Mars Science Laboratory
Software Interface Specification
Chemistry & Mineralogy (CheMin)
Experiment Data Record (EDR)

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SIGNATURES

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CHANGE LOG

DATE	SECTIONS CHANGED	REASON FOR CHANGE	REVISION
08/31/11	All	First draft	Draft v0.1
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2/28/13	Table 4	Update conversion formulas for voltages and temperatures.	V1.4

TBD ITEMS

SECTION	DESCRIPTION
All	Identified by red text
All	Questions about the document, to be resolved, are shown in { braces }
2.3.1	Usage of CODMAC vs. NASA level numbering.

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ACRONYMS AND ABBREVIATIONS

ASCII	American Standard Code for Information Interchange
APSS	Activity Planning and Sequencing Subsystem
CHEMIN	Chemistry Mineralogy Instrument
CODMAC	Committee on Data Management and Computation
CWA	Current Working Area
EDR	Experiment Data Record
FEI	File Exchange Interface
FSW	Flight Software
ICD	Interface Control Document
ISO	International Standards Organization
JPL	Jet Propulsion Laboratory
Kbyte	Kilobytes
LSB	Least Significant Byte
MB	Mega Bytes
MIPL	Multimission Image Processing Laboratory
MPCS	Mission Data Processing and Control System
MSB	Most Significant Byte
MSL	Mars Science Laboratory
NASA	National Aeronautics and Space Administration
ODL	Object Description Language
ODS	Operations Data Store
OPGS	Operations Product Generation Subsystem
PDS	Planetary Data System
PEL	Payload Element Lead
PPPCS	Pointing, Positioning, Phasing & Coordinate Systems
RA	Robotic Arm
RAM	Random Access Memory
RCE	Rover Compute Element
RDR	Reduced Data Record
RSVP	Rover Sequence and Visualization Program
SA-SPaH	Sample Acquistion – Sample Processing and Handling
MSLICE	Science Activity Planner
SCM	Spacecraft Configuration Manager
SFDU	Standard Formatted Data Unit
SIS	Software Interface Specification

SOAS	Science Operations Analysis Subsystem
SPaH	Sample Processing and Handling
TBD	To Be Determined
TC	Temperature Compensation
TDS	Telemetry Delivery Subsystem
URL	Universal Resource Locator
WEB	Warm Electronics Box

GLOSSARY

TERM	DEFINITION
Meta-Data	Selected or summary information about data. PDS catalog objects and data product labels are forms of meta-data for summarizing important aspects of data sets and data products.

1. INTRODUCTION

1.1 Purpose and Scope

The purpose of this data product Software Interface Specification (SIS) is to provide users of the Chemistry Mineralogy (CheMin) Experiment Data Record (EDR) with a detailed description of the product and a description of how it was generated, including data sources and destinations. The CheMin instrument determines the mineralogy and elemental composition of crushed or powdered samples through the combined application of X-ray diffraction (mineral structure analysis) and energy dispersive histogram spectra (chemical analysis).

This SIS is intended to provide enough information to enable users to understand the CheMin EDR data product. The users for whom this SIS is intended are software developers of the programs used in generating the EDR products and scientists who will analyze the data, including those associated with the Mars Science Laboratory (MSL) Project and those in the general planetary science community.

1.2 Contents

This data product SIS describes how the MSL CheMin instrument acquires its data, and how the data are processed, formatted, labeled, and uniquely identified. The document discusses standards used in generating the product and software that may be used to access the product. The data product structure and organization is described in sufficient detail to enable a user to read the product. Finally, an example of a product label is provided.

1.3 Applicable Documents and Constraints

This data product SIS is responsive to the following MSL documents:

1. Mars Science Laboratory Archive Generation, Validation and Transfer Plan, Joy Crisp, and P. Theisinger, MSL-214-1333, JPL D-35281, May 28, 2010.
2. MSL Instrument Standard Electrical and Interface Specification, MSL-336-0314, JPL D-27193, April 3, 2007
3. CheMin Functional Design Document, MSL 375-1232, JPL D-34222, July 27, 2010.
4. Pointing, Positioning, Phasing & Coordinate Systems (3PCS), Volume 1, Santi Udomkesmalee, MSL-376-1297, JPL D-34642, May 29, 2007.
5. Mars Science Laboratory Surface Attitude, Positioning, and Pointing Functional Design Description (FDD), Steve Peters, MSL-376-1089, JPL D-34217, December 13, 2010.
6. Position Localization and Attitude Correction Estimate Storage (PLACES) User's Guide, JPL D-7112, MSL-586-3653, URL:https://jplwiki.jpl.nasa.gov:8443/display/places/Home

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

7. Planetary Data System Archive Preparation Guide, Version 1.4, JPL D-31224, April 1, 2010.
8. Planetary Science Data Dictionary Document, Version 1.81, November 24, 2010.
9. Planetary Science Data Standards Reference, JPL D-7669, Part 2, Feb. 27, 2009

Finally, this SIS is meant to be consistent with the contract negotiated between the MSL Project and the CheMin Principal Investigator (PI) in which experiment data records and documentation are explicitly defined as deliverable products.

1.4 Relationships with Other Interfaces

Changes to this CheMin EDR SIS document affect the products, software, and/or documents listed in Table 1.

Table 1: Product and Software Interfaces to this SIS

Name	Type P=product S=software D=document	Owner
CheMin EDRs	P	OPGS/MIPL
msledrgen	S	MIPL
MIPL database schema	P	MIPL
CheMin RDRs	P	CheMin Science Team
CheMin RDR SIS	D	CheMin Science Team
Other CheMin Programs/Products/Documents	P/S/D	CheMin Science Team

2. DATA PRODUCT CHARACTERISTICS AND ENVIRONMENT

2.1 Instrument Overview

The Chemistry & Mineralogy X-ray Diffraction (CheMin) instrument is the MSL mineralogy instrument, performing mineralogical and elemental analysis of samples. Mounted under the rover deck, CheMin consists of a sample collecting and handling assembly, an X-ray optical and detector assembly, and electronics. It has the capability to accept and analyze at least 74 samples of rock and/or regolith. CheMin illuminates the sample with a collimated beam of X-rays, and the fluoresced, diffracted and transmitted X-rays are detected by a CCD. The unique X-ray patterns and energy levels will be used to identify and quantify minerals in samples. This assists in the assessment of water history and the search for possible biosignatures. The nominal duration of a single experiment, sufficient to quantitatively analyze a single mineral such as quartz or olivine, is 4 hours. Complex assemblages such as basalt with 8 or more minerals may require up to 10 hours of data. This data need not be taken contiguously.

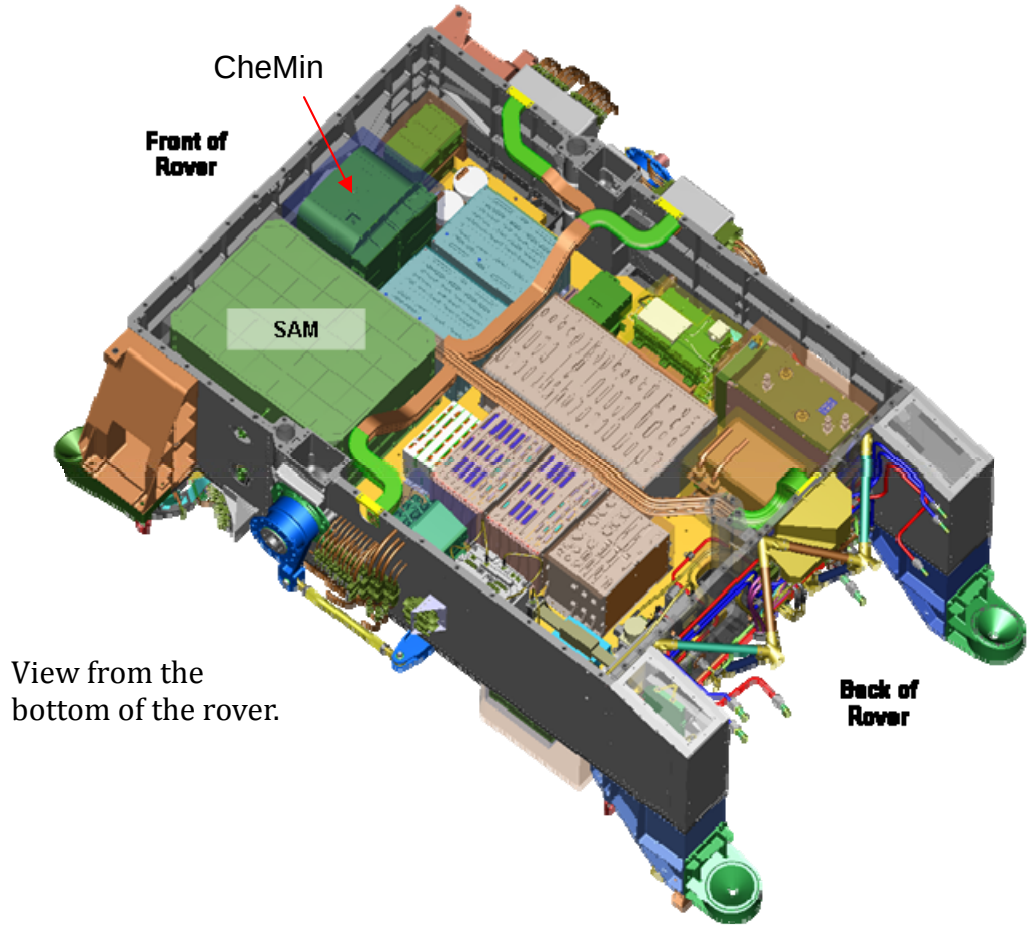

Figure 1: View from bottom of the rover

2.2 Data Product Overview

Each CheMin EDR will consist of two files. The first file is an ASCII formatted detached PDS label. The second file is a binary data file. The CheMin EDR data file is a binary file typically containing housekeeping data and either an image or a histogram. The EDR consists of unprocessed data stored in binary format along with additional Rover FSW meta-data. The housekeeping record is padded with zeroes to make the EDR a fixed length data file.

2.3 Data Processing

2.3.1 Data Processing Level

This SIS uses the CODMAC data level numbering system to describe the processing level of the EDR data product. CheMin EDR data products are considered "Level 2" or "Edited Data" products. The EDR data files are generated from "Level 1" or "Raw Data", which are the telemetry packets within the project specific Standard Formatted Data Unit (SFDU) record. Refer to Table 2 for a breakdown of the NASA data processing levels, and their equivalent CODMAC products.

Table 2: 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 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.
Level 3	Derived - Level 5	Geophysical parameters mapped onto uniform space-time grids.

2.3.2 Data Product Generation

The CheMin EDR data products will be generated by the MIPL (Multimission Image Processing Laboratory) at JPL under the OPGS using the telemetry processing software, MSLEdrGen. The EDR data products will be raw uncalibrated data reconstructed from telemetry data products and formatted according to this EDR SIS. Meta-data acquired from the telemetry data headers will be used to populate the PDS label. There will be multiple versions of an CheMin EDR. If telemetry packets are missing during the initial downlink from the rover memory, partial data sets will be created and the missing data will be filled with [zeroes]. The data will be reprocessed after all data are received and the original version will be overwritten.

2.3.3 Data Flow

The CheMin EDR data products generated by MIPL during operations are created collectively from: a) MPCS data products b) SPICE kernels, and c) a meta-data database. They are created on the ODS and then deposited into MIPL's File Exchange Interface (FEI) for electronic distribution to remote via a secure subscription protocol. After a data validation period, the CheMin EDR data products are collected with other science data and delivered to the Planetary Data System for archiving. [see reference 1].

The size of the CheMin EDR data file varies. The CheMin EDR will be generated 60 seconds after the data product for the EDR has been received by MIPL. The CheMin data will be reprocessed only if packets in the original downlink are not received. Partial files are created with missing data filled with zeroes. The CheMin EDR will be reprocessed after all data is

retransmitted and received and the original version will be overwritten and placed into FEI for distribution.

2.3.4 Labeling and Identification

There is a file naming scheme adapted for the MSL image and non-image data products. The scheme applies to the EDR and several RDR data products. The file naming scheme adheres to the Level II 36.3 filename convention to be compliant with PDS standards. The file naming scheme also contains a minimal level of meta-data that retains uniqueness and is searchable.

All MSL 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 camera 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. The metadata fields have been selected based on MER and Phoenix mission lessons learned.

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

<instr><config><sclk><prod><sol><site><drive><seqId><venue/who><ver>.<ext>

where,

instr = (2 alpha character) Instrument ID, denoting the source MSL science or engineering instrument that acquired the data.

Valid values for Instrument ID's are:

Valid values for:

"**CM**" - CheMin

Config/ spec = (2 alphanumeric) Instrument Configuration, an operational attribute of the Instrument that assists in characterizing the data.

Valid values for MSL camera instruments:

Instrument	**Configuration**	
	Values	Description
CheMin	"**A**_" "B_" "__"	**RCE String Identification**

sclk = (9 alphanumeric) Spacecraft Clock Start Count, in units of seconds.

Which specific SCLK is used depends on the instrument but is generally expected to be the time the data was acquired. For CheMin, it is Data Product SCLK which matches the DVT (Data Validity Time) used for operational data management.

The valid values, in their progression, are as follows (non-Hex):

Range 000000000 thru 999999999 - "**000000000**", "**000000001**", **…**

"**999999999**"
Range 1000000000 thru 1099999999 - "**A00000000**", "**A00000001**", **…**
"**A99999999**"
Range 1100000000 thru 1199999999 - "**B00000000**", **"B00000001**", **…**
"B99999999"

•
•
•

Range 3500000000 thru 3599999999 - "**Z00000000**", "**Z00000001**", **…**
"**Z99999999**"

prod = (3 char) Product Type identifier.

This field has the following rule-of-thumb:

Beginning "**E**" - Type of **E**DR, which is the first order product with no processing applied,
The 2nd two characters identify the type of CheMin EDR and whether it is complete or partial.

Valid values for Product identifiers are listed below for EDRs:

Product Type Description	Value
CCD Frame	"**ECC**"
Diffraction Single	"**ED1**"
Diffraction Split	"**EDS**"
Diffraction All	"**EDA**"
Energy All	"**EEA**"
Energy Single	"**EE1**"
Energy Split	"**EES**"
Film	"**EFM**"
Housekeeping N	**"EHK"**
Transmit Raw	"**ETR**"

sol = (4 numeric) Sol for the SCLK value of the EDR.

site = (3 alphanumeric) Site location count, from the RMC.

This field has the following rules-of-thumb:

a) Site - If value is any 3 alphanumeric characters, or 3 underscores (denoting value is out-of-range), then content represents Site index extracted from RMC.

The valid Site values, in their progression, are as follows (non-Hex):

Range 000 thru 999 - "**000**", "**001**", **…** "**999**"
Range 1000 thru 1099 - "**A00**", "**A01**", **…** "**A99**"
Range 1100 thru 1199 - "**B00**", **"B01**", **…** "**B99**"

•
•
•

Range 3500 thru 3599 - "**Z00**", "**Z01**", **…** "**Z99**"

drive = (4 alphanumeric) Drive (position-within-Site) location count, from the RMC.

This field has the following rules-of-thumb:

a) Drive - If value is any 4 alphanumeric characters, or 4 underscores (denoting value is out-of-range), then content represents Drive index extracted from RMC.

The valid Drive values, in their progression, are as follows (non-Hex):

Range 0000 thru 9999 - "**0000**", "**0001**", **…** "**9999**"
Range 10000 thru 10999 - "**A000**", "**A001**", **…** "**A999**"
Range 11000 thru 11999 - "**B000**", **"B001**", **… "B999**"
•
•
•
Range 35000 thru 35999 - "**Z000**", "**Z001**", **…** "**Z999**"
Range 36000 thru 36099 - "**AA00**", "**AA01**", **…** "**AA99**"
Range 36100 thru 36199 - "**AB00**", "**AB01**", **…** "**AB99**"
•
•
•
Range 38500 thru 38599 - "**AZ00**", "**AZ01**", **…** "**AZ99**"
Range 38600 thru 38699 - "**BA00**", "**BA01**", **…** "**BA99**"
Range 38700 thru 38799 - "**BB00**", "**BB01**", **…** "**BB99**"
•
•
•
Range 41100 thru 41199 - "**BZ00**", "**BZ01**", **…** "**BZ99**"
Range 41200 thru 41299 - "**CA00**", "**CA01**", **…** "**CA99**"
•
•
•
Range 65400 thru 65499 - "**LI00**", "**LI01**", **…** "**LI99**"
Range 65500 thru 65535 - "**LJ00**", "**LJ01**", **…** "**LJ35**"

seqId = (7 alphanumeric) Sequence identifier. Composed of a 2-char subfield and a 5-digit numeric subfield representing the 6-bit "Category" and 14-bit numeric components of the commanded Sequence ID, respectively. The 2 character subfield is the first 2 characters of the value with the last 2 being truncated.

venue / who = (1 alpha character) Venue and Product Producer ID shared in the same field.
Venue denotes Flight Model versus Engineering Model in data acquisition. Product Producer ID identifies the institution that generated the product.

This field has the following rules-of-thumb:

a) Venue - A value in the range "**A** - **P**" indicates Flight Model rover. A value in the range
"**Q** - **Z**" indicates Engineering (testbed) rover. The range "N - O" is not used.

b) Producer - If value is "**P**" (for Flight) or "**Y**" (for Engineering), the provider of the product
is the Principal Investigator. Except for MIPL as the provider ("**M**" for Flight or "**Z**" for
Engineering), the remaining characters are assigned to Co-investigator providers at
the discretion of the P.I. and will be identified in due time. Within the instrument of
the P.I., characters are unique. Across instruments, characters are reusable.

See the following table of valid values:

Venue		by Producer
Flight Model	Eng. Model	
"**M**"	"**Z**"	**M**IPL (OPGS at JPL)
"**P**"	"**Y**"	**P**rincipal Investigator of Instrument … Instrument — Principal Investigator SAM — GSFC (Goddard, MD) REMS — Ministry of Education & Science (Spain) DAN — Federal Space Agency (Russia) RAD — SwRI (Boulder, CO) CheMin — Ames Research Center (Mountain View, CA) APXS — (Canada) SA/SPaH — JPL
"**A**" - "**L**"	"**Q**" - "**X**"	Co-Investigators (to be identified by P.I. per instrument)

ver = (1 alphanumeric) Version identifier.

The valid values, in their progression, are as follows (non-Hex):

Range 1 thru 10 - "**1**", "**2**", **…** "**9**", "**0**"
Range 11 thru 36 - "**A**", "**B**", **…** "**Z**"
Range 37 and higher - "_" (underscore)

The Version number increments by one whenever an otherwise-identical filename would be produced. Note that not every version need exist, e.g. versions 1, 2 and 4 may exist but not 3. In general, the highest-numbered Version represents the "best" version of that product.

NOTE: To be clear, this field increments independently of all fields, including the Special Processing field.

ext = (2 to 3 alpha characters) Product type extension.

Valid values for nominal operations non-camera data products:

"**IMG**" - Non-imaging instrument data Image for ED1, EDS, EDA, and ECC
"**LBL**" - Detached label in PDS format
"**DAT**" - Data file

Example #1:

CMA_013760215ECC00010930008_____M1.IMG

where,

instr	=	"**CM**"	=	CheMin
config	=	"**A**"	=	From RCE A string
spec	=	"_"	=	Always underscore
sclk	=	"**013760215**"	=	Spacecraft Clock Start Count of 13760215 secs
prod	=	"**ECC**"	=	CCD Frame EDR
sol	=	"0001"	=	Sol 1
site	=	"**093**"	=	Site 93
drive	=	"**0008**"	=	Drive (Position-within-Site) 8
seqid	=	"**ch00004**"	=	SequenceId
venue / who	=	"**M**"	=	Flight Model data / produced by MIPL (at JPL)
ver	=	"**1**"	=	Version 1
ext	=	"**IMG**"	=	Data product with PDS label

2.4 Standards Used in Generating Data Products

2.4.1 PDS Standards

The CheMin EDR complies with Planetary Data System standards for file formats and labels, as specified in the PDS Standards Reference [9] and the Planetary Science Data Dictionary Document [8].

2.4.2 Time Standards

The following time standards and conventions are used throughout this document, as well as the MSL project for planning activities and identification of events.

Time Format	*Definition*
SCET	Spacecraft event time. This is the time when an event occurred on-board the spacecraft, in UTC. It is usually derived from SCLK.
SCLK	Spacecraft Clock. This is an on-board 64-bit counter, in units of nano-seconds and increments once every 100 milliseconds. Time zero corresponds to midnight on 1-Jan-1980.
ERT	Earth Received Time. This is the time when the first bit of the packet containing the current data was received at the Deep Space (DSN) station. Recorded in UCT format.
Local Solar Time	Local Solar Time (LST). This is the local solar time defined by the local solar days (sols) from the landing date using a 24 "hour" clock within the current local solar day (HR:MN:SC). Since the Mars day is 24h 37m 22s long, each unit of LST is slightly longer than the corresponding Earth unit. LST is computed using positions of the Sun and the landing site from SPICE kernels. If a landing date is unknown to the program (e.g. for calibration data acquired on Earth) then no sol number will be provided on output

	LST examples: SOL 12 12:00:01 SOL 132 01:22:32.498 SOL 29
RCT	Record Creation Time. This is the time when the first telemetry packet, containing a give data, set was created on the ground. Recorded in UTC format.
True Local Solar Time	This is related to LST, which is also known as the mean solar time. It is the time of day based on the position of the Sun, rather than the measure of time based on midnight to midnight "day". TLST is used in all MIPL/OPGS generated products.
SOL	Solar Day Number, also known as PLANET DAY NUMBER in PDS label. This is the number of complete solar days on Mars since landing. The landing day therefore is SOL zero.

2.4.3 Coordinate Frame Standards

The MSL Frame Manager defines several dozen coordinate frames, which can be used for commanding and pointing among other things. Refer to the Pointing, Positioning, Phasing and Coordinate Systems (PPPCS) document [4], or the Surface Attitude, Positioning and Pointing (SAPP) Functional Design Description (FDD) [5] for more details on all MSL coordinate frames. This SIS, and APXS products only use a subset of the define frames as shown in table 3.

The only place in this SIS where the full set of frames can appear is in the INSTRUMENT_COORD_FRAME_ID label, which is a command echo.

A subset of these frames needed for a specific image or data set are defined by the *_COORDINATE_SYSTEM groups.

