.subseconds SCLK kernel</p>
POSITIVE_AZIMUTH_DIRECTION	<p>Provides the direction in which azimuth is measured in positive degrees for an observer on the surface of a body. The azimuth is measured with respect to the elevation reference plane. A value of CLOCKWISE indicates that azimuth is measured positively Clockwise, and COUNTERCLOCKWISE indicates that azimuth increases positively Counter-clockwise.</p>	String		"CLOCKWISE", "COUNTERCLOCKWISE"	<p>LOCATION a) ROVER_COORDINATE_SYSTEM (Group) b) START_IDD_COORDINATE_SYSTEM (Group) c) STOP_IDD_COORDINATE_SYSTEM (Group)</p> <p>SOURCE Static Value</p>

Keyword Name	Definition	Type	Units	Valid Values	<ul style="list-style-type: none"> Location in PDS Label Source
POSITIVE_ELEVATION_DIRECTION	<p>Provides the direction in which elevation is measured in positive degrees for an observer on the surface of a body. The elevation is measured with respect to the azimuth reference plane.</p> <p>A value of UP indicates that elevation is measured positively upwards, i.e., the zenith point would be at +90 degrees and the nadir point at -90 degrees. DOWN indicates that the elevation is measured positively downwards; the zenith point would be at -90 degrees and the nadir point at +90 degrees.</p> <p>For MER, increasing elevation ("UP") moves towards the negative Z axis.</p>	String		"UP", "DOWN"	<p>LOCATION</p> <p>a) ROVER_COORDINATE_SYSTEM (Group)</p> <p>b) START_IDD_COORDINATE_SYSTEM (Group)</p> <p>c) STOP_IDD_COORDINATE_SYSTEM (Group)</p> <p>SOURCE</p> <p>Static Value</p>
PRODUCER_INSTITUTION_NAME	Identifies a university, research center, NASA center or other institution associated with the production of a data set. This would generally be an institution associated with the element PRODUCER_FULL_NAME.	string(60)		"MULTIMISSION IMAGE PROCESSING SUBSYSTEM, JET PROPULSION LAB"	<p>LOCATION</p> <p>IDENTIFICATION (Class)</p> <p>SOURCE</p> <p>Static Value</p>
PRODUCT_CREATION_TIME	Defines the UTC system format time when a product was created. Formation rule: YYYY-MM-DDThh:mm:ss[.fff]Z	string			<p>LOCATION</p> <p>IDENTIFICATION (Class)</p> <p>SOURCE</p> <p>Calculated</p>
PRODUCT_ID	<p>Represents a permanent, unique identifier assigned to a data product by its producer. See also: source_product_id.</p> <p>In the PDS, the value assigned to product_id must be unique within its data set. The product_id can describe the lowest-level data object that has a PDS label.</p>	string(40)			<p>LOCATION</p> <p>IDENTIFICATION (Class)</p> <p>SOURCE</p> <p>Calculated</p> <p>Filename less the extension</p>
PRODUCT_TYPE	Identifies the type or category of a data product within a data set.	String(8)		"MB_EDR" "APXS_EDR"	<p>LOCATION</p> <p>IDENTIFICATION (Class)</p> <p>SOURCE</p> <p>Static Value</p>