Note that the PLACES database [6] maintains both telemetered and re-localized versions of the Site and Rover NAV frames at every available index.

Table 3 - Coordinate Frames Used for MSL Surface Operations

Frame Name	SHORT	REFERENCE	Coordinate Frame

(Label Keyword Value)	NAME (SAPP FDD)	FRAME (USED TO DEFINE)	Origin	Orientation
ROVER_NAV_FRAME	RNAV	Enclosing SITE_FRAME	Attached to rover	Aligned with rover
ROVER_MECH_FRAME	RMECH	Enclosing SITE_FRAME	Attached to rover	Aligned with rover
LOCAL_LEVEL_FRAME	LL	Enclosing SITE_FRAME	Attached to rover (coincident with Rover Nav Frame)	North/East/Nadir
SITE_FRAME	SITE(n)	Previous SITE_FRAME	Attached to surface	North/East/Nadir
RSM_HEAD_FRAME	RSM_HEAD	ROVER_NAV_FRAME	Attached to mast head	Aligned with pointing of mast head. This corresponds to RSM_HEAD in the Frame Manager
Arm Frames: ARM_TURRET_FRAME ARM_DRILL_FRAME ARM_DRT_FRAME ARM_MAHLI_FRAME ARM_APXS_FRAME ARM_PORTION_FRAME ARM_SCOOP_TIP_FRAME ARM_SCOOP_TCP_FRAME	Arm Frames: TURRET DRILL DRT MAHLI APXS PORTION SCOOP_TIP SCOOP_TCP	ROVER_NAV_FRAME	Attached to the tool; see PPPCS for the specific tool frame.	Aligned with tool in some way; see PPPCS [Ref 1] for the specific tool Frame.

2.4.4 Rover Navigation (Rover NAV) Frame

The Rover NAV frame (RNAV) is the one used for surface navigation and mobility. By definition, the frame is attached to the rover, and moves with it when the rover moves while on the surface. Its Z origin is defined to be 0.5 mm above the deck, with the Y origin centered on the rover and the X origin aligned with the middle wheels' rotation axis for the deployed rover and suspension system on a flat plane. The +X axis points to the front of the rover, +Y to the right side, and +Z down (perpendicular to the chassis deck). See Figure 2.1.

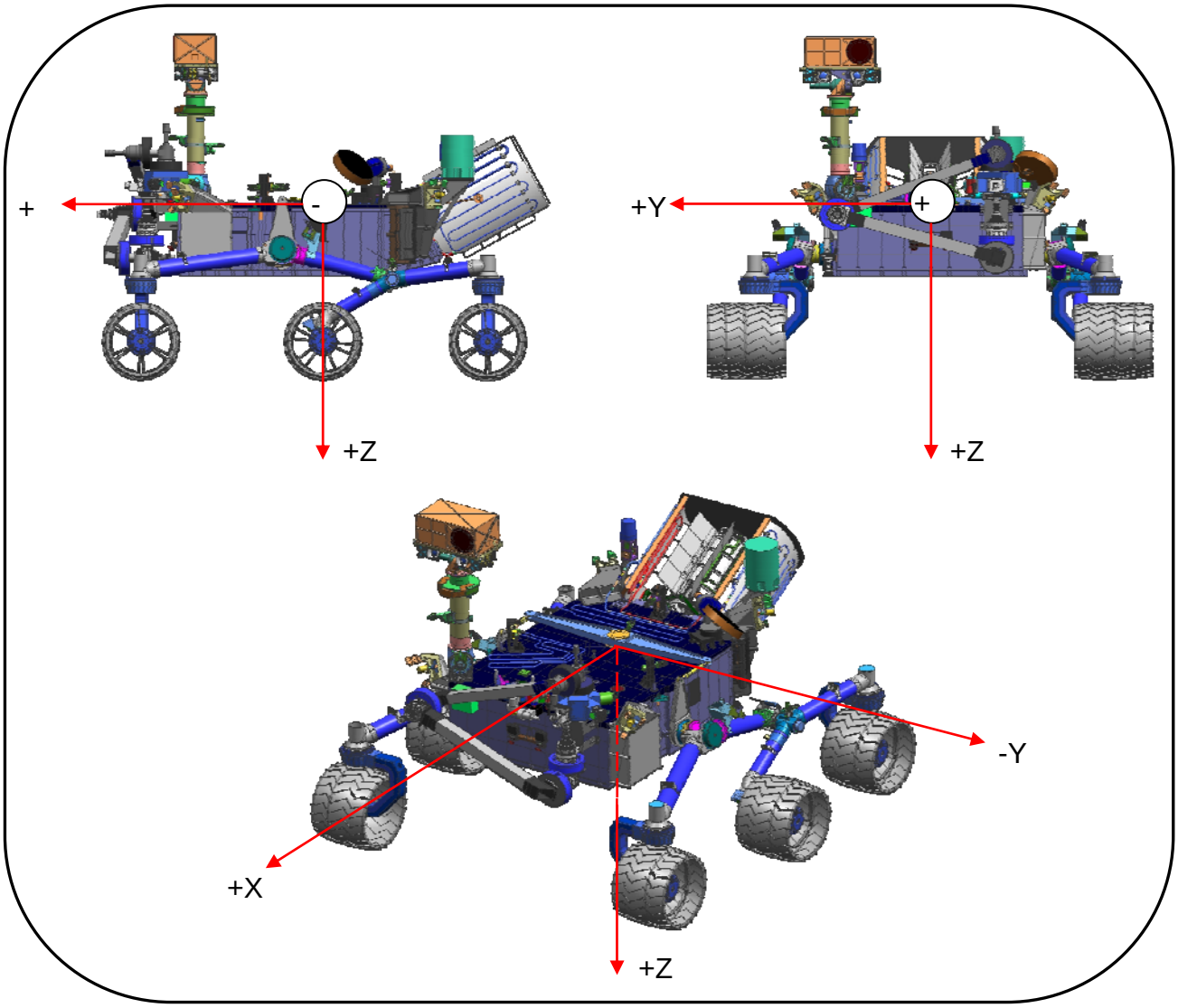

Figure 2.1: Rover Navigation (RNAV) Coordinate Frame.

The Rover NAV frame is specified via an offset from the current Site frame, and a quaternion that represents the rotation between the two. A new instance of the Rover NAV frame, with a potentially unique offset/quaternion, is created every time the ROVER_MOTION_COUNTER increments.

Orientation of the rover (and thus Rover NAV) with respect to Local Level or Site is also sometimes described by Euler angles as shown in Figure 2.2, where ψ is heading, θ is attitude or pitch, and ϕ is bank or roll.

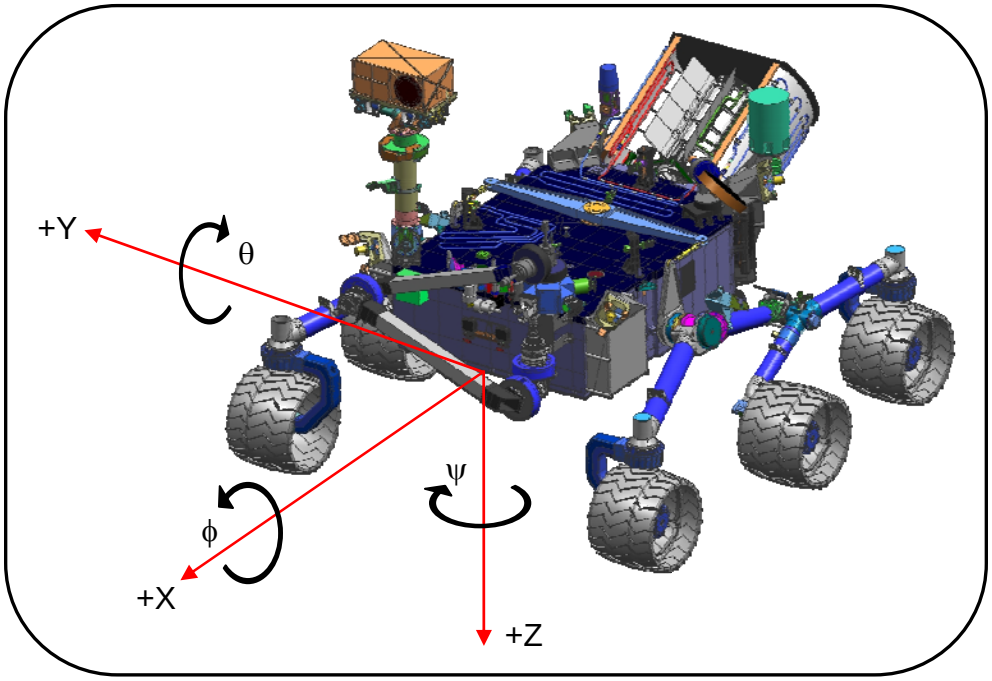

Figure 2.2: Yaw, Pitch and Roll Definitions.

2.4.5 Rover Mechanical (Rover Mech) Frame

The Rover Mechanical (RMECH) frame is oriented identically to the Rover Nav frame. The origin is forward of Rover NAV by x=0.09002 meters. In other words, given a point expressed in Rover Mech, if you add (0.09002, 0.0, 0.0) you will get the same point expressed in Rover NAV. Rover Mech is not used by any nominal products (EDR or RDR) but could appear in certain special products, generally having to do with arm kinematics.

2.4.6 Local Level Frame

The Local Level frame is coincident with the Rover Nav frame, i.e. they share the same origin at all times. The orientation is different, however. The +X axis points North, +Z points down to nadir along the local gravity vector, and +Y completes the right-handed system. Thus the orientation matches the orientation of Site frames.

Local Level frames are defined by an offset from the current Site frame, with an identity quaternion.

2.4.7 Site Frame

Site frames are used to reduce accumulation of rover localization error. They are used to provide a common reference point for all operations within a local area. Rover Nav and Local Level frames are specified using an offset from this origin. When a new Site is declared, that becomes the new reference, and the offset is zeroed. In this way, long-term localization error is relegated to the offset between Sites, becoming irrelevant to

local operations, because the positions are reset with each new Site.

When a Site frame is declared, it is identical to the Local Level frame, sharing both orientation and position. However, the Site frame is fixed to the Mars surface; when the rover moves, Local Level moves with it but Site stays put. Therefore, for the Site frame, +X points North, +Z points down to nadir along the local gravity vector, and +Y completes the right-handed system.

Sites are indexed, meaning there are multiple instances. Site 1 by definition represents the landing location. New Sites are declared as needed during operations, as the rover moves away from the local area. See Figure 2.3.

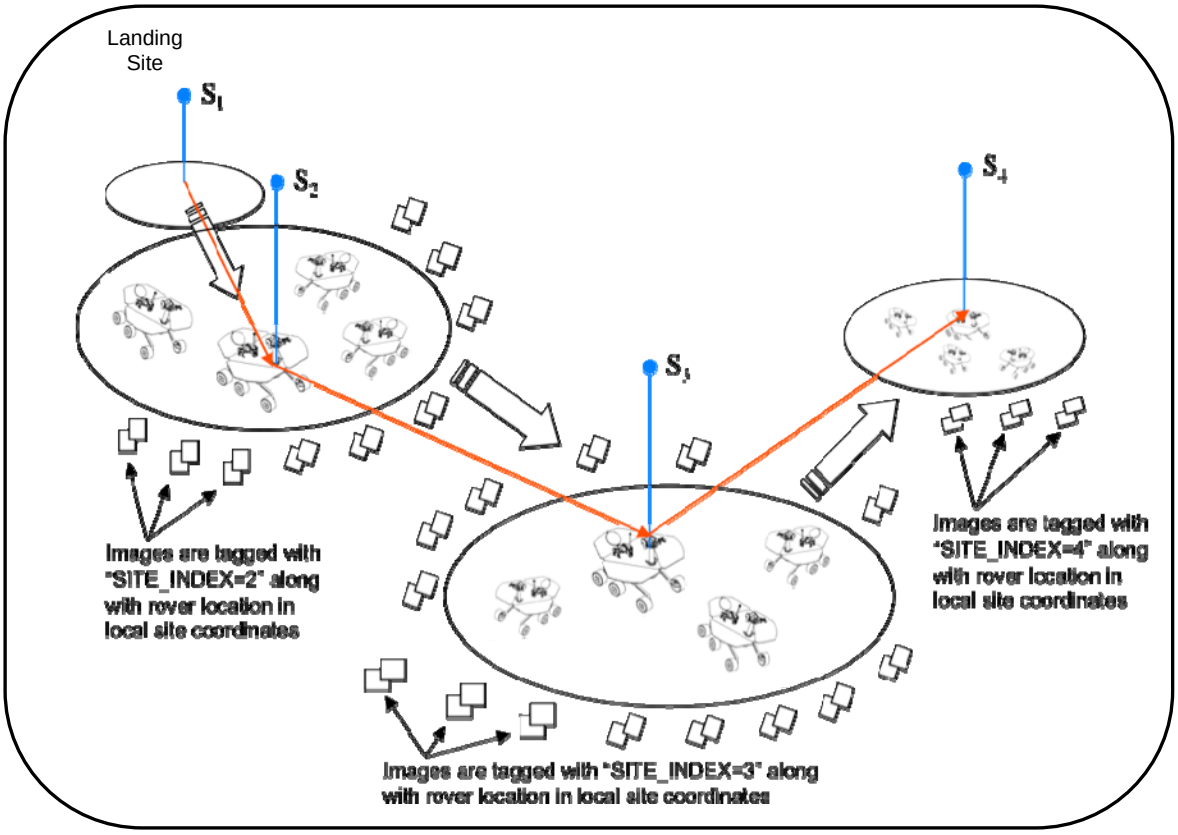

Figure 2.3: Site and Rover Frames.

The PLACES database [6] stores the set of all site-to-site offsets; such offsets are not in the image label.

2.4.8 RSM Frame

The RSM frame is attached to the Remote Sensing Mast (RSM) camera head, and moves with it. See the PPPCS for specific definition. It is expressed as an offset and quaternion from the Rover NAV frame.

2.4.9 Arm Frames

The various tool frames are attached to and aligned with the tool in some manner specific to that tool. See the PPPCS [4] for actual frame definitions.

2.4.10 Data Storage Conventions

The CheMin EDR data files contain binary data. CheMin data are 8-bit, 16-bit and 32-bit integers stored in MSB first order. The detached PDS labels for CheMin EDR's are stored as ASCII text.

2.5 Data Validation

Validation of the MSL EDRs will fall into two primary categories: automated and manual. Automated validation will be performed on every EDR product produced for the mission. Manual validation will only be performed on a subset.

Automated validation will be performed as a part of the archiving process, and will be done simultaneously with the archive volume validation. Validations performed, will include such things as verification that the checksum in the label matches a calculated checksum for the data product (i.e., that the data product included in the archive is identical to that produced by the real-time process), a validation of the PDS syntax of the label, a check of the label values against the database and against the index tables included on the archive volume, and checks for internal consistency of the label items. The latter include such things as verifying that the product creation date is later than the earth received time, and comparing the geometry pointing information with the specified target. As problems are discovered and/or new possibilities identified for automated verification, they will be added to the validation procedure.

Manual validation of the data will be performed both as spot-checking of data throughout the life of the mission, and comprehensive validation of a subset of the data (for example, a couple of days' worth of data). These products will be viewed by a human. Validation in this case will include inspection of the image or other data object for errors (like missing lines) not specified in the label parameters, verification that the target shown / apparent geometry matches that specified in the labels, verification that the product is viewable using the specified software tools, and a general check for any problems that might not have been anticipated in the automated validation procedure.

3. DETAILED DATA PRODUCT SPECIFICATIONS

3.1 Data Product Structure and Organization

The structure of the CheMin EDR consists of a detached ASCII PDS label and a binary data file as shown in Figure 2.

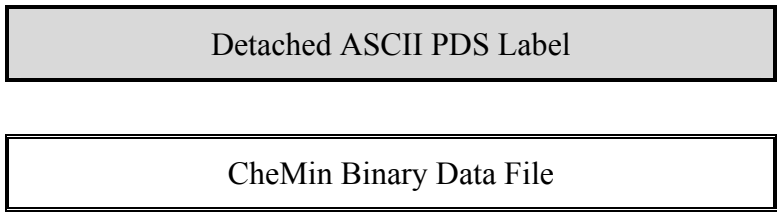

Figure 3.1: The CheMin EDR consists of two files.

3.2 Data Format Descriptions

An CheMin Science EDR data file consists of a CheMin binary data with a detached ASCII PDS label (see sec. 3.2.1). The CheMin CCD Frame and the CheMin transmit raw frame are two files that are returned from the instrument and contain a transfer frame wrapper. Each CheMin data is either byte, halfword (16-bit) or integer (32-bit) data. The formats are described below.

Transfer frame header (12 bytes) Housekeeping Data (300 bytes)
602 rows X 610 columns 16-bit integer data.
Checksum(4 bytes)

Figure 3.2: Schematic of a CheMin Science EDR data file for the CheMin CCD frame data (ECC). (734756 bytes).

Housekeeping Data (300 bytes)
582 rows X 600 columns byte data. (349200 bytes)

Figure 3.3: Schematic of a CheMin Science EDR data file for the CheMin Diffractional data (ED1, EDS, EDA). (349500 bytes)

Housekeeping Data (300 bytes)
1 row X 4096 columns signed integer histogram. (16384 bytes)

Figure 3.4: Schematic of a CheMin Science EDR data file for the CheMin Energy data (EE1, EES, EEA). (16684 bytes)

Housekeeping Data (300 bytes)
582 rows X 600 columns integer data. (20-bit packed)

Figure 3.5: Schematic of a CheMin Science EDR data file for the CheMin Film data (EFM).

Transfer Frame Header (12 bytes) Housekeeping Data (300 bytes)
582 rows X 600 columns 16-bit integer data.
Checksum (4 bytes)

Figure 3.6: Schematic of a CheMin Science EDR data file for the Transmit Raw data (ETR). The ChmnTransmitRaw is a 698716 byte x 1-20 file.

Ancillary Data (512 bytes) Transfer Frame Header (12 bytes)
Housekeeping Data (300 bytes) x n
Checksum (4 bytes)

Figure 3.7: Schematic of an CheMin Science EDR data file for the HouskeepingN data (EHK) The ChmnHousekeepingN is a 300 byte x n file, where n is up to 3,333.

A CheMin EDR data file consists of binary data with a detached ASCII PDS label (see sec. 3.1). CheMin data consists of housekeeping information and data. (Figure 3-8). Some files may contain additional ancillary or transfer frame data.

During a nominal 10-hour analysis, CheMin collects and stores X-ray data as individual 582 X 600 pixel CCD images of 5-30 seconds exposure each. A "minor frame" consists of ½ hour of these images, nominally 60-360 frames depending on integration time. A typically complete 10 hour analysis of a sample comprises 20 such minor frames and is called a "major frame." There is insufficient bandwidth to deliver all of CheMin's raw data to Earth. CheMin's Floating Point Gate Array (FPGA) on the RCE (on command from the ground) partially processes the raw data for each minor frame, in order to reduce the data volume. Each minor frame of data transmitted to Earth contains one or more raw frames in order to assess the health of the detector, a variety of engineering and health information about the instrument, and one or more of four possible reduced data products. The four types of data products are described below:

1. 1. In "fully processed mode," each image is reduced to a pixel map containing ones and zeros, where "1" represents the detection of a Co-Kα (or Co-Kβ) photon, and "0" represents everything else. Each image is summed into a 582 X 600 counting number array of pixel positions; the result is 2-D energy-filtered Co-Kα (or Co-Kβ) diffraction patterns. In addition, a histogram is made of all of the photons detected vs. energy, which amounts to an X-ray energy-dispersive spectrum of the sample material. The EDR product type (***prod***) designations, as listed in section 2.3.4, that fall under fully processed mode are ED1, EDS, EDA, EEA, EE1, and EES.
2. In film mode, images are summed into a 582 X 600 array as raw data. A single real number array holds the summed images for each minor frame. The EDR product type (***prod***) designation, as listed in section 2.3.4, that falls under film mode is EFM.
3. In "modified raw" mode, pixels below a selected threshold are set to zero, and pixels that are above that threshold are run-length encoded with x, y, and intensity information preserved. The detected photons above background are reassembled on the ground as individual raw frames, and processed to yield Kα, Kβ, energy histogram and film mode data. Modified raw mode can include all of the product types listed in section 2.3.4 that can be fully processed (ED1, EDS, EDA, EEA, EE1, and EES) as well as film mode (EFM). However, modified raw processing will only be invoked for off-nominal situations where it may be deemed necessary to get all frames returned for scrutiny, albeit without the ability to include background in the analysis. In the case where modified raw processing is used, this will be stated in the file metadata and the threshold level used will be explained.
4. In the event that an off-nominal result is obtained such that Kα thresholds are incorrect or some other unforeseen circumstance renders the data reduction algorithms ineffectual, raw data can be sent to the RCE (MSL computer) and processed using algorithms that can be written on the ground and uplinked to the rover. The EDR product type (***prod***) designation, as listed in section 2.3.4, that falls under this mode is ETR. In addition, individual frames are routinely downlinked to evaluate XRD quality (product ECC).

Because the raw images collected by CheMin are stored in flash memory until they are overwritten, it is possible to generate reduced data products more than once, if the first data products downlinked are found to be off-nominal (e.g., if the energy window chosen for Co-Kα is incorrect or the dark current in the CCD is higher than expected).

Table 4: MSL CheMin Housekeeping Data Components

Bytes	Description
1-128	64 Parameters. Each parameter is a 16-bit MSB first unsigned integer. [0] - FPGS Version at the time of acquisition [1] - Configuration bit [2] - XRS Thermister 1 Heater set point in DN. Valid: 0-4095 Default: 2048 [3] - XRS Thermister 2 Heater set point in DN. Valid: 0-4095 Default: 2048 [4] - CCD PRT 1 set point for power on of decontamination heater in DN. Default: 0 [5] - CCD PRT 2 set point for power on of decontamination heater in DN. Default: 0 [6] - Temperature to be reached for cryocooler power on for CCD PRT 1 in DN. Valid: 0-4095 Default: 2048 [7] - Temperature to be reached for cryocooler power on for CCD PRT 2 in DN. Valid: 0-4095 Default: 2048 [8] - Contains the final value that will be applied to the KV_PROG input of the XRS, after ramping up. Valid: 0-4095 Default: 0 [9] - Contains the final value that will be applied to the GRID_PROG input of the XRS, after ramping up. Valid: 0-4095 Default: 0 [10] - Contains the final value that will be applied to the UA_PROG input of the XRS, after ramping up. Valid: 0-4095 Default: 0 [11] - XRS (X-Ray Ramp Speed) period in 4ms units. Valid: 4-255 Default: 255 [12] - Funnel Piezo amplitude in bits/DN. Valid: 0-15 Default: 0 [13] - Amplitude Cell value during chaos mode in DN. Valid: 0-4095 Default: 0 [14] - Nominal Amplitude cell value during analysis. Valid: 0-4095 Default: 0 [15] - High Amplitude cell value during analysis. Valid: 0-4095 Default: 0 [16] - Period for nominal cell value or length in ms (in time) of sweep, 1 ms to 66 sec Valid: 0-65535 Default: 950 [17] - Period for high cell value or length in ms (in time) of sweep, 1 ms to 60 sec. Valid: 0-65535 Default: 50 [18] - SWM (Sample Wheel Motor) step period in ms. Valid: 32-255 Default: 33 [19] - CM (Clamp Motor) step period in ms. Valid: 8-255 Default: 10 [20] - CM number of steps when clamping. Valid: 0-1023 Default: 100 [21] - CM number of steps when unclamping. Valid: -1024-0 Default: -100 [22] - Temperature limit (in DN) for the HOP (High Output Paraffin) actuator that defeats the wheel clamp mechanism. Valid: 0-4095 Default: 0 [23] - Time in seconds over which the HOP (High Output Paraffin) can be energized. Valid: 0-4095 Default: 0 [24] - Configuration bits [25] - Left and right signal chain offset in DN. Valid: 0-4095 Default: 0 [26] - rows of CCD data, 1-602 are used, everything else is dark. Valid: 0-1023 Default: 582 [27] - rows to zap, 1-602 are used, everything else is dark. Valid: 0-1023 Default: 610 [28] - CCD integation time in seconds, Valid: 0-255 Default: 30 [29] - CCD Sync pulse time in clocks. Valid: 0-255 Default: 0 [30-31] – Unused

Bytes	Description
	[32] - Temperature to wait (in DN) until the CCD is cooled below (temp <= param). X-Ray source won't produce X-Rays until CCD below this temperature. Valid: 0-4095 Default: 0 [33] - Temperature to wait (in DN) until the CCD is cooled below (temp <= param). X-Ray source won't produce X-Rays until CCD below this temperature. Valid: 0-4095 Default: 0 [34] - Every nth frame is a Chaos Frame. Valid: 0-4095 Default: 60 [35] - Frames per major frame. Valid: 0-2728 Default: 480 [36] - Low raw value for internal thresholding. Valid: 0-4095 Default: 0 (no thresholding) [37] - High raw value for internal thresholding. Valid: 0-4095 Default: 4095 (no thresholding) [38] - Transmit n HK (housekeeping) frames, 0=return all(up to 3,333 frames within 10 seconds) Valid: 0-3333 Default: 1 (most recent HK) [39] – unused [40] - memory flash page to read or write memory. Valid: 0-63 Default: 0 [41] - flash memory block to read or write. Valid: 0-4095 Default: 0 [42] - The temperature fault protection limit for the HKT00 PRT, located at the end of the thermal strap connected to the XRS, Valid: 0-4095 Default: 2539 [43] - The temperature fault protection limit for the HKT01 PRT, placed adjacent to OP AMP on SW board. Valid: 0-4095 Default: 2681 [44] - The temperature fault protection limit for the HKT02 PRT, located on SW board near external edge close to wheel. Valid: 0-4095 Default: 2681 [45] - The temperature fault protection limit for the HKT03 PRT, located on the SW motor housing. Valid: 0-4095 Default: 2895 [46] - The temperature fault protection limit for the PRT, located on the Clamp motor housing. Valid: 0-4095 Default: 2895 [47] - The temperature fault protection limit for the HKT05 PRT, located on the HOP housing, heater end. Valid: 0-4095 Default: 2824 [48] - The temperature fault protection limit for the HKT06 PRT, located on the Cooler motor housing. Valid: 0-4095 Default: 2624 [49] - The temperature fault protection limit for the HKT07 PRT, located on the funnel driver. Valid: 0-4095 Default: 2824 [50] - The temperature fault protection limit for the HKT08 PRT, PRT #1 located inside the HVPS. Valid: 0-4095 Default: 2660 [51] - The temperature fault protection limit for the HKT09 PRT, PRT #2 located inside the HVPS. Valid: 0-4095 Default: 25936 [52] - The temperature fault protection limit for the HKT10 PRT, PRT #1 located outside the XRS adjacent to heaters. Valid: 0-4095 Default: 2610 [53] - The temperature fault protection limit for the HKT11 PRT, PRT #2 located outside the XRS adjacent to heaters. Valid: 0-4095 Default: 2610 [54] - The temperature fault protection limit for the HKT12 PRT, PRT #1 located behind CCd on support structure. Valid: 0-4095 Default: 2713 [55] - The temperature fault protection limit for the HKT13 PRT, PRT #2 located behind CCd on support structure. Valid: 0-4095 Default: 2713

Bytes	Description
	[56] - Safe if force > value when moving wheel. Valid: 0-4095 Default: 4095 [57] - 12 resolver bits. 0=disable fault, 1=enable. Valid: 0-65535 Default: 65520 [58] - Safe after number of specified seconds. Valid: 0-4095 Default: 3600 (1 hr) 0: disable. [59] - Safe if XRS is on and v< this value. Valid: 0-4095 Default: 1285 [60] - Safe if XRS is on and temp < this value. Valid: 0-4095 Default: 2237 [61] - Safe if XRS is on and temp < this value. Valid: 0-4095 Default: 2237 [62] - CCD PRT #1, fault protection limit. Safe if temp > this value. Valid: 0-4095 Default: 2276 [63] - CCD PRT #2, fault protection limit. Safe if temp > this value. Valid: 0-4095 Default: 2276
129-160	16 voltages in raw counts. Each voltage is a 16-bit MSB first unsigned integer. [0] - HKV00_UA_MON [1] - HKV01_KV_MON [2] - HKV02_GRID_MON [3] - HKV03_P_MON [4] - HKV04_FC_MON [5] - HKV05_CLAMP_SG [6] - HKV06_CC_15V [7] - HKV07_CC_15V_I [8] - HKV08_X1_15V [9] - HKV09_X1_15V_I [10] - HKV10_XMP_V [11] - HKV11_UTIL_V [12] - HKV12_CCD_V [13] - HKV13_GND [14] - HKV14_5V [15] - HKV15_3_3V Conversion equations from raw count to Voltage: HKV00(voltage)=8.25*HKV00(raw count)/HKV15(raw count) HKV01(voltage)=8.25*HKV01(raw count)/HKV15(raw count) HKV02(voltage)=8.25*HKV02(raw count)/HKV15(raw count) HKV03(voltage)=8.25*HKV03(raw count)/HKV15(raw count) HKV04(voltage)=8.25*HKV04(raw count)/HKV15(raw count) HKV05(voltage)=3.3*HKV05(raw count)/HKV15(raw count) HKV06(voltage)=14.85*HKV06(raw count)/HKV15(raw count) HKV07(voltage)=0.825*HKV07(raw count)/HKV15(raw count) HKV08(voltage)=14.85*HKV08(raw count)/HKV15(raw count) HKV09(voltage)=0.825*HKV09(raw count)/HKV15(raw count) HKV10(voltage)=29.7*HKV010(raw count)/HKV15(raw count) HKV11(voltage)=29.7*HKV011(raw count)/HKV15(raw count) HKV12(voltage)=29.7*HKV012(raw count)/HKV15(raw count) HKV13(voltage)=3.3*HKV013(raw count)/HKV15(raw count)

Bytes	Description
	HKV14(voltage)=4.95*HKV014(raw count)/HKV15(raw count) HKV15(voltage)=3.3V (this is the reference for the other channels and is assumed to be a stable 3.3V)
161-192	14 temperatures in raw counts plus 2 calibration points. Each temperature is a 16-bit MSB first unsigned integer. [0] - HKT00_XRS_STRAP [1] - HKT01_SW_1 [2] - HKT02_SW_2 [3] - HKT03_SW_MOTOR [4] - HKT04_CLAMP_MOTOR [5] - HKT05_CLAMP_HOP [6] - HKT06_CC_MOTOR [7] - HKT07_FUNNEL_DRIVE [8] - HKT08_X1_THERM1 [9] - HKT09_X1_THERM2 [10] - HKT10_XRS_1 [11] - HKT11_XRS_2 [12] - HKT12_CCD_1 [13] - HKT13_CCD_2 [14] - HKT14_825 (resistance reference) [15] - HKT15_1210 (resistance reference) Temperature channels For each channel HKTxx (HKT00 through HKT13 or xx is 00 through 13), define "HKTerm_xx"= ((385*((HKTxx(raw count)-HKT14_825(raw count))/(HKT15_1210(raw count)-HKT14_825(raw count)))+825))/1000 The temperature in degrees C may be found by HKTa0_xx+(HKTa1_xx*HKTerm_xx)+(HKTa2_xx*(HKTerm_xx^2)), where HKTa0_xx, HKTa1_xx, and HKTa2_xx are constants with the values listed below, with each set listed in order from HKT00 to HKT13: HKTa0_00 = -236.4570877 HKTa0_01 = -236.7780994 HKTa0_02 = -236.5198373 HKTa0_03 = -235.11436 HKTa0_04 = -239.4855414 HKTa0_05 = -239.7177329 HKTa0_06 = -237.4921626 HKTa0_07 = -234.9929293 HKTa0_08 = -236.1675963 HKTa0_09 = -246.9378576 HKTa0_10 = -233.8818125

Bytes	Description
	HKTa0_11 = -235.158739 HKTa0_12 = -234.5712332 HKTa0_13 = -231.7678388 HKTa1_00 = 188.4441662 HKTa1_01 = 181.945173 HKTa1_02 = 183.7176016 HKTa1_03 = 188.0562472 HKTa1_04 = 188.5540807 HKTa1_05 = 188.8849824 HKTa1_06 = 185.8705991 HKTa1_07 = 187.013173 HKTa1_08 = 183.1937215 HKTa1_09 = 204.4796279 HKTa1_10 = 184.3174487 HKTa1_11 = 189.9343886 HKTa1_12 = 183.4904974 HKTa1_13 = 183.8825894 HKTa2_00 = 45.4351327 HKTa2_01 = 50.74171705 HKTa2_02 = 49.43258211 HKTa2_03 = 47.29567173 HKTa2_04 = 45.51918041 HKTa2_05 = 45.70296596 HKTa2_06 = 46.1953967 HKTa2_07 = 43.6197435 HKTa2_08 = 50.41336705 HKTa2_09 = 39.84405476 HKTa2_10 = 47.22079786 HKTa2_11 = 44.46414728 HKTa2_12 = 49.78098673 HKTa2_13 = 48.08736939
193-196	Time. 32-bit MSB first unsigned integer.
197-200	The low bits mimic status flags and condition code, the other bits are assigned. 32-bit MSB first unsigned integer. 0 – FALSE, 1 = TRUE. [0] - XMP_PWR_ENABLE [1] - XRS_HTR_ENABLE [2] - DECON_HTR_ENABLE [3] - F_PIEZO_CTRL

Bytes	Description
	[4] - SW_PIEZO_CTRL4 [5] - SW_PIEZO_CTRL5 [6] - XRS_UA_FAULT_ASSERTED [7] - XRS_FC_FAULT_ASSERTED [8] - XRS_KV_FAULT_ASSERTED [9] - XRS_PWR_ENABLE [10] - CC_PWR_ON [11] - ANALYSIS_PAUSED [12] - INST_ERR_REPORTED [13] - UNUSED [14] - SCIENCE_DATA_AVAILABLE [15] - SAFE_MODE [16] - XMP_PWR_ON [17] - XRS_HTR_ON [18] - DECON_HTR_ON [19] - F_PIEZO_ON [20] - SW_PIEZO_CTRL4_ON [21] - SW_PIEZO_CTRL5_ON [22] - CC_COOL_ASSERTED [23] - ANALYSIS_MODE [24] - XRS_EN!_ASSERTED [25] - XRS_PWR_ON [26] - CC_COOLING [27-31] - FLASH_READ_STATUS (bits 0-4) 00001=last flash read ok 10001=flash EDAC read single bit error (corrected) 10010=flash EDAC read multiple bit error (science data bad)
201-202	Read pointer. Read address for TRANSMIT command. 16-bit MSB first unsigned integer.
203-204	Write pointer. Write address for ANALYZE command. 16-bit MSB first unsigned integer.
205-208	Last command. Header only. 32-bit MSB first unsigned integer.
209-210	S-wheel position. Last position read from resolver during last MOVE_WHEEL command. 16-bit MSB first unsigned integer.
211-212	S-wheel steps. Number of steps actually taken during last MOVE_WHEEL command. 16-bit MSB first unsigned integer.
213-214	OK command count. 16-bit MSB first unsigned integer.
215-216	Retry command count. 16-bit MSB first unsigned integer.

Bytes	Description
217-218	Bad command count. Number of commands for which the command reply condition code was not equal to zero. 16-bit MSB first unsigned integer.
219-220	Raw frame number. 16-bit MSB first unsigned integer.
221-300	40 spares. 16-bit MSB first unsigned integer.

3.3 Label and Header Descriptions

3.3.1 PDS Label

CheMin EDR data products have detached PDS labels stored as ASCII. A PDS label is object-oriented and describes the objects in the data file. The PDS label contains keywords for product identification and for data object definitions. The label also contains descriptive information needed to interpret or process the data objects in the file.

PDS labels are written in Object Description Language (ODL) [7]. 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 file:

^object = location

where the carat character (^, also called a pointer) is followed by the name of the specific data object. The location is the starting record number for the data object within the file.

Each PDS keyword defined for the CheMin label will always be included in the PDS label. If a keyword does not have a value, a value of NA will be given as the keyword value.

3.3.2 PDS Data Objects

A CheMin EDR consists of data objects that are described in the PDS label as tables or an image object. The housekeeping object is a table of the CheMin instrument state information at the time of the observation. The second data object in the CheMin EDR data file is an image the science data.

4. APPLICABLE SOFTWARE

4.1 Utility Programs

A reader program, called NASAview, will be available for a variety of computer platforms to view the CheMin EDR binary format data in ASCII format.

APPENDIX A - EXAMPLES OF CHEMIN SCIENCE EDR LABELS

A.1 CheMin CCD Frame EDR (Product Type ECC)

```
PDS_VERSION_ID                  = PDS3

/* FILE DATA ELEMENTS */

RECORD_TYPE                     = FIXED_LENGTH
RECORD_BYTES                    = 734756
FILE_RECORDS                    = 1

^CCD_HEADER_TABLE    = ("CMA_385726663ECC20120010000CH00001M1.IMG",1)
^IMAGE               = ("CMA_385726663ECC20120010000CH00001M1.IMG",313<BYTES>)
^ERROR_CONTROL_TABLE = ("CMA_385726663ECC20120010000CH00001M1.IMG",734753<BYTES>)

/* IDENTIFICATION DATA ELEMENTS */

DATA_SET_ID                     = "MSL-M-CHEMIN-2-EDR-V1.0"
DATA_SET_NAME                   = "MSL MARS CHEMISTRY & MINERALOGY
                                   X-RAY INSTRUMENT 2 EDR V1.0"
COMMAND_SEQUENCE_NUMBER         = 8
INSTRUMENT_HOST_ID              = "MSL"
INSTRUMENT_HOST_NAME            = "MARS SCIENCE LABORATORY"
INSTRUMENT_ID                   = CHEMIN
INSTRUMENT_NAME                 = "CHEMISTRY AND MINERALOGY"
INSTRUMENT_TYPE                 = SPECTROMETER
MSL:LOCAL_MEAN_SOLAR_TIME           = "UNK"
LOCAL_TRUE_SOLAR_TIME           = "UNK"
MISSION_NAME                    = "MARS SCIENCE LABORATORY"
MISSION_PHASE_NAME              = "DEVELOPMENT"
OBSERVATION_ID                  = "UNK"
PLANET_DAY_NUMBER               = 2012
PRODUCER_INSTITUTION_NAME       = "MULTIMISSION INSTRUMENT PROCESSING LAB,
                                     JET PROPULSION LAB"
PRODUCT_CREATION_TIME           = 2012-04-09T18:01:02.000
PRODUCT_ID                      = "CMA_385726663ECC20120010000CH00001M1"
PRODUCT_TYPE                    = CHEMIN_ECC
PRODUCT_VERSION_ID              = "V1.0 D-69260"
RELEASE_ID                      = "0001"
REQUEST_ID                    = "0"
ROVER_MOTION_COUNTER            = (1,0,0,0,0,0,0,0,0,0)
ROVER_MOTION_COUNTER_NAME       = (SITE, DRIVE, POSE, ARM, CHIMRA,
                                  DRILL, RSM, HGA, DRT, IC)
SEQUENCE_ID                     = "chmn00001"
SEQUENCE_VERSION_ID             = "0"
MSL:ACTIVE_FLIGHT_STRING_ID     = A
SPACECRAFT_CLOCK_CNT_PARTITION  = 1
SPACECRAFT_CLOCK_START_COUNT    = ""
SPACECRAFT_CLOCK_STOP_COUNT     = "UNK"
START_TIME                      = 2012-03-22T22:18:09.444
STOP_TIME                       = "UNK"
TARGET_NAME                     = MARS
TARGET_TYPE                     = PLANET
```

```
/* TELEMETRY DATA ELEMENTS */

APPLICATION_PROCESS_ID           = 148
APPLICATION_PROCESS_NAME         = "ChmnCcdFrame"
MSL:AUTO_DELETE_FLAG             = "FALSE"
MSL:COMMUNICATION_SESSION_ID     = "0"
DOWNLOAD_PRIORITY                = 73
EARTH_RECEIVED_START_TIME        = 2012-03-22T22:25:17.615
EARTH_RECEIVED_STOP_TIME         = 2012-03-22T22:29:35.447
EXPECTED_PACKETS                 = 72
MSL:EXPECTED_TRANSMISSION_PATH   = "3851"
MSL:FLIGHT_SOFTWARE_MODE         = "5"
FLIGHT_SOFTWARE_VERSION_ID       = "127774343"
MSL:PRODUCT_COMPLETION_STATUS    = "COMPLETE_CHECKSUM_PASS"
MSL:PRODUCT_TAG                  = "2"
MSL:SEQUENCE_EXECUTION_COUNT     = 3
RECEIVED_PACKETS                 = 72
SPICE_FILE_NAME                  = "chronos.msl"
TELEMETRY_PROVIDER_ID            = "MPCS_MSL_DP"
MSL:TELEMETRY_SOURCE_CHECKSUM    = 25050
MSL:TELEMETRY_SOURCE_HOST_NAME   = "mslmpcs1"
TELEMETRY_SOURCE_NAME            = "ChmnCcdFrame_0385726663-02653-1.dat"
MSL:TELEMETRY_SOURCE_SIZE        = 734756
MSL:TELEMETRY_SOURCE_TYPE        = "DATA PRODUCT"
MSL:TRANSMISSION_PATH            = "65535"
MSL:VIRTUAL_CHANNEL_ID           = "0"


/* HISTORY DATA ELEMENTS */

GROUP                            = MSLEDRGEN_HISTORY_PARMS
 SOFTWARE_NAME                   = MSLEDRGEN
 SOFTWARE_VERSION_ID             = "V1.0 04-01-2011"
 PROCESSING_HISTORY_TEXT         = "CODMAC LEVEL 1 TO LEVEL 2 CONVERSION
                                    VIA JPL/MIPL MSLEDRGEN"
END_GROUP                        = MSLEDRGEN_HISTORY_PARMS

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

GROUP                            = ROVER_COORDINATE_SYSTEM
 COORDINATE_SYSTEM_NAME          = "ROVER_NAV_FRAME"
 COORDINATE_SYSTEM_INDEX         = (1,0,0,0,0,0,0,0,0,0)
 COORDINATE_SYSTEM_INDEX_NAME    = (SITE, DRIVE, POSE, ARM, CHIMRA,
                                   DRILL, RSM, HGA, DRT, IC)
 ORIGIN_OFFSET_VECTOR            = (0,0,0)
 ORIGIN_ROTATION_QUATERNION      = (1,0,0,0)
 POSITIVE_AZIMUTH_DIRECTION      = CLOCKWISE
 POSITIVE_ELEVATION_DIRECTION    = UP
 REFERENCE_COORD_SYSTEM_NAME     = SITE_FRAME
 REFERENCE_COORD_SYSTEM_INDEX    = 1
END_GROUP                        = ROVER_COORDINATE_SYSTEM

/* ARTICULATION DEVICE STATE: ROBOTIC ARM */

GROUP                            = ARM_ARTICULATION_STATE
 ARTICULATION_DEVICE_ID          = ARM
```

```
 ARTICULATION_DEVICE_NAME        = "SAMPLE ARM"
 ARTICULATION_DEVICE_ANGLE       = (1.0e+30<rad>, 1.0e+30<rad>, 1.0e+30<rad>,
                                    1.0e+30<rad>, 1.0e+30<rad>)
 ARTICULATION_DEVICE_ANGLE_NAME  = ("JOINT 1 AZIMUTH-ENCODER",
                                    "JOINT 2 SHOULDER ELEVATION",
                                    "JOINT 3 ELBOW-ENCODER",
                                    "JOINT 4 WRIST-ENCODER",
                                    "JOINT 5 TURRET-ENCODER")
END_GROUP                        = ARM_ARTICULATION_STATE

/* ARTICULATION DEVICE STATE: REMOTE SENSING MAST */

GROUP                            = RSM_ARTICULATION_STATE
 ARTICULATION_DEVICE_ID          = RSM
 ARTICULATION_DEVICE_NAME        = "REMOTE SENSING MAST"
 ARTICULATION_DEVICE_ANGLE       = (1.0e+30<rad>, 1.0e+30<rad>)
 ARTICULATION_DEVICE_ANGLE_NAME  = (AZIMUTH, ELEVATION)
END_GROUP                        = RSM_ARTICULATION_STATE

/* OBSERVATION REQUEST */

GROUP                            = OBSERVATION_REQUEST_PARMS
 SOURCE_ID                       = "GROUND COMMANDED"
 INSTRUMENT_COORDINATE_NAME      = “N/A”
 INSTRUMENT_COORDINATE           = ‘N/A’
END_GROUP                        = OBSERVATION_REQUEST_PARMS

/* CHEMIN CCD DATA HEADER OBJECT */

OBJECT                           = CCD_HEADER_TABLE
   NAME                          = CCD_HEADER
   INTERCHANGE_FORMAT            = BINARY
   ROWS                          = 1
   ROW_BYTES                     = 312
   COLUMNS                       = 18
   DESCRIPTION                   = "
    This table contains CHEMIN Science Frame plus housekeeping
    data associated instrument parameters as observed by the
    Mars Science Laboratory (MSL) CHEMIN.

    Detailed descriptions for the parameters defined below are
    contained in the CHEMIN EDR SIS document.

    The complete column definitions are contained in an external file
    found in the LABEL directory of the archive volume.
    "
   ^STRUCTURE                    = "CHMN_EDR_CCD_HEADER_FRAME.FMT"
END_OBJECT                       = CCD_HEADER_TABLE

/* CHEMIN IMAGE DATA OBJECT */

OBJECT                           = IMAGE
   LINES                         = 602
   LINE_SAMPLES                  = 610
   SAMPLE_TYPE                   = MSB_UNSIGNED_INTEGER
   SAMPLE_BITS                   = 16
END_OBJECT                       = IMAGE
```

```
/* ERROR CONTROL VALUE OBJECT */

OBJECT                          = ERROR_CONTROL_TABLE
    NAME                        = ERROR_CONTROL
    INTERCHANGE_FORMAT          = BINARY
    ROWS                        = 1
    ROW_BYTES                   = 4
    COLUMNS                     = 1

      OBJECT                    = COLUMN
        NAME                    = ERROR_CONTROL_VALUE
        DATA_TYPE               = LSB_UNSIGNED_INTEGER
        START_BYTE              = 1
        BYTES                   = 4
        DESCRIPTION             = "Contains a CRC or Fletcher checksum value
                                  as indicated in the CHMN_HSKN_HEADER_TABLE
                                  control and status error control type field."
      END_OBJECT                = COLUMN
END_OBJECT                      = ERROR_CONTROL_TABLE
END
```