Keyword Name	Definition	Type	Units	Valid Values	<ul style="list-style-type: none"> ● Location in PDS Label ● Source
QUATERNION_MEASUREMENT_METHOD	<p>Specifies the quality of the rover orientation estimate.</p> <p>“UNKNOWN” – The attitude should simply not be trusted. This is the initial grade given on Landing, for example.</p> <p>“TILT_ONLY” – The attitude estimate is only good for tilt determination (2-axis knowledge). Activities which require azimuth knowledge should be careful.</p> <p>“COARSE” – The attitude estimate is “complete” (it has all three axes) but is crude. This can occur because a sungaze has not yet been performed or because some event (such as traverses or IDD activity) have reduced the quality of the estimate (a.k.a. “ThreeAxisCoarse”).</p> <p>“FINE” – Sungaze completed successfully, and the attitude estimate is sufficient for pointing HGA (a.k.a. “ThreeAxisFine”).</p>	String		0 = “UNKNOWN” 1 = “TILT_ONLY” 2 = “COARSE” 3 = “FINE”	<p>LOCATION ROVER_COORDINATE_SYSTEM (Group)</p> <p>SOURCE Table Lookup a) IDPH:bgn->att_qual</p>
RECEIVED_PACKETS	<p>Provides the total number of telemetry packets that constitute a reconstructed data product.</p>	Integer			<p>LOCATION TELEMETRY (Class)</p> <p>SOURCE Calculated UPTH:PacketNumber</p>
RECORD_TYPE	<p>Indicates the record format of a file.</p> <p>In the PDS, when record_type is used in a detached label file it always describes its corresponding detached data file, not the label file itself. The use of record_type along with other file-related data elements is fully described in the PDS Standards Reference.</p>	string(20)		“FIXED_LENGTH”	<p>LOCATION FILE (Class)</p> <p>SOURCE Static Value</p>

Keyword Name	Definition	Type	Units	Valid Values	<ul style="list-style-type: none"> ● Location in PDS Label ● Source
REFERENCE_COORD_SYSTEM_INDEX	<p>Identifies which instance of the coordinate system named by REFERENCE_COORD_SYSTEM_NAME is the reference coordinate system for the group in which the keyword occurs. This index is a set of integers which serve to identify coordinate system instances in a mission-specific manner.</p> <p>For MER, the indices are based on the ROVER_MOTION_COUNTER. This counter is incremented each time the rover moves (or may potentially have moved, e.g. due to arm motion). The full counter may have up to 5 values (SITE, DRIVE, IDD, PMA, HGA), but normally only the first value (for SITE frames) or the five values (for LOCAL_LEVEL or ROVER frames) are used for defining reference coordinate system instances. It is legal to use any number of indices to describe a reference coordinate system instance, however.</p> <p>See also REFERENCE_COORD_SYSTEM_NAME and COORDINATE_SYSTEM_INDEX.</p>	Integer array[5]			<p>LOCATION</p> <ul style="list-style-type: none"> a) START_IDD_COORDINATE_SYSTEM (Group) b) STOP_IDD_COORDINATE_SYSTEM (Group) c) ROVER_COORDINATE_SYSTEM (Group) <p>SOURCE</p> <p># of values used is group dependent</p> <ul style="list-style-type: none"> a) IDPH:bgn->rmc(0,1) b) IDPH:bgn->rmc(0,1) c) IDPH:bgn->rmc(0) <p>Calculated from IDPH:bgn->rmc and REFERENCE_COORD_SYSTEM_NAME</p> <p>Use all five elements except if the REFERENCE_COORD_SYSTEM_NAME = SITE_FRAME, then only use the first element.</p>
REFERENCE_COORD_SYSTEM_NAME	<p>Provides the full name of the reference coordinate system for the group in which the keyword occurs. All vectors and positions relating to 3-D space within the enclosing group are expressed using this reference coordinate system. Non-unique coordinate systems (such as "SITE" for rover missions), that have multiple instances using the same name, also require REFERENCE_COORD_SYSTEM_INDEX to completely identify the reference coordinate system.</p> <p>For MER, the reference is usually a SITE frame.</p>	string(20)		ROVER_FRAME, SITE_FRAME, MAST_FRAME, PANCAM_FRAME, LOCAL_LEVEL_FRAME, LANDER_FRAME	<p>LOCATION</p> <ul style="list-style-type: none"> a) START_IDD_COORDINATE_SYSTEM (Group) b) STOP_IDD_COORDINATE_SYSTEM (Group) c) ROVER_COORDINATE_SYSTEM (Group) <p>SOURCE</p> <p># of values used is group dependent</p> <ul style="list-style-type: none"> a) "ROVER_FRAME" b) "ROVER_FRAME" c) "SITE_FRAME"

Keyword Name	Definition	Type	Units	Valid Values	<ul style="list-style-type: none"> ● Location in PDS Label ● Source
RELEASE_ID	<p>Unique identifier associated with the release to the public of all or part of a data set. The first release of a data set should have a RELEASE_ID of "0001"</p> <p>When a data set is released incrementally, such as every three months during a mission, the RELEASE_ID is updated each time part of the data set is released. For each Rover mission, the first release of a data set should have a value of "0001"</p> <p>For example, the first release of EDR data set on MER-1 will be August 3, 2004 (according to the Archive Plan), so those products will have RELEASE_ID = "0001". The next EDR release will be October 4, 2004, so those products will have RELEASE_ID = "0002"..</p>	String			<p>LOCATION IDENTIFICATION</p> <p>SOURCE User Parameter</p>

Keyword Name	Definition	Type	Units	Valid Values	<ul style="list-style-type: none"> ● Location in PDS Label ● Source
ROVER_MOTION_COUNTER	<p>A set of integers that describe a (potentially) unique location (position/orientation) for a rover. Each time something happens that moves, or could potentially move, the rover, a new motion counter value is created. This includes intentional motion due to drive commands, as well as potential motion due to other articulating devices, such as arms or antennae. This motion counter (or part of it) is used as a reference to define instances of coordinate systems that can move such as SITE or ROVER frames. The motion counter is defined in a mission-specific manner. Although the original intent was to have incrementing indices (e.g. MER), the motion counter could also contain any integer values that conform to the above definition, such as time or spacecraft clock values.</p> <p>For MER, the motion counter consists of five values. In order, they are Site, Drive, IDD, PMA, and HGA. The Site value increments whenever a new major Site frame is declared. The Drive value increments any time intentional driving is done. Each of those resets all later indices to 0 when they increment. The IDD, PMA, and HGA increment whenever the corresponding articulation device moves.</p>	Integer array[5]			<p>LOCATION IDENTIFICATION (Class)</p> <p>SOURCE IDPH:bgn->rmc(5)</p>
ROVER_MOTION_COUNTER_NAME	An array that provides the formal names identifying each integer in ROVER_MOTION_COUNTER.	String array[5]		(SITE, DRIVE, IDD, PMA, HGA)	<p>LOCATION IDENTIFICATION (Class)</p> <p>SOURCE Static Value</p>
SAMPLING_COUNT	The sampling_count element provides the number of data samples taken by an instrument or detector.	integer			<p>LOCATION TELEMETRY (Class)</p> <p>SOURCE IDPH:telemetry_count</p>
SEQUENCE_ID	Provides an identification of the spacecraft sequence associated with the given product. This element replaces the older seq_id, that should no longer be used.	string(30)			<p>LOCATION IDENTIFICATION (Class)</p> <p>SOURCE UPTH:PrdCmdID:SequenceID</p>