A.2 CheMin Diffraction Single EDR (Product Type ED1)

Product types EDS (diffraction split) and EDA (diffraction all) have similar labels.

```
PDS_VERSION_ID                  = PDS3

/* FILE DATA ELEMENTS */

RECORD_TYPE                     = FIXED_LENGTH
RECORD_BYTES                    = 349500
FILE_RECORDS                    = 1

^HOUSEKEEPING_TABLE  = ("CMB_353900651ED1201100000001015808M1.IMG",1)
^IMAGE               = ("CMB_353900651ED1201100000001015808M1.IMG",301<BYTES>)

/* IDENTIFICATION DATA ELEMENTS */

DATA_SET_ID                     = "MSL-M-CHEMIN-2-EDR-V1.0"
DATA_SET_NAME                   = "MSL MARS CHEMISTRY & MINERALOGY
                                   X-RAY INSTRUMENT 2 EDR V1.0"
COMMAND_SEQUENCE_NUMBER         = 1722
INSTRUMENT_HOST_ID              = "MSL"
INSTRUMENT_HOST_NAME            = "MARS SCIENCE LABORATORY"
INSTRUMENT_ID                   = CHEMIN
INSTRUMENT_NAME                 = "CHEMISTRY AND MINERALOGY"
INSTRUMENT_TYPE                 = SPECTROMETER
MSL:LOCAL_MEAN_SOLAR_TIME           = "UNK"
LOCAL_TRUE_SOLAR_TIME           = "UNK"
MISSION_NAME                    = "MARS SCIENCE LABORATORY"
MISSION_PHASE_NAME              = "DEVELOPMENT"
OBSERVATION_ID                  = "UNK"
PLANET_DAY_NUMBER               = 2011
PRODUCER_INSTITUTION_NAME       = "MULTIMISSION INSTRUMENT PROCESSING LAB,
                                    JET PROPULSION LAB"
```

```
PRODUCT_CREATION_TIME            = 2012-04-09T18:01:03.000
PRODUCT_ID                       = "CMB_353900651ED1201100000001015808M1"
PRODUCT_TYPE                     = CHEMIN_ED1
PRODUCT_VERSION_ID               = "V1.0 D-69260"
RELEASE_ID                       = "0001"
MSL:REQUEST_ID                   = "0"
ROVER_MOTION_COUNTER             = (0,0,0,0,0,0,0,0,0,0)
ROVER_MOTION_COUNTER_NAME        = (SITE, DRIVE, POSE, ARM, CHIMRA,
                                   DRILL, RSM, HGA, DRT, IC)
SEQUENCE_ID                      = "1015808"
SEQUENCE_VERSION_ID              = "0"
MSL:ACTIVE_FLIGHT_STRING_ID      = B
SPACECRAFT_CLOCK_CNT_PARTITION   = 1
SPACECRAFT_CLOCK_START_COUNT     = ""
SPACECRAFT_CLOCK_STOP_COUNT      = "UNK"
START_TIME                       = 2011-03-20T13:43:04.816
STOP_TIME                        = "UNK"
TARGET_NAME                      = MARS
TARGET_TYPE                      = PLANET

/* TELEMETRY DATA ELEMENTS */

APPLICATION_PROCESS_ID           = 149
APPLICATION_PROCESS_NAME         = "ChmnDiffSingle"
MSL:AUTO_DELETE_FLAG             = "FALSE"
MSL:COMMUNICATION_SESSION_ID     = "0"
DOWNLOAD_PRIORITY                = 34
EARTH_RECEIVED_START_TIME        = 2011-03-20T13:43:24.135
EARTH_RECEIVED_STOP_TIME         = 2011-03-20T13:43:20.316
EXPECTED_PACKETS                 = 36
MSL:EXPECTED_TRANSMISSION_PATH   = "3851"
MSL:FLIGHT_SOFTWARE_MODE         = "1"
FLIGHT_SOFTWARE_VERSION_ID       = "97208714"
MSL:PRODUCT_COMPLETION_STATUS    = "COMPLETE_CHECKSUM_PASS"
MSL:PRODUCT_TAG                  = "0"
MSL:SEQUENCE_EXECUTION_COUNT     = 0
RECEIVED_PACKETS                 = 36
SPICE_FILE_NAME                  = "chronos.msl"
TELEMETRY_PROVIDER_ID            = "MPCS_MSL_DP"
MSL:TELEMETRY_SOURCE_CHECKSUM    = 32299
MSL:TELEMETRY_SOURCE_HOST_NAME   = "mslatlompcs4"
TELEMETRY_SOURCE_NAME            = "ChmnDiffSingle_0353900651_36916-1.dat"
MSL:TELEMETRY_SOURCE_SIZE        = 349500
MSL:TELEMETRY_SOURCE_TYPE        = "DATA PRODUCT"
MSL:TRANSMISSION_PATH            = "65535"
MSL:VIRTUAL_CHANNEL_ID           = "32"


/* HISTORY DATA ELEMENTS */

GROUP                            = MSLEDRGEN_HISTORY_PARMS
 SOFTWARE_NAME                   = MSLEDRGEN
 SOFTWARE_VERSION_ID             = "V1.0 04-01-2011"
 PROCESSING_HISTORY_TEXT         = "CODMAC LEVEL 1 TO LEVEL 2 CONVERSION
                                    VIA JPL/MIPL MSLEDRGEN"
END_GROUP                        = MSLEDRGEN_HISTORY_PARMS
```

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

GROUP                           = ROVER_COORDINATE_SYSTEM
 COORDINATE_SYSTEM_NAME         = "ROVER_NAV_FRAME"
 COORDINATE_SYSTEM_INDEX        = (0,0,0,0,0,0,0,0,0,0)
 COORDINATE_SYSTEM_INDEX_NAME   = (SITE, DRIVE, POSE, ARM, CHIMRA,
                                   DRILL, RSM, HGA, DRT, IC)
 ORIGIN_OFFSET_VECTOR           = (0,0,0)
 ORIGIN_ROTATION_QUATERNION     = (0,0,0,0)
 POSITIVE_AZIMUTH_DIRECTION     = CLOCKWISE
 POSITIVE_ELEVATION_DIRECTION   = UP
 REFERENCE_COORD_SYSTEM_NAME    = SITE_FRAME
 REFERENCE_COORD_SYSTEM_INDEX   = 0
END_GROUP                       = ROVER_COORDINATE_SYSTEM

/* ARTICULATION DEVICE STATE: ROBOTIC ARM */

GROUP                           = ARM_ARTICULATION_STATE
 ARTICULATION_DEVICE_ID         = ARM
 ARTICULATION_DEVICE_NAME       = "SAMPLE ARM"
 ARTICULATION_DEVICE_ANGLE      = (0<rad>, 0<rad>, 0<rad>,
                                   0<rad>, 0<rad>)
 ARTICULATION_DEVICE_ANGLE_NAME = ("JOINT 1 AZIMUTH-ENCODER",
                                   "JOINT 2 SHOULDER ELEVATION",
                                   "JOINT 3 ELBOW-ENCODER",
                                   "JOINT 4 WRIST-ENCODER",
                                   "JOINT 5 TURRET-ENCODER")
END_GROUP                       = ARM_ARTICULATION_STATE

/* ARTICULATION DEVICE STATE: REMOTE SENSING MAST */

GROUP                           = RSM_ARTICULATION_STATE
 ARTICULATION_DEVICE_ID         = RSM
 ARTICULATION_DEVICE_NAME       = "REMOTE SENSING MAST"
 ARTICULATION_DEVICE_ANGLE      = (0<rad>, 0<rad>)
 ARTICULATION_DEVICE_ANGLE_NAME = (AZIMUTH, ELEVATION)
END_GROUP                       = RSM_ARTICULATION_STATE

/* OBSERVATION REQUEST */

GROUP                           = OBSERVATION_REQUEST_PARMS
 SOURCE_ID                      = "GROUND COMMANDED"
 INSTRUMENT_COORDINATE_NAME     = “N/A”
 INSTRUMENT_COORDINATE          = ‘N/A’
END_GROUP                       = OBSERVATION_REQUEST_PARMS

/* CHEMIN HOUSEKEEPING TABLE OBJECT */

OBJECT                          = HOUSEKEEPING_TABLE
   NAME                         = HOUSEKEEPING
   INTERCHANGE_FORMAT           = BINARY
   ROWS                         = 1
   ROW_BYTES                    = 300
   COLUMNS                      = 15
   DESCRIPTION                  = "
    This table contains CHEMIN housekeeping data
```

```
    as observed by the Mars Science Laboratory (MSL)
    Chemistry and Mineralogy Instrument.

    Detailed descriptions for the data are contained in the
    CHEMIN EDR SIS document.

    The complete column definitions are contained in an external file
    found in the LABEL directory of the archive volume.
    "
   ^STRUCTURE                    = "CHMN_EDR_HOUSEKEEPING.FMT"
END_OBJECT                       = HOUSEKEEPING_TABLE

/* CHEMIN IMAGE DATA OBJECT */

OBJECT                           = IMAGE
   LINES                         = 582
   LINE_SAMPLES                  = 600
   SAMPLE_TYPE                   = MSB_UNSIGNED_INTEGER
   SAMPLE_BITS                   = 8
END_OBJECT                       = IMAGE
END
```

A.3 CheMin Energy Single EDR (Product Type EE1)

Product types EES (energy split) and EEA (energy all) have similar labels.

```
PDS_VERSION_ID                   = PDS3

/* FILE DATA ELEMENTS */

RECORD_TYPE                      = FIXED_LENGTH
RECORD_BYTES                     = 16684
FILE_RECORDS                     = 1

^HOUSEKEEPING_TABLE           = ("CMB_353900651EE12011000000001015808M1.DAT",1)
^HISTOGRAM                  = ("CMB_353900651EE12011000000001015808M1.DAT",301<BYTES>)

/* IDENTIFICATION DATA ELEMENTS */

DATA_SET_ID                      = "MSL-M-CHEMIN-2-EDR-V1.0"
DATA_SET_NAME                    = "MSL MARS CHEMISTRY & MINERALOGY
                                    X-RAY INSTRUMENT 2 EDR V1.0"
COMMAND_SEQUENCE_NUMBER          = 1722
INSTRUMENT_HOST_ID               = "MSL"
INSTRUMENT_HOST_NAME             = "MARS SCIENCE LABORATORY"
INSTRUMENT_ID                    = CHEMIN
INSTRUMENT_NAME                  = "CHEMISTRY AND MINERALOGY"
INSTRUMENT_TYPE                  = SPECTROMETER
MSL:LOCAL_MEAN_SOLAR_TIME           = "UNK"
LOCAL_TRUE_SOLAR_TIME            = "UNK"
MISSION_NAME                     = "MARS SCIENCE LABORATORY"
MISSION_PHASE_NAME               = "DEVELOPMENT"
OBSERVATION_ID                   = "UNK"
PLANET_DAY_NUMBER                = 2011
PRODUCER_INSTITUTION_NAME        = "MULTIMISSION INSTRUMENT PROCESSING LAB,
                                    JET PROPULSION LAB"
```

```
PRODUCT_CREATION_TIME            = 2012-04-09T18:01:06.000
PRODUCT_ID                       = "CMB_353900651EE120110000000101580 8M1"
PRODUCT_TYPE                     = CHEMIN_EE1
PRODUCT_VERSION_ID               = "V1.0 D-69260"
RELEASE_ID                       = "0001"
MSL:REQUEST_ID                   = "0"
ROVER_MOTION_COUNTER             = (0,0,0,0,0,0,0,0,0,0)
ROVER_MOTION_COUNTER_NAME        = (SITE, DRIVE, POSE, ARM, CHIMRA,
                                   DRILL, RSM, HGA, DRT, IC)
SEQUENCE_ID                      = "1015808"
SEQUENCE_VERSION_ID              = "0"
MSL:ACTIVE_FLIGHT_STRING_ID      = B
SPACECRAFT_CLOCK_CNT_PARTITION   = 1
SPACECRAFT_CLOCK_START_COUNT     = ""
SPACECRAFT_CLOCK_STOP_COUNT      = "UNK"
START_TIME                       = 2011-03-20T13:43:04.816
STOP_TIME                        = "UNK"
TARGET_NAME                      = MARS
TARGET_TYPE                      = PLANET

/* TELEMETRY DATA ELEMENTS */

APPLICATION_PROCESS_ID           = 154
APPLICATION_PROCESS_NAME         = "ChmnEnergySingle"
MSL:AUTO_DELETE_FLAG             = "FALSE"
MSL:COMMUNICATION_SESSION_ID     = "0"
DOWNLOAD_PRIORITY                = 34
EARTH_RECEIVED_START_TIME        = 2011-03-20T13:43:24.098
EARTH_RECEIVED_STOP_TIME         = 2011-03-20T13:43:18.402
EXPECTED_PACKETS                 = 2
MSL:EXPECTED_TRANSMISSION_PATH   = "3851"
MSL:FLIGHT_SOFTWARE_MODE         = "1"
FLIGHT_SOFTWARE_VERSION_ID       = "97208714"
MSL:PRODUCT_COMPLETION_STATUS    = "COMPLETE_CHECKSUM_PASS"
MSL:PRODUCT_TAG                  = "0"
MSL:SEQUENCE_EXECUTION_COUNT     = 0
RECEIVED_PACKETS                 = 2
SPICE_FILE_NAME                  = "chronos.msl"
TELEMETRY_PROVIDER_ID            = "MPCS_MSL_DP"
MSL:TELEMETRY_SOURCE_CHECKSUM    = 61142
MSL:TELEMETRY_SOURCE_HOST_NAME   = "mslatlompcs4"
TELEMETRY_SOURCE_NAME            = "ChmnEnergySingle_0353900651_35245-1.dat"
MSL:TELEMETRY_SOURCE_SIZE        = 16684
MSL:TELEMETRY_SOURCE_TYPE        = "DATA PRODUCT"
MSL:TRANSMISSION_PATH            = "65535"
MSL:VIRTUAL_CHANNEL_ID           = "32"


/* HISTORY DATA ELEMENTS */

GROUP                            = MSLEDRGEN_HISTORY_PARMS
 SOFTWARE_NAME                   = MSLEDRGEN
 SOFTWARE_VERSION_ID             = "V1.0 04-01-2011"
 PROCESSING_HISTORY_TEXT         = "CODMAC LEVEL 1 TO LEVEL 2 CONVERSION
                                    VIA JPL/MIPL MSLEDRGEN"
END_GROUP                        = MSLEDRGEN_HISTORY_PARMS
```

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

GROUP                           = ROVER_COORDINATE_SYSTEM
 COORDINATE_SYSTEM_NAME         = "ROVER_NAV_FRAME"
 COORDINATE_SYSTEM_INDEX        = (0,0,0,0,0,0,0,0,0,0)
 COORDINATE_SYSTEM_INDEX_NAME   = (SITE, DRIVE, POSE, ARM, CHIMRA,
                                   DRILL, RSM, HGA, DRT, IC)
 ORIGIN_OFFSET_VECTOR           = (0,0,0)
 ORIGIN_ROTATION_QUATERNION     = (0,0,0,0)
 POSITIVE_AZIMUTH_DIRECTION     = CLOCKWISE
 POSITIVE_ELEVATION_DIRECTION   = UP
 REFERENCE_COORD_SYSTEM_NAME    = SITE_FRAME
 REFERENCE_COORD_SYSTEM_INDEX   = 0
END_GROUP                       = ROVER_COORDINATE_SYSTEM

/* ARTICULATION DEVICE STATE: ROBOTIC ARM */

GROUP                           = ARM_ARTICULATION_STATE
 ARTICULATION_DEVICE_ID         = ARM
 ARTICULATION_DEVICE_NAME       = "SAMPLE ARM"
 ARTICULATION_DEVICE_ANGLE      = (0<rad>, 0<rad>, 0<rad>,
                                   0<rad>, 0<rad>)
 ARTICULATION_DEVICE_ANGLE_NAME = ("JOINT 1 AZIMUTH-ENCODER",
                                   "JOINT 2 SHOULDER ELEVATION",
                                   "JOINT 3 ELBOW-ENCODER",
                                   "JOINT 4 WRIST-ENCODER",
                                   "JOINT 5 TURRET-ENCODER")
END_GROUP                       = ARM_ARTICULATION_STATE

/* ARTICULATION DEVICE STATE: REMOTE SENSING MAST */

GROUP                           = RSM_ARTICULATION_STATE
 ARTICULATION_DEVICE_ID         = RSM
 ARTICULATION_DEVICE_NAME       = "REMOTE SENSING MAST"
 ARTICULATION_DEVICE_ANGLE      = (0<rad>, 0<rad>)
 ARTICULATION_DEVICE_ANGLE_NAME = (AZIMUTH, ELEVATION)
END_GROUP                       = RSM_ARTICULATION_STATE

/* OBSERVATION REQUEST */

GROUP                           = OBSERVATION_REQUEST_PARMS
 SOURCE_ID                      = "GROUND COMMANDED"
 INSTRUMENT_COORDINATE_NAME     = “N/A”
 INSTRUMENT_COORDINATE          = ‘N/A’
END_GROUP                       = OBSERVATION_REQUEST_PARMS

/* CHEMIN HOUSEKEEPING TABLE OBJECT */

OBJECT                          = HOUSEKEEPING_TABLE
   NAME                         = HOUSEKEEPING
   INTERCHANGE_FORMAT           = BINARY
   ROWS                         = 1
   ROW_BYTES                    = 300
   COLUMNS                      = 15
   DESCRIPTION                  = "
    This table contains CHEMIN housekeeping data
```

```
    as observed by the Mars Science Laboratory (MSL)
    Chemistry and Mineralogy Instrument.

    Detailed descriptions for the data are contained in the
    CHEMIN EDR SIS document.

    The complete column definitions are contained in an external file
    found in the LABEL directory of the archive volume.
    "
   ^STRUCTURE                    = "CHMN_EDR_HOUSEKEEPING.FMT"
END_OBJECT                       = HOUSEKEEPING_TABLE

/* CHEMIN ENERGY DATA OBJECT */

OBJECT                           = HISTOGRAM
   INTERCHANGE_FORMAT            = BINARY
   ITEMS                         = 4096
   DATA_TYPE                     = MSB_UNSIGNED_INTEGER
   ITEM_BYTES                    = 4
   BYTES                         = 16384
END_OBJECT                       = HISTOGRAM
END
```

A.4 CheMin Film EDR (Product Type EFM)

```
PDS_VERSION_ID                   = PDS3

/* FILE DATA ELEMENTS */

RECORD_TYPE                      = FIXED_LENGTH
RECORD_BYTES                     = 873300
FILE_RECORDS                     = 1

^HOUSEKEEPING_TABLE           = ("CMB_353900116EFM20110000000001015808M1.DAT",1)
^FILM_TABLE          = ("CMB_353900116EFM20110000000001015808M1.DAT",301<BYTES>)

/* IDENTIFICATION DATA ELEMENTS */

DATA_SET_ID                      = "MSL-M-CHEMIN-2-EDR-V1.0"
DATA_SET_NAME                    = "MSL MARS CHEMISTRY & MINERALOGY
                                    X-RAY INSTRUMENT 2 EDR V1.0"
COMMAND_SEQUENCE_NUMBER          = 1720
INSTRUMENT_HOST_ID               = "MSL"
INSTRUMENT_HOST_NAME             = "MARS SCIENCE LABORATORY"
INSTRUMENT_ID                    = CHEMIN
INSTRUMENT_NAME                  = "CHEMISTRY AND MINERALOGY"
INSTRUMENT_TYPE                  = SPECTROMETER
MSL:LOCAL_MEAN_SOLAR_TIME           = "UNK"
LOCAL_TRUE_SOLAR_TIME            = "UNK"
MISSION_NAME                     = "MARS SCIENCE LABORATORY"
MISSION_PHASE_NAME               = "DEVELOPMENT"
OBSERVATION_ID                   = "UNK"
PLANET_DAY_NUMBER                = 2011
PRODUCER_INSTITUTION_NAME        = "MULTIMISSION INSTRUMENT PROCESSING LAB,
                                    JET PROPULSION LAB"
PRODUCT_CREATION_TIME            = 2012-04-09T18:01:12.000
```

```
PRODUCT_ID                        = "CMB_353900116EFM20110000000101580 8M1"
PRODUCT_TYPE                      = CHEMIN_EFM
PRODUCT_VERSION_ID                = "V1.0 D-69260"
RELEASE_ID                        = "0001"
MSL:REQUEST_ID                    = "0"
ROVER_MOTION_COUNTER              = (0,0,0,0,0,0,0,0,0,0)
ROVER_MOTION_COUNTER_NAME         = (SITE, DRIVE, POSE, ARM, CHIMRA,
                                    DRILL, RSM, HGA, DRT, IC)
SEQUENCE_ID                       = "1015808"
SEQUENCE_VERSION_ID               = "0"
MSL:ACTIVE_FLIGHT_STRING_ID       = B
SPACECRAFT_CLOCK_CNT_PARTITION    = 1
SPACECRAFT_CLOCK_START_COUNT      = ""
SPACECRAFT_CLOCK_STOP_COUNT       = "UNK"
START_TIME                        = 2011-03-20T13:34:09.816
STOP_TIME                         = "UNK"
TARGET_NAME                       = MARS
TARGET_TYPE                       = PLANET

/* TELEMETRY DATA ELEMENTS */

APPLICATION_PROCESS_ID            = 156
APPLICATION_PROCESS_NAME          = "ChmnFilmData"
MSL:AUTO_DELETE_FLAG              = "FALSE"
MSL:COMMUNICATION_SESSION_ID      = "0"
DOWNLOAD_PRIORITY                 = 34
EARTH_RECEIVED_START_TIME         = 2011-03-20T13:34:29.388
EARTH_RECEIVED_STOP_TIME          = 2011-03-20T13:34:28.491
EXPECTED_PACKETS                  = 87
MSL:EXPECTED_TRANSMISSION_PATH    = "3851"
MSL:FLIGHT_SOFTWARE_MODE          = "1"
FLIGHT_SOFTWARE_VERSION_ID        = "97208714"
MSL:PRODUCT_COMPLETION_STATUS     = "COMPLETE_CHECKSUM_PASS"
MSL:PRODUCT_TAG                   = "0"
MSL:SEQUENCE_EXECUTION_COUNT      = 0
RECEIVED_PACKETS                  = 87
SPICE_FILE_NAME                   = "chronos.msl"
TELEMETRY_PROVIDER_ID             = "MPCS_MSL_DP"
MSL:TELEMETRY_SOURCE_CHECKSUM     = 62028
MSL:TELEMETRY_SOURCE_HOST_NAME    = "mslatlompcs4"
TELEMETRY_SOURCE_NAME             = "ChmnFilmData_0353900116_45998-1.dat"
MSL:TELEMETRY_SOURCE_SIZE         = 873300
MSL:TELEMETRY_SOURCE_TYPE         = "DATA PRODUCT"
MSL:TRANSMISSION_PATH             = "65535"
MSL:VIRTUAL_CHANNEL_ID            = "32"


/* HISTORY DATA ELEMENTS */

GROUP                             = MSLEDRGEN_HISTORY_PARMS
 SOFTWARE_NAME                    = MSLEDRGEN
 SOFTWARE_VERSION_ID              = "V1.0 04-01-2011"
 PROCESSING_HISTORY_TEXT          = "CODMAC LEVEL 1 TO LEVEL 2 CONVERSION
                                     VIA JPL/MIPL MSLEDRGEN"
END_GROUP                         = MSLEDRGEN_HISTORY_PARMS

/* ROVER STATE */
```

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

GROUP                           = ROVER_COORDINATE_SYSTEM
 COORDINATE_SYSTEM_NAME         = "ROVER_NAV_FRAME"
 COORDINATE_SYSTEM_INDEX        = (0,0,0,0,0,0,0,0,0,0)
 COORDINATE_SYSTEM_INDEX_NAME   = (SITE, DRIVE, POSE, ARM, CHIMRA,
                                  DRILL, RSM, HGA, DRT, IC)
 ORIGIN_OFFSET_VECTOR           = (0,0,0)
 ORIGIN_ROTATION_QUATERNION     = (0,0,0,0)
 POSITIVE_AZIMUTH_DIRECTION     = CLOCKWISE
 POSITIVE_ELEVATION_DIRECTION   = UP
 REFERENCE_COORD_SYSTEM_NAME    = SITE_FRAME
 REFERENCE_COORD_SYSTEM_INDEX   = 0
END_GROUP                       = ROVER_COORDINATE_SYSTEM

/* ARTICULATION DEVICE STATE: ROBOTIC ARM */

GROUP                           = ARM_ARTICULATION_STATE
 ARTICULATION_DEVICE_ID         = ARM
 ARTICULATION_DEVICE_NAME       = "SAMPLE ARM"
 ARTICULATION_DEVICE_ANGLE      = (0<rad>, 0<rad>, 0<rad>,
                                   0<rad>, 0<rad>)
 ARTICULATION_DEVICE_ANGLE_NAME = ("JOINT 1 AZIMUTH-ENCODER",
                                  "JOINT 2 SHOULDER ELEVATION",
                                  "JOINT 3 ELBOW-ENCODER",
                                  "JOINT 4 WRIST-ENCODER",
                                  "JOINT 5 TURRET-ENCODER")
END_GROUP                       = ARM_ARTICULATION_STATE

/* ARTICULATION DEVICE STATE: REMOTE SENSING MAST */

GROUP                           = RSM_ARTICULATION_STATE
 ARTICULATION_DEVICE_ID         = RSM
 ARTICULATION_DEVICE_NAME       = "REMOTE SENSING MAST"
 ARTICULATION_DEVICE_ANGLE      = (0<rad>, 0<rad>)
 ARTICULATION_DEVICE_ANGLE_NAME = (AZIMUTH, ELEVATION)
END_GROUP                       = RSM_ARTICULATION_STATE

/* OBSERVATION REQUEST */

GROUP                           = OBSERVATION_REQUEST_PARMS
 SOURCE_ID                      = "GROUND COMMANDED"
 INSTRUMENT_COORDINATE_NAME     = “N/A”
 INSTRUMENT_COORDINATE          = ‘N/A’
END_GROUP                       = OBSERVATION_REQUEST_PARMS

/* CHEMIN HOUSEKEEPING TABLE OBJECT */

OBJECT                          = HOUSEKEEPING_TABLE
   NAME                         = HOUSEKEEPING
   INTERCHANGE_FORMAT           = BINARY
   ROWS                         = 1
   ROW_BYTES                    = 300
   COLUMNS                      = 15
   DESCRIPTION                  = "
    This table contains CHEMIN housekeeping data
    as observed by the Mars Science Laboratory (MSL)
```

```
    Chemistry and Mineralogy Instrument.

    Detailed descriptions for the data are contained in the
    CHEMIN EDR SIS document.

    The complete column definitions are contained in an external file
    found in the LABEL directory of the archive volume.
    "
   ^STRUCTURE                    = "CHMN_EDR_HOUSEKEEPING.FMT"
END_OBJECT                       = HOUSEKEEPING_TABLE

/* CHEMIN FILM TABLE DATA OBJECT */

OBJECT                           = FILM_TABLE
   NAME                          = FILM_EDR
   INTERCHANGE_FORMAT            = BINARY
   ROWS                          = 1
   ROW_BYTES                     = 873000
   COLUMNS                       = 1
   DESCRIPTION                   = "The CheMin Film EDR is a 582 by 600 array
     of 20-bit MSB unsigned integer elements. The elements are packed; that
     is, they cross byte boundaries. Two 20-bit array elements take up 40
     bits, or five 8-bit bytes, of storage. The total size of the array is
     873,000 bytes. The array storage order is such that the second axis
     index varies fastest, i.e.,
     (1,1), (1,2), (1,3), ... (1, 600),
     (2,1), (2,2), (2,3), ... (2, 600),
     ...
     (582,598), (582,599), (582,600)."

   OBJECT                        = CONTAINER
     NAME                        = "ALL ELEMENTS"
     START_BYTE                  = 1
     BYTES                       = 5
     REPETITIONS                 = 174600
     DESCRIPTION                 = "The array is described as if it were a
       table with all the elements in one row. In order to define columns
       that respect byte boundaries, one 5-byte column is defined to hold
       two 20-bit array elements. There are 174600 repetitions of this
       5-byte column for a total of 873000 bytes, or 582 * 600 * 20 bits."

     OBJECT                      = COLUMN
        NAME                     = "TWO ELEMENTS"
        DATA_TYPE                = MSB_BIT_STRING
        START_BYTE               = 1
        BYTES                    = 5
        DESCRIPTION              = "These 5 bytes hold two 20-bit elements."

        OBJECT                   = BIT_COLUMN
          NAME                   = ELEMENT_1
          BIT_DATA_TYPE          = MSB_UNSIGNED_INTEGER
          START_BIT              = 1
          BITS                   = 20
          DESCRIPTION            = "The first of two elements in this column."
        END_OBJECT               = BIT_COLUMN

        OBJECT                   = BIT_COLUMN
```

```
          NAME                = ELEMENT_2
          BIT_DATA_TYPE       = MSB_UNSIGNED_INTEGER
          START_BIT           = 21
          BITS                = 20
          DESCRIPTION         = "The second of two elements in this column."
        END_OBJECT            = BIT_COLUMN

     END_OBJECT               = COLUMN
   END_OBJECT                 = CONTAINER

END_OBJECT                    = FILM_TABLE
END
```

A.5 CheMin HousekeepingN EDR (Product Type EHK)

```
PDS_VERSION_ID                = PDS3

/* FILE DATA ELEMENTS */

RECORD_TYPE                   = FIXED_LENGTH
RECORD_BYTES                  = 18528
FILE_RECORDS                  = 1

^CHMN_HSK_HEADER_TABLE        = ("CMA_385726689EHK20120010000AU04096M1.DAT",1)
^HOUSEKEEPING_TABLE  = ("CMA_385726689EHK20120010000AU04096M1.DAT",525<BYTES>)
^ERROR_CONTROL_TABLE = ("CMA_385726689EHK20120010000AU04096M1.DAT",18525<BYTES>)

/* IDENTIFICATION DATA ELEMENTS */

DATA_SET_ID                   = "MSL-M-CHEMIN-2-EDR-V1.0"
DATA_SET_NAME                 = "MSL MARS CHEMISTRY & MINERALOGY
                                 X-RAY INSTRUMENT 2 EDR V1.0"
COMMAND_SEQUENCE_NUMBER       = 0
INSTRUMENT_HOST_ID            = "MSL"
INSTRUMENT_HOST_NAME          = "MARS SCIENCE LABORATORY"
INSTRUMENT_ID                 = CHEMIN
INSTRUMENT_NAME               = "CHEMISTRY AND MINERALOGY"
INSTRUMENT_TYPE               = SPECTROMETER
MSL:LOCAL_MEAN_SOLAR_TIME         = "UNK"
LOCAL_TRUE_SOLAR_TIME         = "UNK"
MISSION_NAME                  = "MARS SCIENCE LABORATORY"
MISSION_PHASE_NAME            = "DEVELOPMENT"
OBSERVATION_ID                = "UNK"
PLANET_DAY_NUMBER             = 2012
PRODUCER_INSTITUTION_NAME     = "MULTIMISSION INSTRUMENT PROCESSING LAB,
                                   JET PROPULSION LAB"
PRODUCT_CREATION_TIME         = 2012-04-09T18:01:14.000
PRODUCT_ID                    = "CMA_385726689EHK20120010000AU04096M1"
PRODUCT_TYPE                  = CHEMIN_EHK
PRODUCT_VERSION_ID            = "V1.0 D-69260"
RELEASE_ID                    = "0001"
MSL:REQUEST_ID                = "0"
ROVER_MOTION_COUNTER          = (1,0,0,0,0,0,0,0,0,0)
ROVER_MOTION_COUNTER_NAME     = (SITE, DRIVE, POSE, ARM, CHIMRA,
                                DRILL, RSM, HGA, DRT, IC)
```

```
SEQUENCE_ID                      = "aut_04096"
SEQUENCE_VERSION_ID              = "0"
MSL:ACTIVE_FLIGHT_STRING_ID      = A
SPACECRAFT_CLOCK_CNT_PARTITION   = 1
SPACECRAFT_CLOCK_START_COUNT     = ""
SPACECRAFT_CLOCK_STOP_COUNT      = "UNK"
START_TIME                       = 2012-03-22T22:18:35.444
STOP_TIME                        = "UNK"
TARGET_NAME                      = MARS
TARGET_TYPE                      = PLANET

/* TELEMETRY DATA ELEMENTS */

APPLICATION_PROCESS_ID           = 159
APPLICATION_PROCESS_NAME         = "ChmnHousekeepingN"
MSL:AUTO_DELETE_FLAG             = "FALSE"
MSL:COMMUNICATION_SESSION_ID     = "0"
DOWNLOAD_PRIORITY                = 34
EARTH_RECEIVED_START_TIME        = 2012-03-22T22:26:21.028
EARTH_RECEIVED_STOP_TIME         = 2012-03-22T22:26:33.941
EXPECTED_PACKETS                 = 3
MSL:EXPECTED_TRANSMISSION_PATH   = "3851"
MSL:FLIGHT_SOFTWARE_MODE         = "5"
FLIGHT_SOFTWARE_VERSION_ID       = "127774343"
MSL:PRODUCT_COMPLETION_STATUS    = "COMPLETE_CHECKSUM_PASS"
MSL:PRODUCT_TAG                  = "2"
MSL:SEQUENCE_EXECUTION_COUNT     = 0
RECEIVED_PACKETS                 = 3
SPICE_FILE_NAME                  = "chronos.msl"
TELEMETRY_PROVIDER_ID            = "MPCS_MSL_DP"
MSL:TELEMETRY_SOURCE_CHECKSUM    = 35210
MSL:TELEMETRY_SOURCE_HOST_NAME   = "mslmpcs1"
TELEMETRY_SOURCE_NAME            = "ChmnHousekeepingN_0385726689-28289-1.dat"
MSL:TELEMETRY_SOURCE_SIZE        = 18528
MSL:TELEMETRY_SOURCE_TYPE        = "DATA PRODUCT"
MSL:TRANSMISSION_PATH            = "65535"
MSL:VIRTUAL_CHANNEL_ID           = "0"


/* HISTORY DATA ELEMENTS */

GROUP                            = MSLEDRGEN_HISTORY_PARMS
 SOFTWARE_NAME                   = MSLEDRGEN
 SOFTWARE_VERSION_ID             = "V1.0 04-01-2011"
 PROCESSING_HISTORY_TEXT         = "CODMAC LEVEL 1 TO LEVEL 2 CONVERSION
                                    VIA JPL/MIPL MSLEDRGEN"
END_GROUP                        = MSLEDRGEN_HISTORY_PARMS

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

GROUP                            = ROVER_COORDINATE_SYSTEM
 COORDINATE_SYSTEM_NAME          = "ROVER_NAV_FRAME"
 COORDINATE_SYSTEM_INDEX         = (1,0,0,0,0,0,0,0,0,0)
 COORDINATE_SYSTEM_INDEX_NAME    = (SITE, DRIVE, POSE, ARM, CHIMRA,
                                   DRILL, RSM, HGA, DRT, IC)
 ORIGIN_OFFSET_VECTOR            = (0,0,0)
```

```
 ORIGIN_ROTATION_QUATERNION      = (1,0,0,0)
 POSITIVE_AZIMUTH_DIRECTION      = CLOCKWISE
 POSITIVE_ELEVATION_DIRECTION    = UP
 REFERENCE_COORD_SYSTEM_NAME     = SITE_FRAME
 REFERENCE_COORD_SYSTEM_INDEX    = 1
END_GROUP                        = ROVER_COORDINATE_SYSTEM

/* ARTICULATION DEVICE STATE: ROBOTIC ARM */

GROUP                            = ARM_ARTICULATION_STATE
 ARTICULATION_DEVICE_ID          = ARM
 ARTICULATION_DEVICE_NAME        = "SAMPLE ARM"
 ARTICULATION_DEVICE_ANGLE       = (1.0e+30<rad>, 1.0e+30<rad>, 1.0e+30<rad>,
                                    1.0e+30<rad>, 1.0e+30<rad>)
 ARTICULATION_DEVICE_ANGLE_NAME  = ("JOINT 1 AZIMUTH-ENCODER",
                                    "JOINT 2 SHOULDER ELEVATION",
                                    "JOINT 3 ELBOW-ENCODER",
                                    "JOINT 4 WRIST-ENCODER",
                                    "JOINT 5 TURRET-ENCODER")
END_GROUP                        = ARM_ARTICULATION_STATE

/* ARTICULATION DEVICE STATE: REMOTE SENSING MAST */

GROUP                            = RSM_ARTICULATION_STATE
 ARTICULATION_DEVICE_ID          = RSM
 ARTICULATION_DEVICE_NAME        = "REMOTE SENSING MAST"
 ARTICULATION_DEVICE_ANGLE       = (1.0e+30<rad>, 1.0e+30<rad>)
 ARTICULATION_DEVICE_ANGLE_NAME  = (AZIMUTH, ELEVATION)
END_GROUP                        = RSM_ARTICULATION_STATE

/* OBSERVATION REQUEST */

GROUP                            = OBSERVATION_REQUEST_PARMS
 SOURCE_ID                       = "GROUND COMMANDED"
 INSTRUMENT_COORDINATE_NAME      = “N/A”
 INSTRUMENT_COORDINATE           = ‘N/A’
END_GROUP                        = OBSERVATION_REQUEST_PARMS

/* CHEMIN HOUSEKEEPING N OBJECTS */

OBJECT                           = CHMN_HSKN_HEADER_TABLE
   NAME                          = HOUSEKEEPING_N_HEADER
   INTERCHANGE_FORMAT            = BINARY
   ROWS                          = 1
   ROW_BYTES                     = 524
   COLUMNS                       = 5
   DESCRIPTION                   = "
    This table contains CHEMIN ancillary, science and housekeeping
    data as observed by the Mars Science Laboratory (MSL)
    Chemistry and Mineralogy Instrument.

    Detailed descriptions for the data are contained in the
    CHEMIN EDR SIS document.

    The complete column definitions are contained in an external file
    found in the LABEL directory of the archive volume.
    "
```

```
   ^STRUCTURE                    = "CHMN_EDR_HSK_N_HEADER.FMT"
END_OBJECT                       = CHMN_HSKN_HEADER_TABLE

OBJECT                           = HOUSEKEEPING_TABLE
   NAME                          = HOUSEKEEPING
   INTERCHANGE_FORMAT            = BINARY
   ROWS                          = 60
   ROW_BYTES                     = 300
   COLUMNS                       = 15
   DESCRIPTION                   = "
    This table contains CHEMIN housekeeping data
    as observed by the Mars Science Laboratory (MSL)
    Chemistry and Mineralogy Instrument.

    Detailed descriptions for the are contained in the
    CHEMIN EDR SIS document.

    The complete column definitions are contained in an external file
    found in the LABEL directory of the archive volume.
    "
   ^STRUCTURE                    = "CHMN_EDR_HOUSEKEEPING.FMT"
END_OBJECT                       = HOUSEKEEPING_TABLE

/* ERROR CONTROL VALUE OBJECT */

OBJECT                           = ERROR_CONTROL_TABLE
    NAME                         = ERROR_CONTROL
    INTERCHANGE_FORMAT           = BINARY
    ROWS                         = 1
    ROW_BYTES                    = 4
    COLUMNS                      = 1

      OBJECT                     = COLUMN
        NAME                     = ERROR_CONTROL_VALUE
        DATA_TYPE                = LSB_UNSIGNED_INTEGER
        START_BYTE               = 1
        BYTES                    = 4
        DESCRIPTION              = “Contains a CRC or Fletcher checksum value
                                   as indicated in the CHMN_HSKN_HEADER_TABLE
                                   control and status error control type field.”
      END_OBJECT                 = COLUMN
END_OBJECT                       = ERROR_CONTROL_TABLE
END
```

A.6 CheMin Transmit Raw EDR (Product Type ETR)

```
PDS_VERSION_ID                   = PDS3

/* FILE DATA ELEMENTS */

RECORD_TYPE                      = FIXED_LENGTH
RECORD_BYTES                     = 9083308
FILE_RECORDS                     = 1

^TRANSMIT_RAW_TABLE           = ("CMB_353898460ETR201100000001015808M1.DAT",1)
```

```
/* IDENTIFICATION DATA ELEMENTS */

DATA_SET_ID                      = "MSL-M-CHEMIN-2-EDR-V1.0"
DATA_SET_NAME                    = "MSL MARS CHEMISTRY & MINERALOGY
                                    X-RAY INSTRUMENT 2 EDR V1.0"
COMMAND_SEQUENCE_NUMBER          = 1719
INSTRUMENT_HOST_ID               = "MSL"
INSTRUMENT_HOST_NAME             = "MARS SCIENCE LABORATORY"
INSTRUMENT_ID                    = CHEMIN
INSTRUMENT_NAME                  = "CHEMISTRY AND MINERALOGY"
INSTRUMENT_TYPE                  = SPECTROMETER
MSL:LOCAL_MEAN_SOLAR_TIME          = "UNK"
LOCAL_TRUE_SOLAR_TIME            = "UNK"
MISSION_NAME                     = "MARS SCIENCE LABORATORY"
MISSION_PHASE_NAME               = "DEVELOPMENT"
OBSERVATION_ID                   = "UNK"
PLANET_DAY_NUMBER                = 2011
PRODUCER_INSTITUTION_NAME        = "MULTIMISSION INSTRUMENT PROCESSING LAB,
                                    JET PROPULSION LAB"
PRODUCT_CREATION_TIME            = 2012-04-09T18:01:19.000
PRODUCT_ID                       = "CMB_353898460ETR20110000000101580 8M1"
PRODUCT_TYPE                     = CHEMIN_ETR
PRODUCT_VERSION_ID               = "V1.0 D-69260"
RELEASE_ID                       = "0001"
MSL:REQUEST_ID                   = "0"
ROVER_MOTION_COUNTER             = (0,0,0,0,0,0,0,0,0,0)
ROVER_MOTION_COUNTER_NAME        = (SITE, DRIVE, POSE, ARM, CHIMRA,
                                   DRILL, RSM, HGA, DRT, IC)
SEQUENCE_ID                      = "1015808"
SEQUENCE_VERSION_ID              = "0"
MSL:ACTIVE_FLIGHT_STRING_ID      = B
SPACECRAFT_CLOCK_CNT_PARTITION   = 1
SPACECRAFT_CLOCK_START_COUNT     = ""
SPACECRAFT_CLOCK_STOP_COUNT      = "UNK"
START_TIME                       = 2011-03-20T13:06:33.816
STOP_TIME                        = "UNK"
TARGET_NAME                      = MARS
TARGET_TYPE                      = PLANET