Keyword Name	Definition	Type	Units	Valid Values	<ul style="list-style-type: none"> Location in PDS Label Source
SEQUENCE_VERSION_ID	Provides the version identifier for a particular observation sequence used during planning or data processing.	string(30)			<p>LOCATION IDENTIFICATION (Class)</p> <p>SOURCE UPTH:PrdCmdID:SequenceVersion</p>
SOURCE_PRODUCT_ID	Identifies the product or products used to generate a derived product.	String(40)			<p>LOCATION IDENTIFICATION (Class)</p> <p>SOURCE EDR</p>
SPACECRAFT_CLOCK_CNT_PARTITION	Indicates the clock partition active for the SPACECRAFT_CLOCK_START_COUNT and SPACECRAFT_CLOCK_STOP_COUNT elements.	integer		1	<p>LOCATION IDENTIFICATION (Class)</p> <p>SOURCE Static Value</p>
SPACECRAFT_CLOCK_START_COUNT	Provides the value of the spacecraft clock at the beginning of a time period of interest. Format is dddddddd.ddd, measured in units of seconds and stored internally as a floating point number.	string(30)			<p>LOCATION IDENTIFICATION (Class)</p> <p>SOURCE IDPH:bgn->rover_time.seconds IDPH:bgn->rover_time.subseconds</p> <p>Note: It is possible for the sclk to be earlier than the DVT time reported in the data product meta data file and the sclk reported in the data product file name.</p>
SPACECRAFT_CLOCK_STOP_COUNT	Provides the value of the spacecraft clock at the end of a time period of interest. Format is dddddddd.ddd, measured in units of seconds and stored internally as a floating point number.	string(30)			<p>LOCATION IDENTIFICATION (Class)</p> <p>SOURCE IDPH:end->rover_time.seconds IDPH:end->rover-time.subseconds</p>
SPICE_FILE_NAME	Provides the names of the SPICE files used in processing the data.	string (180)			<p>LOCATION TELEMETRY (Class)</p> <p>SOURCE User parameter</p>

Keyword Name	Definition	Type	Units	Valid Values	<ul style="list-style-type: none"> Location in PDS Label Source
START_TIME	Provides the date and time of the beginning of an event or observation (whether it be a spacecraft, ground-based, or system event) in UTC system format. Formation rule: YYYY-MM-DDThh:mm:ss[.fff]	string			<p>LOCATION IDENTIFICATION (Class)</p> <p>SOURCE Calculated IDPH:bgn->rover_time.seconds IDPH:bgn->rover_time.subseconds SCLK kernel</p>
STOP_TIME	Provides the date and time of the beginning of an event or observation (whether it be a spacecraft, ground-based, or system event) in UTC system format. Formation rule: YYYY-MM-DDThh:mm:ss[.fff]	string			<p>LOCATION IDENTIFICATION (Class)</p> <p>SOURCE Calculated IDPH:end->rover_time.seconds IDPH:end->rover_time.subseconds IDPH:ImgTImHdr:exp_time SCLK kernel</p>
TARGET_NAME	Identifies a target. The target may be a planet, satellite, ring, region, feature, asteroid or comet. See TARGET_TYPE.	string(30)		"MARS", "CALIBRATION"	<p>LOCATION a) IDENTIFICATION (Class)</p> <p>SOURCE a) MARS</p>
TARGET_TYPE	Identifies the type of a named target.	string		"CALIBRATION", "DUST", "N/A", "SUN", "PLANET"	<p>LOCATION a) IDENTIFICATION (Class)</p> <p>SOURCE a) Static Value – PLANET</p>
TELEMETRY_FORMAT_ID	A telemetry format code	String		APXS 100="SPT" – APXS Spectra	<p>LOCATION TELEMETRY (Class)</p> <p>SOURCE Table Lookup IDPH: flavor</p>
TELEMETRY_PROVIDER_ID	Identifies the provider and version of the telemetry data used in the generation of this data.	string(3)		"SSW MER_DP" "TTACS"	<p>LOCATION TELEMETRY (Class)</p> <p>SOURCE User Parameter</p>

Keyword Name	Definition	Type	Units	Valid Values	<ul style="list-style-type: none"> • Location in PDS Label • Source
TELEMETRY_SOURCE_NAME	Identifies the name of the telemetry source used in the creation of this data set.	string			<p>LOCATION TELEMETRY (Class)</p> <p>SOURCE Name of the input data product.</p>
TELEMETRY_SOURCE_TYPE	Classifies the source of the telemetry used in creation of this data set.	string(12)		"DATA PRODUCT", "SFDU"	<p>LOCATION TELEMETRY (Class)</p> <p>SOURCE User Parameter</p>
TLM_INST_DATA_HEADER_ID	Indicates the version of the instrument specific information provided with telemetry data products. Incremented by FSW whenever there is a change to the header structure.	Integer			<p>LOCATION TELEMETRY (Class)</p> <p>SOURCE IDPH: version</p>