/* TELEMETRY DATA ELEMENTS */

APPLICATION_PROCESS_ID           = 162
APPLICATION_PROCESS_NAME         = "ChmnTransmitRaw"
MSL:AUTO_DELETE_FLAG             = "FALSE"
MSL:COMMUNICATION_SESSION_ID     = "0"
DOWNLOAD_PRIORITY                = 34
EARTH_RECEIVED_START_TIME        = 2011-03-20T13:26:06.356
EARTH_RECEIVED_STOP_TIME         = 2011-03-20T13:26:50.570
EXPECTED_PACKETS                 = 897
MSL:EXPECTED_TRANSMISSION_PATH   = "3851"
MSL:FLIGHT_SOFTWARE_MODE         = "1"
FLIGHT_SOFTWARE_VERSION_ID       = "97208714"
MSL:PRODUCT_COMPLETION_STATUS    = "COMPLETE_CHECKSUM_PASS"
MSL:PRODUCT_TAG                  = "0"
MSL:SEQUENCE_EXECUTION_COUNT     = 0
RECEIVED_PACKETS                 = 897
SPICE_FILE_NAME                  = "chronos.msl"
```

```
TELEMETRY_PROVIDER_ID            = "MPCS_MSL_DP"
MSL:TELEMETRY_SOURCE_CHECKSUM    = 14450
MSL:TELEMETRY_SOURCE_HOST_NAME   = "mslatlompcs4"
TELEMETRY_SOURCE_NAME            = "ChmnTransmitRaw_0353898460_18481-1.dat"
MSL:TELEMETRY_SOURCE_SIZE        = 9083308
MSL:TELEMETRY_SOURCE_TYPE        = "DATA PRODUCT"
MSL:TRANSMISSION_PATH            = "65535"
MSL:VIRTUAL_CHANNEL_ID           = "32"


/* HISTORY DATA ELEMENTS */

GROUP                            = MSLEDRGEN_HISTORY_PARMS
 SOFTWARE_NAME                   = MSLEDRGEN
 SOFTWARE_VERSION_ID             = "V1.0 04-01-2011"
 PROCESSING_HISTORY_TEXT         = "CODMAC LEVEL 1 TO LEVEL 2 CONVERSION
                                    VIA JPL/MIPL MSLEDRGEN"
END_GROUP                        = MSLEDRGEN_HISTORY_PARMS

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

GROUP                            = ROVER_COORDINATE_SYSTEM
 COORDINATE_SYSTEM_NAME          = "ROVER_NAV_FRAME"
 COORDINATE_SYSTEM_INDEX         = (0,0,0,0,0,0,0,0,0,0)
 COORDINATE_SYSTEM_INDEX_NAME    = (SITE, DRIVE, POSE, ARM, CHIMRA,
                                   DRILL, RSM, HGA, DRT, IC)
 ORIGIN_OFFSET_VECTOR            = (0,0,0)
 ORIGIN_ROTATION_QUATERNION      = (0,0,0,0)
 POSITIVE_AZIMUTH_DIRECTION      = CLOCKWISE
 POSITIVE_ELEVATION_DIRECTION    = UP
 REFERENCE_COORD_SYSTEM_NAME     = SITE_FRAME
 REFERENCE_COORD_SYSTEM_INDEX    = 0
END_GROUP                        = ROVER_COORDINATE_SYSTEM

/* ARTICULATION DEVICE STATE: ROBOTIC ARM */

GROUP                            = ARM_ARTICULATION_STATE
 ARTICULATION_DEVICE_ID          = ARM
 ARTICULATION_DEVICE_NAME        = "SAMPLE ARM"
 ARTICULATION_DEVICE_ANGLE       = (0<rad>, 0<rad>, 0<rad>,
                                    0<rad>, 0<rad>)
 ARTICULATION_DEVICE_ANGLE_NAME  = ("JOINT 1 AZIMUTH-ENCODER",
                                   "JOINT 2 SHOULDER ELEVATION",
                                   "JOINT 3 ELBOW-ENCODER",
                                   "JOINT 4 WRIST-ENCODER",
                                   "JOINT 5 TURRET-ENCODER")
END_GROUP                        = ARM_ARTICULATION_STATE

/* ARTICULATION DEVICE STATE: REMOTE SENSING MAST */

GROUP                            = RSM_ARTICULATION_STATE
 ARTICULATION_DEVICE_ID          = RSM
 ARTICULATION_DEVICE_NAME        = "REMOTE SENSING MAST"
 ARTICULATION_DEVICE_ANGLE       = (0<rad>, 0<rad>)
 ARTICULATION_DEVICE_ANGLE_NAME  = (AZIMUTH, ELEVATION)
END_GROUP                        = RSM_ARTICULATION_STATE
```

```
/* OBSERVATION REQUEST */

GROUP                           = OBSERVATION_REQUEST_PARMS
 SOURCE_ID                      = "GROUND COMMANDED"
 INSTRUMENT_COORDINATE_NAME     = “N/A”
 INSTRUMENT_COORDINATE          = ‘N/A’
END_GROUP                       = OBSERVATION_REQUEST_PARMS

/* CHEMIN TRANSMIT RAW OBJECT */

OBJECT                          = TRANSMIT_RAW_TABLE
   NAME                         = RAW_SCIENCE
   INTERCHANGE_FORMAT           = BINARY
   ROWS                         = 13
   ROW_BYTES                    = 698716
   COLUMNS                      = 20
   DESCRIPTION                  = "
    This table contains CHEMIN instrument data
    as observed by the Mars Science Laboratory (MSL)
    Chemistry and Mineralogy Instrument.

    Detailed descriptions for the data are contained in the
    CHEMIN EDR SIS document.

    The complete column definitions are contained in an external file
    found in the LABEL directory of the archive volume.
    "
   ^STRUCTURE                   = "CHMN_EDR_TRANSMIT_RAW.FMT"
END_OBJECT                      = TRANSMIT_RAW_TABLE
END
```

A.7 CHMN_EDR_HOUSKEEPING.FMT

```
/* HOUSEKEEPING HEADER TABLE OBJECT */

OBJECT              = COLUMN
   NAME             = PARAMETERS
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 1
   BYTES            = 128
   ITEMS            = 64
   ITEM_BYTES       = 2
   DESCRIPTION      = "CheMin paramters.
                      [0]  - FPGS Version at the time of acquisition.
                      [1]  - Configuration bits
                      [2]  - XRS Thermister 1 Heater set point in DN.
                             Valid: 0-4095 Default: 2048
                      [3]  - XRS Thermister 2 Heater set point in DN.
                             Valid: 0-4095 Default: 2048
                      [4]  - CCD PRT 1 set point for power on of
                             decontamination heater in DN.  Default: 0
                      [5]  - CCD PRT 2 set point for power on of
                             decontamination heater in DN.  Default: 0
                      [6]  - Temperature to be reached for cryocooler power
                             on for CCD PRT 1 in DN.
```

```
       Valid: 0-4095 Default: 2048
[7]  - Temperature to be reached for cryocooler power
       on for CCD PRT 2 in DN.
       Valid: 0-4095 Default: 2048
[8]  - Contains the final value that will be applied
       to the KV_PROG input of the XRS, after ramping
       up. Valid: 0-4095 Default: 0
[9]  - Contains the final value that will be applied
       to the GRID_PROG input of the XRS, after ramping
       up. Valid: 0-4095 Default: 0
[10] - Contains the final value that will be applied
       to the UA_PROG input of the XRS, after ramping
       up. Valid: 0-4095 Default: 0
[11] - XRS (X-Ray Ramp Speed) period in 4ms units.
       Valid: 4-255 Default: 255
[12] - Funnel Piezo amplitude in bits/DN.
       Valid: 0-15 Default: 0
[13] - Amplitude Cell value during chaos mode in DN.
       Valid: 0-4095 Default: 0
[14] - Nominal Amplitude cell value during analysis.
       Valid: 0-4095 Default: 0
[15] - High Amplitude cell value during analysis.
       Valid: 0-4095 Default: 0
[16] - Period for nominal cell value or length in ms
       (in time) of sweep, 1 ms to 66 sec.
       Valid: 0-65535 Default: 950
[17] - Period for high cell value or length in ms
       (in time) of sweep, 1 ms to 60 sec.
       Valid: 0-65535 Default: 50
[18] - SWM (Sample Wheel Motor) step period in ms .
       Valid: 32-255 Default: 33
[19] - CM (Clamp Motor) step period in ms.
       Valid: 8-255 Default: 10
[20] - CM number of steps when clamping.
       Valid: 0-1023 Default: 100
[21] - CM number of steps when unclamping.
       Valid: -1024-0 Default: -100  U16 or I16???
[22] - Temperature limit (in DN) for the HOP
       (High Output Paraffin) actuator that defeats
       the wheel clamp mechanism.
       Valid: 0-4095 Default: 0
[23] - Time in seconds over which the HOP
       (High Output Paraffin) can be energized.
       Valid: 0-4095 Default: 0
[24] - Configuration bits
[25] - Left and right signal chain offset in DN.
       Valid: 0-4095 Default: 0
[26] - rows of CCD data, 1-602 are used, everything
       else is dark.
       Valid: 0-1023 Default: 582
[27] - rows to zap, 1-602 are used, everything else
       is dark.
       Valid: 0-1023 Default: 610
[28] - CCD integation time in seconds,
       Valid: 0-255 Default: 30
[29] - CCD Sync pulse time in clocks.
       Valid: 0-255 Default: 0
```

```
[30-31] - Unused
[32] - Temperature to wait (in DN) until the CCD is
       cooled below (temp <= param).  X-Ray source
       won't produce X-Rays until CCD below this
       temperature. Valid: 0-4095 Default: 0
[33] - Temperature to wait (in DN) until the CCD is
       cooled below (temp <= param).  X-Ray source
       won't produce X-Rays until CCD below this
       temperature. Valid: 0-4095 Default: 0
[34] - Every nth frame is a Chaos Frame.
       Valid: 0-4095 Default: 60
[35] - Frames per major frame.
       Valid: 0-2728 Default: 480
[36] - Low raw value for internal thresholding,
       Valid: 0-4095 Default: 0 (no thresholding)
[37] - High raw value for internal thresholding,
       Valid: 0-4095 Default: 4095 (no thresholding)
[38] - Transmit n HK (housekeeping) frames,
       0=return all(up to 3,333 frames within 10 sec)
       Valid: 0-3333 Default: 1 (most recent HK)
[39] - unused
[40] - memory flash page to  read or write memory.
       Valid: 0-63 Default: 0
[41] - flash memory block to  read or write .
       Valid: 0-4095 Default: 0
[42] - The temperature fault protection limit for the
       HKT00 PRT, located at the end of the thermal
       strap connected to the XRS,
       Valid: 0-4095 Default: 2539
[43] - The temperature fault protection limit for the
       HKT01 PRT, placed adjacent to OP AMP on SW
       board. Valid: 0-4095 Default: 2681
[44] - The temperature fault protection limit for the
       HKT02 PRT, located on SW board near external
       edge close to wheel.
       Valid: 0-4095 Default: 2681
[45] - The temperature fault protection limit for the
       HKT03 PRT, located on the SW motor housing.
       Valid: 0-4095 Default: 2895
[46] - The temperature fault protection limit for the
       HKT04 PRT, located on the Clamp motor housing.
       Valid: 0-4095 Default: 2895
[47] - The temperature fault protection limit for the
       HKT05 PRT, located on the HOP housing, heater
       end. Valid: 0-4095 Default: 2824
[48] - The temperature fault protection limit for the
       HKT06 PRT, located on the Cooler motor housing.
       Valid: 0-4095 Default: 2624
[49] - The temperature fault protection limit for the
       HKT07 PRT, located on the funnel driver.
       Valid: 0-4095 Default: 2824
[50] - The temperature fault protection limit for the
       HKT08 PRT, PRT #1 located inside the HVPS.
       Valid: 0-4095 Default: 2660
[51] - The temperature fault protection limit for the
       HKT09 PRT, PRT #2 located inside the HVPS.
       Valid: 0-4095 Default: 25936
```

```
                      [52] - The temperature fault protection limit for the
                             HKT10 PRT, PRT #1 located outside the XRS
                             adjacent to heaters.
                             Valid: 0-4095 Default: 2610
                      [53] - The temperature fault protection limit for the
                             HKT11 PRT, PRT #2 located outside the XRS
                             adjacent to heaters.
                             Valid: 0-4095 Default: 2610
                      [54] - The temperature fault protection limit for the
                             HKT12 PRT, PRT #1 located behind CCd on support
                             structure.
                             Valid: 0-4095 Default: 2713
                      [55] - The temperature fault protection limit for the
                             HKT13 PRT, PRT #2 located behind CCd on support
                             structure.
                             Valid: 0-4095 Default: 2713
                      [56] - Safe if force > value when moving wheel.
                             Valid: 0-4095 Default: 4095
                      [57] - 12 resolver bits.  0=disable fault, 1=enable
                             Valid: 0-65535 Default: 65520
                      [58] - Safe after number of specified seconds.
                             Valid: 0-4095 Default: 3600 (1 hr) 0: disable
                      [59] - Safe if XRS is on and v< this value.
                             Valid: 0-4095 Default: 1285
                      [60] - Safe if XRS is on and temp < this value.
                             Valid: 0-4095 Default: 2237
                      [61] - Safe if XRS is on and temp < this value.
                             Valid: 0-4095 Default: 2237
                      [62] - CCD PRT #1, fault protection limit.  Safe
                             if temp > this value
                             Valid: 0-4095 Default: 2276
                      [63] - CCD PRT #2, fault protection limit.  Safe
                             if temp > this value
                             Valid: 0-4095 Default: 2276
                      "
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = VOLTAGES
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 129
   BYTES            = 32
   ITEMS            = 16
   ITEM_BYTES       = 2
   DESCRIPTION      = "CheMin voltages in raw counts.
                      Refer to the SIS for conversion formulas."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = TEMPERATURES
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 161
   BYTES            = 32
   ITEMS            = 16
   ITEM_BYTES       = 2
   DESCRIPTION      = "CheMin 14 temperatures plus 2 calibration points in
                      raw.  Refer to the SIS for conversion
```

```
                    formulas."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = TIME
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 193
   BYTES            = 4
   DESCRIPTION      = "CheMin instrument SCLK time in seconds."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = INSTRUMENT_STATUS
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 197
   BYTES            = 4
   DESCRIPTION      = "CheMin low bits mimic status flags and condition
                      codes.  Refer to the SIS for status codes."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = READ_POINTER
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 201
   BYTES            = 2
   DESCRIPTION      = "CheMin read address for transmit instrument commands."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = WRITE_POINTER
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 203
   BYTES            = 2
   DESCRIPTION      = "CheMin write address for ANALYZE."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = LAST_COMMAND
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 205
   BYTES            = 4
   DESCRIPTION      = "CheMin command received, header only."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = SAMPLE_WHEEL_POSITION
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 209
   BYTES            = 2
   DESCRIPTION      = "Last sample wheel position read from resolver during
                      last MOVE_WHEEL command."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = SAMPLE_WHEEL_STEPS
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 211
```

```
   BYTES            = 2
   DESCRIPTION      = "Number of sample wheel steps actually taken during the
                      last MOVE_WHEEL command."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = OKAY_COMMAND_COUNT
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 213
   BYTES            = 2
   DESCRIPTION      = "Number of valid commands received with command
                      condition code=1 since instrument power on."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = RETRY_COMMAND_COUNT
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 215
   BYTES            = 2
   DESCRIPTION      = "Number of valid commands received with command
                      Condition code=2 or 18 since instrument power on."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = BAD_COMMAND_COUNT
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 217
   BYTES            = 2
   DESCRIPTION      = "Number of rejected commands with condition
                      code <> 1 since instrument power on."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = RAW_FRAME_NUMBER
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 219
   BYTES            = 2
   DESCRIPTION      = "CheMin raw frame number within an analysis."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = SPARES
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 221
   BYTES            = 80
   ITEMS            = 40
   ITEM_BYTES       = 2
   DESCRIPTION      = "CheMin spare fields."
END_OBJECT          = COLUMN
```

A.8 CHMN_EDR_CCD_HEADER_FRAME.FMT

```
OBJECT              = COLUMN
   NAME             = SCIENCE_FRAME_LENGTH
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 1
```

```
   BYTES            = 4
   DESCRIPTION      = "CHEMIN instrument Science Frame
                      data length in bytes."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = SCI_FRM_CONTROL_AND_STATUS
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 5
   BYTES            = 4

    OBJECT          = BIT_COLUMN
      NAME          = OPCODE
      BIT_DATA_TYPE = UNSIGNED_INTEGER
      START_BIT     = 1
      BITS          = 8
      DESCRIPTION   = "Opcode."
    END_OBJECT      = BIT_COLUMN

    OBJECT          = BIT_COLUMN
      NAME          = ERROR_CONTROL_TYPE
      BIT_DATA_TYPE = UNSIGNED_INTEGER
      START_BIT     = 9
      BITS          = 2
      DESCRIPTION   = "The type of error control algorithm applied by
                      the Instrument Transfer Frame. Valid:
                      0=reserved.
                      1=The CRC error control algorithm was applied
                      and placed in the error control field at the.
                      end of the frame.
                      2=The fletcher checksum error control algorithm
                      was applied and placed in the error control field
                      at the end of the frame.
                      3=No error control algorithm was applied and no
                      error control field is included."
    END_OBJECT      = BIT_COLUMN

    OBJECT          = BIT_COLUMN
      NAME          = DATA_PRESENT_FLAG
      BIT_DATA_TYPE = UNSIGNED_INTEGER
      START_BIT     = 11
      BITS          = 1
      DESCRIPTION   = "Indicate the presence or absence of both the
                      Header Field Data Length and the Instrument
                      Transfer Frame Data Field. A value of '0'
                      indicates the Header Field Data Length and the
                      Instrument Transfer Frame Data Field are not
                      present; a value of '1' indicates the Header
                      Field Data Length and Instrument Transfer Frame
                      Data Field are present."
    END_OBJECT      = BIT_COLUMN

    OBJECT          = BIT_COLUMN
      NAME          = COMMAND_REPLY_FLAG_TYPE
      BIT_DATA_TYPE = UNSIGNED_INTEGER
      START_BIT     = 12
      BITS          = 1
```

```
    DESCRIPTION   = "Indicates the type of data returned. Valid:
                    0=Science Data Frame
                    1=Command reply Frame"
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = ERROR_REPORTED
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 13
    BITS          = 1
    DESCRIPTION   = "CheMin error reported in housekeeping
                    data. Valid: 0=False, 1=True"
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = UNUSED
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 14
    BITS          = 1
    DESCRIPTION   = "Reserved."
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = SCIENCE_DATA_READY_FLAG
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 15
    BITS          = 1
    DESCRIPTION   = "Indicates if science data is available.
                    Valid: 0=False, 1=True"
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = SAFE_MODE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 16
    BITS          = 1
    DESCRIPTION   = "Indicates if the instrument is in safe mode,
                    implies an internal fault has been detected.
                    Valid: 0=see the ANALYSIS_MODE flag, 1=SAFE mode"
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = XMP_BOARD_MODE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 17
    BITS          = 1
    DESCRIPTION   = "Indicates the XMP board is powered.
                    0=Off, 1=On"
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = XRAY_SOURCE_HEATER_MODE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 18
    BITS          = 1
    DESCRIPTION   = "Indicates the X-Ray Source heater is operating. Valid:
                    0 = Off, 1 = On"
```

```
    END_OBJECT      = BIT_COLUMN

    OBJECT          = BIT_COLUMN
      NAME          = DECON_HEATER_MODE
      BIT_DATA_TYPE = UNSIGNED_INTEGER
      START_BIT     = 19
      BITS          = 1
      DESCRIPTION   = "Indicates the decontamination heater is operating.
                      Valid: 0=Off, 1=On"
    END_OBJECT      = BIT_COLUMN

    OBJECT          = BIT_COLUMN
      NAME          = FUNNEL_PIEZO_MODE
      BIT_DATA_TYPE = UNSIGNED_INTEGER
      START_BIT     = 20
      BITS          = 1
      DESCRIPTION   = "Identifies whether the Funnel Piezo is vibrating.
                      Valid: 0=False, 1=True."
    END_OBJECT      = BIT_COLUMN

    OBJECT          = BIT_COLUMN
      NAME          = SW_PIEZO_CTRL_MODE
      BIT_DATA_TYPE = UNSIGNED_INTEGER
      START_BIT     = 21
      BITS          = 2
      DESCRIPTION   = "Indicates if the SW_PIEZO_CTRL4 (bit 21) and the
                      SW_PIEZO_CTRL5 (bit 22) have been toggled via
                      control_power or automomously through analysis.
                      Valid:
                      0=Sample Wheel Piezo is off
                      1=Unknown
                      2=Sample Wheel Piezo is in normal mode.
                      3=Sample Wheel Piezo is in Chaos mode."
    END_OBJECT      = BIT_COLUMN

    OBJECT          = BIT_COLUMN
      NAME          = CRYO_COOLER_TEMP_FLAG
      BIT_DATA_TYPE = UNSIGNED_INTEGER
      START_BIT     = 23
      BITS          = 1
      DESCRIPTION   = "Indicates if the Cryo Cooler is maintaining
                      temperature. Valid: 0=False, 1=True."
    END_OBJECT      = BIT_COLUMN

    OBJECT          = BIT_COLUMN
      NAME          = ANALYSIS_MODE
      BIT_DATA_TYPE = UNSIGNED_INTEGER
      START_BIT     = 24
      BITS          = 1
      DESCRIPTION   = "Indicates if CheMin is performaing science analysis.
                      Valid:
                      0=SAFE if SAFE_MODE is set else IDLE, 1=True."
    END_OBJECT      = BIT_COLUMN

    OBJECT          = BIT_COLUMN
      NAME          = XRAY_SOURCE_ENABLE_ASSERT
      BIT_DATA_TYPE = UNSIGNED_INTEGER
```

```
      START_BIT     = 25
      BITS          = 1
      DESCRIPTION   = "Indicates if an X-Ray source ramp-up has been
                      initiated by either set_param or autonomously via
                      analysis. Valid: 0=False, 1=True."
    END_OBJECT      = BIT_COLUMN

    OBJECT          = BIT_COLUMN
      NAME          = XRAY_SOURCE_POWER_MODE
      BIT_DATA_TYPE = UNSIGNED_INTEGER
      START_BIT     = 26
      BITS          = 1
      DESCRIPTION   = "Indicates if an XRS is operating.
                      Valid: 0=False, 1=True."
    END_OBJECT      = BIT_COLUMN

    OBJECT          = BIT_COLUMN
      NAME          = CRYO_COOLER_COOLING_MODE
      BIT_DATA_TYPE = UNSIGNED_INTEGER
      START_BIT     = 27
      BITS          = 1
      DESCRIPTION   = "Indicates if the Cryocooler is cooling.
                      Valid: 0=False, 1=True."
    END_OBJECT      = BIT_COLUMN

    OBJECT          = BIT_COLUMN
      NAME          = COMMAND_CONDITION_CODE
      BIT_DATA_TYPE = UNSIGNED_INTEGER
      START_BIT     = 28
      BITS          = 5
      DESCRIPTION   = "Frame command condition code.  Valid: 0=reserved;
                       1=nominal execution; 2=Indicates a framing error
                       in the received command.  CheMin received a command
                       with a length that is not an even multiple of 32 bits.
                       The RCE should retry the instrument command.
                       3-5=unused; 6=Op code not defined for this
                       instrument; 7-9=Unused.
                       10=CheMin received a command frame with a condition
                       code other than 1; 11=Unused.
                       12=checksum or CRC failed;
                       13=instrument in the wrong state or mode to
                       process this command. 14=Invalid, inconsistent or
                       unexpected data for this opcode; physical length is
                       unexpected for the received opcode. "
    END_OBJECT      = BIT_COLUMN
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = SCIENCE_FRAME_DATA_LEN
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 9
   BYTES            = 4
   DESCRIPTION      = "Science frame data length in bytes."
END_OBJECT          = COLUMN

OBJECT              = CONTAINER
   NAME             = HOUSEKEEPING
```

```
   ^STRUCTURE       = "CHMN_EDR_HOUSEKEEPING.FMT"
   START_BYTE       = 13
   BYTES            = 300
   REPETITIONS      = 1
   DESCRIPTION      = "This container represents the format of the
                      housekeeping structure."
END_OBJECT          = CONTAINER
```

A.9 CHMN_EDR_HSK_N_HEADER.FMT

```
/* CHEMIN SCIENCE AND HOUSEKEEPING HEADER TABLE OBJECT */

OBJECT              = COLUMN
   NAME             = TWO_D_CORRELATION_FILE
   DATA_TYPE        = CHARACTER
   START_BYTE       = 1
   BYTES            = 255
   DESCRIPTION      = "CHEMIN two dimensional correlation
                      filename."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = HOT_PIXEL_FILE
   DATA_TYPE        = CHARACTER
   START_BYTE       = 256
   BYTES            = 257
   DESCRIPTION      = "CHEMIN hot pixel filename."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = SCIENCE_FRAME_LENGTH
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 513
   BYTES            = 4
   DESCRIPTION      = "CHEMIN instrument Science Frame
                      data length in bytes."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = SCI_FRM_CONTROL_AND_STATUS
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 517
   BYTES            = 4

    OBJECT          = BIT_COLUMN
      NAME          = OPCODE
      BIT_DATA_TYPE = UNSIGNED_INTEGER
      START_BIT     = 1
      BITS          = 8
      DESCRIPTION   = "Opcode."
    END_OBJECT      = BIT_COLUMN

    OBJECT          = BIT_COLUMN
      NAME          = ERROR_CONTROL_TYPE
      BIT_DATA_TYPE = UNSIGNED_INTEGER
      START_BIT     = 9
```

```
    BITS          = 2
    DESCRIPTION   = "The type of error control algorithm applied by
                    the Instrument Transfer Frame. Valid:
                    0=reserved.
                    1=The CRC error control algorithm was applied
                    and placed in the error control field at the.
                    end of the frame.
                    2=The fletcher checksum error control algorithm
                    was applied and placed in the error control field
                    at the end of the frame.
                    3=No error control algorithm was applied and no
                    error control field is included."
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = DATA_PRESENT_FLAG
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 11
    BITS          = 1
    DESCRIPTION   = "Indicate the presence or absence of both the
                    Header Field Data Length and the Instrument
                    Transfer Frame Data Field. A value of '0'
                    indicates the Header Field Data Length and the
                    Instrument Transfer Frame Data Field are not
                    present; a value of '1' indicates the Header
                    Field Data Length and Instrument Transfer Frame
                    Data Field are present."
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = COMMAND_REPLY_FLAG_TYPE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 12
    BITS          = 1
    DESCRIPTION   = "Indicates the type of data returned. Valid:
                    0=Science Data Frame
                    1=Command reply Frame"
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = ERROR_REPORTED
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 13
    BITS          = 1
    DESCRIPTION   = "CheMin error reported in housekeeping
                    data. Valid: 0=False, 1=True"
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = UNUSED
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 14
    BITS          = 1
    DESCRIPTION   = "Reserved."
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
```

```
    NAME          = SCIENCE_DATA_READY_FLAG
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 15
    BITS          = 1
    DESCRIPTION   = "Indicates if science data is available.
                    Valid: 0=False, 1=True"
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = SAFE_MODE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 16
    BITS          = 1
    DESCRIPTION   = "Indicates if the instrument is in safe mode,
                    implies an internal fault has been detected.
                    Valid: 0=see the ANALYSIS_MODE flag, 1=SAFE mode"
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = XMP_BOARD_MODE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 17
    BITS          = 1
    DESCRIPTION   = "Indicates the XMP board is powered.
                    0=Off, 1=On"
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = XRAY_SOURCE_HEATER_MODE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 18
    BITS          = 1
    DESCRIPTION   = "Indicates the X-Ray Source heater is operating. Valid:
                    0 = Off, 1 = On"
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = DECON_HEATER_MODE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 19
    BITS          = 1
    DESCRIPTION   = "Indicates the decontamination heater is operating.
                    Valid: 0=Off, 1=On"
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = FUNNEL_PIEZO_MODE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 20
    BITS          = 1
    DESCRIPTION   = "Identifies whether the Funnel Piezo is vibrating.
                    Valid: 0=False, 1=True."
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = SW_PIEZO_CTRL_MODE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
```

```
    START_BIT     = 21
    BITS          = 2
    DESCRIPTION   = "Indicates if the SW_PIEZO_CTRL4 (bit 21) and the
                    SW_PIEZO_CTRL5 (bit 22) have been toggled via
                    control_power or automomously through analysis.
                    Valid:
                    0=Sample Wheel Piezo is off
                    1=Unknown
                    2=Sample Wheel Piezo is in normal mode.
                    3=Sample Wheel Piezo is in Chaos mode."
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = CRYO_COOLER_TEMP_FLAG
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 23
    BITS          = 1
    DESCRIPTION   = "Indicates if the Cryo Cooler is maintaining
                    temperature. Valid: 0=False, 1=True."
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = ANALYSIS_MODE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 24
    BITS          = 1
    DESCRIPTION   = "Indicates if CheMin is performaing science analysis.
                    Valid:
                    0=SAFE if SAFE_MODE is set else IDLE, 1=True."
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = XRAY_SOURCE_ENABLE_ASSERT
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 25
    BITS          = 1
    DESCRIPTION   = "Indicates if an X-Ray source ramp-up has been
                    initiated by either set_param or autonomously via
                    analysis. Valid: 0=False, 1=True."
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = XRAY_SOURCE_POWER_MODE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 26
    BITS          = 1
    DESCRIPTION   = "Indicates if an XRS is operating.
                    Valid: 0=False, 1=True."
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = CRYO_COOLER_COOLING_MODE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 27
    BITS          = 1
    DESCRIPTION   = "Indicates if the Cryocooler is cooling.
                    Valid: 0=False, 1=True."
```

```
    END_OBJECT      = BIT_COLUMN

    OBJECT          = BIT_COLUMN
      NAME          = COMMAND_CONDITION_CODE
      BIT_DATA_TYPE = UNSIGNED_INTEGER
      START_BIT     = 28
      BITS          = 5
      DESCRIPTION   = "Frame command condition code.  Valid: 0=reserved;
                       1=nominal execution; 2=Indicates a framing error
                       in the received command.  CheMin received a command
                       with a length that is not an even multiple of 32 bits.
                       The RCE should retry the instrument command.
                       3-5=unused; 6=Op code not defined for this
                       instrument; 7-9=Unused.
                       10=CheMin received a command frame with a condition
                       code other than 1; 11=Unused.
                       12=checksum or CRC failed;
                       13=instrument in the wrong state or mode to
                       process this command. 14=Invalid, inconsistent or
                       unexpected data for this opcode; physical length is
                       unexpected for the received opcode. "
    END_OBJECT      = BIT_COLUMN
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = SCIENCE_FRAME_DATA_LEN
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 521
   BYTES            = 4
   DESCRIPTION      = "Science frame data length in bytes."
END_OBJECT          = COLUMN
```

A.10 CHMN_EDR_TRANSMIT_RAW.FMT

```
/* CHEMIN SCIENCE AND HOUSEKEEPING HEADER TABLE OBJECT */

OBJECT              = COLUMN
   NAME             = SCIENCE_FRAME_LENGTH
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 1
   BYTES            = 4
   DESCRIPTION      = "CHEMIN instrument Science Frame
                      data length in bytes."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = SCI_FRM_CONTROL_AND_STATUS
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 5
   BYTES            = 4

    OBJECT          = BIT_COLUMN
      NAME          = OPCODE
      BIT_DATA_TYPE = UNSIGNED_INTEGER
      START_BIT     = 1
```

```
    BITS          = 8
    DESCRIPTION   = "Opcode."
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = ERROR_CONTROL_TYPE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 9
    BITS          = 2
    DESCRIPTION   = "The type of error control algorithm applied by
                    the Instrument Transfer Frame. Valid:
                    0=reserved.
                    1=The CRC error control algorithm was applied
                    and placed in the error control field at the.
                    end of the frame.
                    2=The fletcher checksum error control algorithm
                    was applied and placed in the error control field
                    at the end of the frame.
                    3=No error control algorithm was applied and no
                    error control field is included."
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = DATA_PRESENT_FLAG
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 11
    BITS          = 1
    DESCRIPTION   = "Indicate the presence or absence of both the
                    Header Field Data Length and the Instrument
                    Transfer Frame Data Field. A value of '0'
                    indicates the Header Field Data Length and the
                    Instrument Transfer Frame Data Field are not
                    present; a value of '1' indicates the Header
                    Field Data Length and Instrument Transfer Frame
                    Data Field are present."
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = COMMAND_REPLY_FLAG_TYPE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 12
    BITS          = 1
    DESCRIPTION   = "Indicates the type of data returned. Valid:
                    0=Science Data Frame
                    1=Command reply Frame"
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = ERROR_REPORTED
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 13
    BITS          = 1
    DESCRIPTION   = "CheMin error reported in housekeeping
                    data. Valid: 0=False, 1=True"
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
```

```
    NAME          = UNUSED
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 14
    BITS          = 1
    DESCRIPTION   = "Reserved."
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = SCIENCE_DATA_READY_FLAG
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 15
    BITS          = 1
    DESCRIPTION   = "Indicates if science data is available.
                    Valid: 0=False, 1=True"
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = SAFE_MODE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 16
    BITS          = 1
    DESCRIPTION   = "Indicates if the instrument is in safe mode,
                    implies an internal fault has been detected.
                    Valid: 0=see the ANALYSIS_MODE flag, 1=SAFE mode"
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = XMP_BOARD_MODE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 17
    BITS          = 1
    DESCRIPTION   = "Indicates the XMP board is powered.
                    0=Off, 1=On"
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = XRAY_SOURCE_HEATER_MODE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 18
    BITS          = 1
    DESCRIPTION   = "Indicates the X-Ray Source heater is operating. Valid:
                    0 = Off, 1 = On"
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = DECON_HEATER_MODE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 19
    BITS          = 1
    DESCRIPTION   = "Indicates the decontamination heater is operating.
                    Valid: 0=Off, 1=On"
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = FUNNEL_PIEZO_MODE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 20
```

```
    BITS          = 1
    DESCRIPTION   = "Identifies whether the Funnel Piezo is vibrating.
                    Valid: 0=False, 1=True."
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = SW_PIEZO_CTRL_MODE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 21
    BITS          = 2
    DESCRIPTION   = "Indicates if the SW_PIEZO_CTRL4 (bit 21) and the
                    SW_PIEZO_CTRL5 (bit 22) have been toggled via
                    control_power or automomously through analysis.
                    Valid:
                    0=Sample Wheel Piezo is off
                    1=Unknown
                    2=Sample Wheel Piezo is in normal mode.
                    3=Sample Wheel Piezo is in Chaos mode."
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = CRYO_COOLER_TEMP_FLAG
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 23
    BITS          = 1
    DESCRIPTION   = "Indicates if the Cryo Cooler is maintaining
                    temperature. Valid: 0=False, 1=True."
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = ANALYSIS_MODE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 24
    BITS          = 1
    DESCRIPTION   = "Indicates if CheMin is performaing science analysis.
                    Valid:
                    0=SAFE if SAFE_MODE is set else IDLE, 1=True."
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = XRAY_SOURCE_ENABLE_ASSERT
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 25
    BITS          = 1
    DESCRIPTION   = "Indicates if an X-Ray source ramp-up has been
                    initiated by either set_param or autonomously via
                    analysis. Valid: 0=False, 1=True."
  END_OBJECT      = BIT_COLUMN

  OBJECT          = BIT_COLUMN
    NAME          = XRAY_SOURCE_POWER_MODE
    BIT_DATA_TYPE = UNSIGNED_INTEGER
    START_BIT     = 26
    BITS          = 1
    DESCRIPTION   = "Indicates if an XRS is operating.
                    Valid: 0=False, 1=True."
  END_OBJECT      = BIT_COLUMN
```

```
    OBJECT          = BIT_COLUMN
      NAME          = CRYO_COOLER_COOLING_MODE
      BIT_DATA_TYPE = UNSIGNED_INTEGER
      START_BIT     = 27
      BITS          = 1
      DESCRIPTION   = "Indicates if the Cryocooler is cooling.
                      Valid: 0=False, 1=True."
    END_OBJECT      = BIT_COLUMN

    OBJECT          = BIT_COLUMN
      NAME          = COMMAND_CONDITION_CODE
      BIT_DATA_TYPE = UNSIGNED_INTEGER
      START_BIT     = 28
      BITS          = 5
      DESCRIPTION   = "Frame command condition code.  Valid: 0=reserved;
                       1=nominal execution; 2=Indicates a framing error
                       in the received command.  CheMin received a command
                       with a length that is not an even multiple of 32 bits.
                       The RCE should retry the instrument command.
                       3-5=unused; 6=Op code not defined for this
                       instrument; 7-9=Unused.
                       10=CheMin received a command frame with a condition
                       code other than 1; 11=Unused.
                       12=checksum or CRC failed;
                       13=instrument in the wrong state or mode to
                       process this command. 14=Invalid, inconsistent or
                       unexpected data for this opcode; physical length is
                       unexpected for the received opcode. "
    END_OBJECT      = BIT_COLUMN
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = SCIENCE_FRAME_DATA_LEN
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 9
   BYTES            = 4
   DESCRIPTION      = "Science frame data length in bytes."
END_OBJECT          = COLUMN

OBJECT              = CONTAINER
   NAME             = HOUSEKEEPING
   ^STRUCTURE       = "CHMN_EDR_HOUSEKEEPING.FMT"
   START_BYTE       = 13
   BYTES            = 300
   REPETITIONS      = 1
   DESCRIPTION      = "This container represents the format of the
                      housekeeping structure."
END_OBJECT          = CONTAINER

OBJECT              = COLUMN
   NAME             = SCIENCE_DATA
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 313
   BYTES            = 698400
   ITEMS            = 349200
   ITEM_BYTES       = 2
```

```
   DESCRIPTION      = "Science raw data."
END_OBJECT          = COLUMN

OBJECT              = COLUMN
   NAME             = SCI_FRAME_CHECKSUM
   DATA_TYPE        = MSB_UNSIGNED_INTEGER
   START_BYTE       = 698713
   BYTES            = 4
   DESCRIPTION      = "Fletcher checksum of science frame."
END_OBJECT          = COLUMN
```

APPENDIX B – CHEMIN LABEL KEYWORD DEFINITIONS

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
Ops Keyword ACTIVE_FLIGHT_STRING_ID **PDS Keyword** MSL:ACTIVE_FLIGHT_STRING_ID **Definition** Indicates which flight computer string was active when this product was acquired.	**Valid Values** “A”, “B” **Type** string **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** EMD in XML format **Field as “<xml name>:[<element>]:[<element>]:<field>”** “MslEarthProductMetadata:MslProductMetadata:CreationStringId” **Type** U16
Ops Keyword APPLICATION_PROCESS_ID **Definition** Specifies the name associated with the source or process which created the data. For MSL, the Application Process Identifier (APID) identifies the data type encapsulated in the packet. The APIDS can vary between each version of FSW. As of FSW version **TBD**, integer APIDs will be static and remain unchanged. However, only APID Names uniquely identify Data Product types across all FSW versions. See also APPLICATION_PROCESS_NAME and Appendix C.	**Valid Values** (as of FSW version 10.5.7) CHEMIN APID Name “148” ChmnCcdFrame “149” ChmnDiffSingle “150” ChmnDiffSplit “151” ChmnDiffractionAll “153” ChmnEnergyAll “154” ChmnEnergySingle “155” ChmnEnergySplit “156” ChmnFilmdata “159” ChmnHousekeepingN “162” ChmnTransmitRaw **Type** string(256) **Units** n/a **Location** TELEMETRY (Class)	**Mode** EMD in XML format **Field as “<xml name>:[<element>]:[<element>]:<field>”** “MslEarthProductMetadata:MslProductMetadata:Apid” **Type** n/a
Ops Keyword APPLICATION_PROCESS_NAME	**Valid Values**	**Mode** EMD in XML format

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
Definition Specifies the name associated with the source or process which created the data. For MSL, the Application Process Identifier (APID) identifies the data type encapsulated in the packet. The APIDS can vary between each version of FSW. As of FSW version **TBD**, integer APIDs will be static and remain unchanged. However, only APID Names uniquely identify Data Product types across all FSW versions. See also APPLICATION_PROCESS_ID and Appendix C.	CHEMIN (As of FSW 10.5.7) Name — APID "ChmnCcdFrame" **148** "ChmnDiffSingle" **149** "ChmnDiffSplit" **150** "ChmnDiffractionAll" **151** "ChmnEnerfyAll" **153** "ChmnenergySingle" **154** "ChmnEnergySplit **155** "ChmnFilmData" **156** " ChmnHousekeepingN" 159 "ChmnTransmitRaw" **162** **Type** string(256) **Units** n/a **Location** TELEMETRY (Class)	**Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:ProductName" **Type** n/a
Ops Keyword ARTICULATION_DEVICE_ANGLE **Definition** Specifies the value of an angle between two parts or segments of an articulated device. NOTE: MER used radians. The PDS default unit for this keyword is degrees, so the <rad> tag is required for MSL data.	**Valid Values** n/a **Type** float array[5] **Units** radians (<rad> unit tag required) **Units** n/a **Location** 1) ARM_ARTICULATION_STATE (Group)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:SampleArmOrientation" **Type** 4) F32[5]

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
Ops Keyword ARTICULATION_DEVICE_ANGLE_NAME **Definition** Specifies the formal name which identifies each of the values used in ARTICULATION_DEVICE_ANGLE.	**Valid Values** ARM ("JOINT 1 AZIMUTH-ENCODER ", "JOINT 2 ELEVATION-ENCODER ", "JOINT 3 ELBOW-ENCODER", "JOINT 4 WRIST-ENCODER", "JOINT 5 TURRET-ENCODER") **Type** string array[5] **Units** n/a **Location** ARM_ARTICULATION_STATE (Group)	**Mode** Static values **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a
Ops Keyword ARTICULATION_DEVICE_ID **Definition** Specifies the unique abbreviated identification of an articulation device. 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.). NOTE: The ARTICULATION_DEVICE_ID is not a unique identifier for a given articulated device. Note also that the associated ARTICULATION_DEVICE_NAME element provides the full name of the articulated device.	**Valid Values** "ARM" **Type** string **Units** n/a **Location** ARM_ARTICULATION_STATE (Group)	**Mode** Static value **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a
Ops Keyword ARTICULATION_DEVICE_NAME **Definition** Specifies the common name of an articulation device. 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.) NOTE: The associated ARTICULATION_DEVICE_ID element provides an abbreviated name or acronym for the articulated device.	**Valid Values** "SAMPLE ARM" **Type** string **Units** n/a **Location** ARM_ARTICULATION_STATE (Group)	**Mode** Static value **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
Ops Keyword AUTO_DELETE_FLAG **Definition** Indicates if the DP will be deleted upon transmission: 1 for delete, 0 for no delete.	**Valid Values** n/a **Type** string **Units** n/a **Location** TELEMETRY (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:DeleteOnSend" **Type** n/a
Ops Keyword COMMAND_SEQUENCE_NUMBER **Definition** Specifies a numeric identifier for a sequence of commands sent to a spacecraft or instrument. NOTE: For MER, this is the command number which identifies the specific generating command within the specified sequence.	**Valid Values** n/a **Type** integer **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:CommandNumber" **Type** n/a
Ops Keyword COMMUNICATION_SESSION_ID **PDS Keyword** MSL:COMMUNICATION_SESSION_ID **Definition** Active Communication Session ID at time of MPDU (Metadata Protocol Data Unit) creation. A Data Product is formed into PDUs (Protocol Data Units) by creating one MPDU, one or more PPDUs (Product Data PDUs), and one EPDU (End-of-Product PDU). The MPDU is the first PDU produced for a data product, and contains general and MSL specific "data about the data product". It is wholly contained in a single packet with the Packet Sequence Count always set to zero. (Above text from MSL FGICD, v2.2.1)	**Valid Values** n/a **Type** string **Units** n/a **Location** TELEMETRY (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:CommSessionId" **Type** n/a

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
See also EXPECTED_TRANSMISSION_PATH.		
Ops Keyword COORDINATE_SYSTEM_INDEX **Definition** Specifies an integer array used to record and track the movement of a rover or lander during surface operations. 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. Example: COORDINATE_SYSTEM_INDEX=(1,1) For MSL, see ROVER_MOTION_COUNTER and ROVER_MOTION_COUNTER_NAME for the 10 indices and names.	**Valid Values** n/a **Type** integer array[6] **Units** n/a **Location** ROVER_COORDINATE_SYSTEM (Group)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:RoverMotionCounter NOTES: • Defaults for EDRs: - If ROVER_FRAME or SITE_FRAME or MAST_FRAME or LOCAL_LEVEL_FRAME or DRILL_FRAME, then Site, Drive, Pose, Arm, CHIMRA, Drill, RSM, HGA, DRT and IC indices **Type** U16
Ops Keyword COORDINATE_SYSTEM_INDEX_NAME **Definition** Specifies an array of the formal names identifying each integer specified in COORDINATE_SYSTEM_INDEX.	**Valid Values** 1) "SITE" 2) "DRIVE" 3) "POSE" 4) "ARM" 5) "CHIMRA" 6) "DRILL" 7) "RSM" 8) "HGA" 9) "DRT" 10) "IC" **Type** string array[10]	**Mode** Static Values **Field as "<xml name>:[<element>]:[<element>]:<field>"** NOTES: • Should match the number of values in COORDINATE_SYSTEM_INDEX. **Type** U16

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
	Units n/a **Location** ROVER_COORDINATE_SYSTEM (Group)	
Ops Keyword COORDINATE_SYSTEM_NAME **Definition** Specifies the full name of the coordinate system to which the state vectors are referenced. When in a COORDINATE_SYSTEM 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 or lander missions), which have multiple instances using the same name, also require COORDINATE_SYSTEM_INDEX to completely identify the coordinate system.	**Valid Values** “ROVER_FRAME” **Type** string **Units** n/a **Location** ROVER_COORDINATE_SYSTEM (Group)	**Mode** Static Value **Field as “<xml name>:[<element>]:[<element>]:<field>”** **Type**
Ops Keyword DATA_SET_ID **Definition** Specifies 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. In the PDS, the values for DATA_SET_ID are constructed according to standards outlined in the Standards Reference.	**Valid Values** “MSL-M-CHMN-2-EDR-V1.0”, **Type** string(40) **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** PDS, Table Lookup **Field as “<xml name>:[<element>]:[<element>]:<field>”** n/a **Type** n/a
Ops Keyword	**Valid Values**	**Mode**

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
DATA_SET_NAME **Definition** Specifies the full name given to a data set or a data product. The DATA_SET_NAME typically identifies the instrument that acquired the data, the target of that instrument, and the processing level of the data. In the PDS, values for DATA_SET_NAME are constructed according to standards outlined in the Standards Reference.	"Operations" EDRs "MSL MARS CHEMISTRY AND MINERALOGY INSTRUMENT EDR V1.0", **Type** string **Units** n/a **Location** IDENTIFICATION (Class)	PDS, Table Lookup **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a
Ops Keyword DOWNLOAD_PRIORITY **Definition** Specifies which data to downlink/transmit, based on order of importance. The lower numerical priority (higher-ranked number) data products are transmitted before higher numerical priority (lower-ranked number) data products. For example, an image with a downlink priority of 25 will be transmitted from the rover before an image with a downlink priority of 50.	**Valid Values** "0" to "100" **Type** integer **Units** n/a **Location** TELEMETRY	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:ProductPriority" **Type** U8
Ops Keyword EARTH_RECEIVED_START_TIME **Definition** Specifies the beginning time at which telemetry was received during a time period of interest. This should be represented in UTC system format.	**Valid Values** YYYY-MM-DDThh:mm:ss[.fff] **Type** datetime **Units** n/a **Location** TELEMETRY (Class)	**Mode** EMD in XML format, Calculation **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:FirstPartErt" **Type** n/a
Ops Keyword	**Valid Values**	**Mode**

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
EARTH_RECEIVED_STOP_TIME **Definition** Specifies the ending time for receiving telemetry during a time period of interest. This should be represented in UTC system format.	YYYY-MM-DDThh:mm:ss[.fff] **Type** datetime **Units** n/a **Location** TELEMETRY (Class)	EMD in XML format, Calculation **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata: GroundCreationTime" **Type** n/a
Ops Keyword EXPECTED_PACKETS **Definition** Specifies the total number of telemetry packets which constitute a complete data product, i.e., a data product without missing data. For MSL, "Packets" are also referred to as "Parts".	**Valid Values** n/a **Type** integer **Units** n/a **Location** TELEMETRY (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:PartList: TotalExpected" **Type** n/a
Ops Keyword EXPECTED_TRANSMISION_PATH **PDS Keyword** MSL:EXPECTED_TRANSMISION_PATH **Definition** Routing control at time of MPDU (Metadata PDU) generation. Indicates the planned transmission paths (routes) for the Data Product. See also COMMUNICATION_SESSION_ID.	**Valid Values** n/a **Type** string **Units** n/a **Location** TELEMETRY (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata: TransmissionControlCriterion" **Type** n/a
Ops Keyword FILE_RECORDS	**Valid Values** 1	**Mode** Calculation

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
Definition Specifies the number of physical file records, including both label records and data records. NOTE: In the PDS the use of FILE_RECORDS along with other file-related data elements is fully described in the Standards Reference.	**Type** integer **Units** n/a **Location** FILE_DATA_ELEMENT (Class)	**Field as "<xml name>:[<element>]:[<element>]:<field>"** **Type** U16
Ops Keyword FLIGHT_SOFTWARE_MODE **PDS Keyword** MSL:FLIGHT_SOFTWARE_MODE **Definition** Active Flight Software mode at Data Product creation.	**Valid Values** n/a **Type** string **Units** n/a **Location** TELEMETRY (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:FswMode" **Type** unsigned integer
Ops Keyword FLIGHT_SOFTWARE_VERSION_ID **Definition** The version of the instrument flight software used to acquire the image.	**Valid Values** n/a **Type** string **Units** n/a **Location** TELEMETRY (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:FswVersion" **Type** unsigned integer
Ops Keyword ^ENGINEERING_TABLE **Definition**	**Valid Values** n/a **Type**	**Mode** Calculation **Field as "<xml name>:[<element>]:[<element>]:<field>"**

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
Specifies a pointer to the Engineering Table object. See chapter 14 of the PDS Standards Reference for more information on pointer usage.	NULL **Units** n/a **Location** POINTERS	n/a **Type** n/a
Ops Keyword ^HEADER_TABLE **Definition** Specifies a pointer to the Header Table object. See chapter 14 of the PDS Standards Reference for more information on pointer usage.	**Valid Values** n/a **Type** NULL **Units** n/a **Location** POINTERS	**Mode** Calculation **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a
Ops Keyword INSTRUMENT_HOST_ID **Definition** Specifies 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 which are either SPACECRAFT_ID values or EARTH_BASE_ID values.	**Valid Values** SCID VALUE 158 "SIM" 76 "MSL" **Type** string array **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:Scid" **Type** n/a
Ops Keyword INSTRUMENT_HOST_NAME **Definition**	**Valid Values** SCID VALUE 158 "SIMULATED MARS SCIENCE LABORATORY" 76 "MARS SCIENCE LABORATORY"	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"**

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
Specifies 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 which are either SPACECRAFT_NAME values or EARTH_BASE_NAME values. Note that mosaics may contain more than one value in an array.	**Type** string array **Units** n/a **Location** IDENTIFICATION (Class)	"MslEarthProductMetadata:MslProductMetadata:Scid" **Type** n/a
Ops Keyword INSTRUMENT_ID **Definition** Specifies an abbreviated name or acronym which identifies an instrument. NOTE: INSTRUMENT_ID is not a unique identifier for a given instrument. Note also that the associated INSTRUMENT_NAME element provides the full name of the instrument. Example values: IRTM (for Viking Infrared Thermal Mapper), PWS (for plasma wave spectrometer).	**Valid Values** CHEMIN **Type** string array **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** • "MslEarthProductMetadata:MslProductMetadata:ProductName" **Type** n/a
Ops Keyword INSTRUMENT_NAME **Definition** Specifies the full name of an instrument. Note that the associated INSTRUMENT_ID element provides an abbreviated name or acronym for the instrument. Example values: FLUXGATE MAGNETOMETER, NEAR_INFRARED MAPPING SPECTROMETER.	**Valid Values** "CHEMISTRY AND MINERALOGY INSTRUMENT" **Type** string array **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** • "MslEarthProductMetadata:MslProductMetadata:ProductName" **Type** n/a
Ops Keyword INSTRUMENT_TYPE **Definition** Specifies the type of an instrument.	**Valid Values** Value "SPECTROMETER" **Type** string(15)	**Mode** **Field as "<xml name>:[<element>]:[<element>]:<field>"** **Type**

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
Example values: POLARIMETER, RADIOMETER, REFLECTANCE SPECTROMETER, VIDICON CAMERA. Note that mosaics may contain more than one value in an array.	**Units** n/a **Location** IDENTIFICATION (Class)	n/a
Ops Keyword LOCAL_MEAN_SOLAR_TIME **PDS Keyword** MSL:LOCAL_MEAN_SOLAR_TIME **Definition** Specifies the local mean solar time, or LMST. It 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. The desire to work with solar days, hours, minutes, and seconds of uniform length led to the concept of the fictitious mean Sun or FMS. The FMS is defined as a point that moves on the celestial equator of a planetary body at a constant rate that represents the average mean motion of the Sun over a planetary year. Local mean solar time is defined, by analogy with local true solar time (LTST), as the difference between the areocentric right ascensions of a point on the surface and of the FMS. The difference between LTST and LMST varies over time. The length of a mean solar day is constant and can be computed from the mean motion of the FMS and the rotation rate of a planet. The mean solar day is also called a 'sol'. Mean solar hours, minutes, and seconds are defined in the same way as the true solar units. For MSL, the valid value is expressed in terms of a 24-hour clock, so the acceptable range is “00:00:00.000” to “23:59:59.999”. See also LOCAL_TRUE_SOLAR_TIME.	**Valid Values** Sol-<nnnnn>M<hh>:<mm>:<ss>[.fff] NOTE: Value will be uncalibrated if SPICE kernels are unavailable. **Type** string(12) **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** • Calculation: - SCLK Kernel - Landing Site Kernel - P Kernel **Field as “<xml name>:[<element>]:[<element>]:<field>”** • “MslEarthProductMetadata:MslProductMetadata:DvtCourse” • “MslEarthProductMetadata:MslProductMetadata:DvtFine” **Type** U32
Ops Keyword LOCAL_TRUE_SOLAR_TIME **Definition**	**Valid Values** hh:mm:ss[.fff] NOTE: Value will be uncalibrated if SPICE kernels	**Mode** • Calculation: - SCLK Kernel - Landing Site Kernel

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
Specifies the local true solar time, or LTST. It 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. 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.) 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, LTST = (a(P) - a(TS)) * (24 / 360) + 12 where, LTST = the local true solar time in true solar hours a(P) = ARA of the point on the planet's surface in deg a(TS) = ARA of the true sun in deg The conversion factor of 24/360 is applied to transform the angular measure in decimal degrees into hours-minutes-seconds of arc. This standard representation divides 360 degrees into 24 hours, each hour into 60 minutes, and each minute into 60 seconds of arc. The hours, minutes, and seconds of arc are called 'true solar' hours, minutes, and seconds when used to measure LTST. The constant offset of 12 hours is added to the difference in ARAs to place local noon (12:00:00 in hours, minutes, seconds) at the point where the	unavailable. **Type** string(12) **Units** n/a **Location** IDENTIFICATION (Class)	- P Kernel **Field as "<xml name>:[<element>]:[<element>]:<field>"** • "MslEarthProductMetadata:MslProductMetadata:DvtCourse" • "MslEarthProductMetadata:MslProductMetadata:DvtFine" **Type** U32

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
Sun is directly overhead; at this time, the ARA of the true sun is the same as that of the surface point so that a(P) - a(TS) = 0. The use of 'true solar' time units can be extended to define a true solar day as 24 true solar hours. Due to the eccentricity of planetary orbits and the inclination of orbital planes to equatorial planes (obliquity), the Sun does not move at a uniform rate over the course of a planetary year. Consequently, the number of SI seconds in a true solar day, hour, minute or second is not constant. For MSL, the valid value is expressed in terms of a 24-hour clock, so the acceptable range is “00:00:00.000” to “23:59:59.999”. See also LOCAL_MEAN_SOLAR_TIME.		
Ops Keyword MISSION_NAME **Definition** Specifies a major planetary mission or project. A given planetary mission may be associated with one or more spacecraft. Note that mosaics may contain more than one value in an array.	**Valid Values** “MARS SCIENCE LABORATORY” **Type** string array **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** Static Value **Field as “<xml name>:[<element>]:[<element>]:<field>”** n/a **Type** n/a
Ops Keyword MISSION_PHASE_NAME **Definition** Specifies the commonly-used identifier of a mission phase.	**Valid Values** “CRUISE”, “PRIMARY MISSION”, “ASSEMBLY TEST LAUNCH AND OPS 1”, “ASSEMBLY TEST LAUNCH AND OPS 2”, “SURFACE OPS READINESS TEST 1”, “SURFACE OPS READINESS TEST 2”, “SURFACE OPS READINESS TEST 3”, “SURFACE OPS READINESS TEST 4” **Type** string(30) **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** User specified paramter value **Field as “<xml name>:[<element>]:[<element>]:<field>”** n/a **Type** n/a

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
Ops Keyword OBSERVATION_ID **Definition** Specifies a unique identifier for 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.	**Valid Values** n/a **Type** string **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** DPO in XML format (referenced to APID Name in Appendix C) **Field as "<xml name>:[<element>]:[<element>]:<field>"** Not currently used **Type** **Not currently used**
Ops Keyword ORIGIN_OFFSET_VECTOR **Definition** Specifies the offset from the reference coordinate system's origin to the origin of the coordinate system being defined by the enclosing COORDINATE_SYSTEM group. In other words, it is the location of the current system's origin as measured in the reference system. For MER, here is an 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 tothe Rover frame.	**Valid Values** n/a **Type** float array[3] **Units** meters **Location** ROVER_COORDINATE_SYSTEM (Group)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** • "MslEarthProductMetadata:MslProductMetadata:RoverPosition" **Type** F32[3]
Ops Keyword ORIGIN_ROTATION_QUATERNION **Definition** Specifies an array of four values that specifies the rotation of the coordinate system being defined by the enclosing COORDINATE_SYSTEM group, relative to the reference system. Mathematically 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.	**Valid Values** n/a **Type** float array[4] **Units** n/a **Location** ROVER_COORDINATE_SYSTEM (Group)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** • "MslEarthProductMetadata:MslProductMetadata:RoverAttitude" **Type** F32[4]

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
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 = (x,y,z) vector around which rotation occurs For all the above, the Quaternion is received in the order: (v1, v2, v3, s) For MSL, 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”. For MSL, here is an example: In the case of the PMA_COORDINATE_SYSTEM group, ORIGIN_ROTATION_QUATERNION describes the rotation of the RSM (camera head on Mast) boresight (about the ORIGIN_OFFSET_VECTOR) relative to the Rover frame.		
Ops Keyword PDS_VERSION_ID **Definition** Specifies 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'. Examples: PDS3, PDS4.	**Valid Values** “PDS<*version*>” **Type** string[6] **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** PDS **Field as “<xml name>:[<element>]:[<element>]:<field>”** n/a **Type** n/a
Ops Keyword PLANET_DAY_NUMBER **Definition** Specifies the number of sidereal days (rotation of 360 degrees)	**Valid Values** Mission Phase — Values Cruise — less than 1 Surface — “1” to n	**Mode** • Calculation: - SCLK Kernel

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
elapsed since a reference day (e.g., the day on which a landing vehicle set down). Days are measured in rotations of the planet in question from the reference day. For MSL, the reference day is "1", as Landing day is Sol 1. If before Landing day, then value will be less than "1" and can be negetive.	NOTE: Value will be uncalibrated if SPICE kernels are unavailable. **Type** integer **Units** n/a **Location** IDENTIFICATION (Class)	**Field as "<xml name>:[<element>]:[<element>]:<field>"** • "MslEarthProductMetadata:MslProductMetadata:DvtCourse" • "MslEarthProductMetadata:MslProductMetadata:DvtFine" **Type** U32
Ops Keyword POSITIVE_AZIMUTH_DIRECTION **Definition** Specifies 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 elevational reference plane. A value of CW indicates that Azimuth is measured positively Clockwise, and CCW indicates that Azimuth increases positively Counter-clockwise. For MSL, an example is, if a MastCam image is taken of the sky at an elevation 45 degrees above the horizon, the elevation coordinate in MAST_FRAME would be +0.785398 radians.	**Valid Values** "CLOCKWISE" **Type** string **Units** n/a **Location** COORDINATE_SYSTEM (Group)	**Mode** Static Value: • determined by Coordinate Frame definitions **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a
Ops Keyword POSITIVE_ELEVATION_DIRECTION **Definition** Specifies 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 azimuthal reference plane. 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.	**Valid Values** "UP" **Type** string **Units** n/a **Location** ROVER_COORDINATE_SYSTEM (Group)	**Mode** Static Value: • determined by Coordinate Frame definitions **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
For the MSL operational coordinate frames, which follow the Mars Pathfinder convention, increasing elevation ("UP") moves towards the negative Z axis.		
Ops Keyword PROCESSING_HISTORY_TEXT **Definition** Specifies an entry for each processing step and program used in generating a particular data file.	**Valid Values** "CODMAC LEVEL 1 TO LEVEL 2 CONVERSION VIA JPL/MIPL MSLEDRGEN" **Type** string **Units** n/a **Location** HISTORY (Class)	**Mode** Static Value **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a
Ops Keyword PRODUCER_INSTITUTION_NAME **Definition** Specifies the identity of 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.	**Valid Values** "MULTIMISSION INSTRUMENT PROCESSING LABORATORY, JET PROPULSION LAB" **Type** string(60) **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** Static Value **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a
Ops Keyword PRODUCT_COMPLETION_STATUS **Definition** Status of the product at the time that ground software wrote the data product.	**Valid Values** "PARTIAL", "COMPLETE_NO_CHECKSUM", "COMPLETE_CHECKSUM_PASS", "PARTIAL_CHECKSUM_FAIL" **Type** string **Units** n/a **Location** TELEMETRY (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:GroundStatus" **Type** n/a

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
Ops Keyword PRODUCT_CREATION_TIME **Definition** Specifies the UTC system format for the time when a product was created.	**Valid Values** YYYY-MM-DDThh:mm:ss[.fff] **Type** string **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** Calculation **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a
Ops Keyword PRODUCT_ID **Definition** Specifies a permanent, unique identifier assigned to a data product by its producer. For MSL, it is the filename minus the extension. NOTES: 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.	**Valid Values** n/a **Type** string(40) **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** Filename minus extension **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a
Ops Keyword PRODUCT_TAG **Definition** Data Product Tag. Comment: Use of this tag is defined separately for individual product types. It is anticipated that this tag may be used to associate multiple products for later processing; it may also be used to indicate instrument FSW versions, or other uses.	**Valid Values** n/a **Type** string **Units** n/a **Location** TELEMETRY (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:ProductTag" **Type** n/a

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
Ops Keyword PRODUCT_TYPE **Definition** Identifies the type or category of a data product within a data set.	**Valid Values** CHEMIN_EHK, CHEMIN_ECC, CHEMIN_ED1, CHEMIN_EDS, CHEMIN_EDA, CHEMIN_EEA, CHEMIN_EE1, CHEMIN_EES, CHEMIN_EFM, CHEMIN_ETR **Type** string(40) **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** Static Value **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a
Ops Keyword PRODUCT_VERSION_ID **Definition** Specifies the version of an individual product within a data set. PRODUCT_VERSION_ID is intended for use within AMMOS to identify separate iterations of a given product, which will also have a unique FILE_NAME. For MER, PRODUCT_VERSION_ID includes a Version field that begins with "V" followed by the Version decimal number of the controlling SIS document. Example: "V2.0 D-22846" NOTE: This might not be the same as the data set version that is an element of the DATA_SET_ID value.	**Valid Values** "V<*vernum*> D-69260" **Type** string(12) **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** User specified paramter value **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a
Ops Keyword RECEIVED_PACKETS **Definition** Specifies the total number of telemetry packets which constitute a reconstructed data product.	**Valid Values** n/a **Type** integer **Units** n/a	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:PartList: TotalReceived" **Type**

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
	Location TELEMETRY (Class)	n/a
Ops Keyword RECORD_BYTES **Definition** Specifies the number of bytes in a physical file record, including record terminators and separators. NOTE: In the PDS, the use of record_bytes, along with other file-related data elements is fully described in the Standards Reference.	**Valid Values** "0" to n **Type** integer **Units** n/a **Location** FILE (Class)	**Mode** Calculation **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a
Ops Keyword RECORD_TYPE **Definition** Specifies the record format of a file. NOTE: 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.	**Valid Values** "FIXED_LENGTH" **Type** string(20) **Units** n/a **Location** FILE (Class)	**Mode** Calculation **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a
Ops Keyword REFERENCE_COORD_SYSTEM_INDEX **Definition** Specifies 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. For MSL, these indices are based on the ROVER_MOTION_COUNTER and are in the same order as specified by ROVER_MOTION_COUNTER_NAME. The number of indices can be anything from 1 (used for SITE_FRAME) up to 10; however only 1, 2, 3, and 10 indices are common in RDRs. EDRs will contain 1 or 10, depending	**Valid Values** n/a **Type** integer array[1] **Units** n/a **Location** ROVER_COORDINATE_SYSTEM (Group)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:RoverMotionCounter" **Type** U16

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
on the group in which the keyword occurs. See also REFERENCE_COORD_SYSTEM_NAME and COORDINATE_SYSTEM_INDEX.		
Ops Keyword REFERENCE_COORD_SYSTEM_NAME **Definition** Specifies the full name of the reference coordinate system (CS) 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. For rover or lander missions with non-unique coordinate systems (such as "SITE"), the CS name and index (see (REFERENCE_COORD_SYSTEM_INDEX) together, along with the solution id (see REFERENCE_COORD_SYSTEM_SOLN_ID), completely specify the reference CS. The values appearing in a reference index depend on what the reference name is. The valid coordinate frame names vary by project, but are generally the same as for COORDINATE_SYSTEM_FRAME. For MSL, EDR's use a standard, predefined frame name for each occurrence. However, RDR's can use any value available in COORDINATE_SYSTEM_NAME. Despite that, only a few frame names are commonly used. "SITE_FRAME" is used for most SITE, ROVER, and LOCAL_LEVEL CS definitions, as well as for XYZ data and many mosaics. "ROVER_FRAME" is used for most other CS definitions, surface normals, camera models, and some mosaics. "LOCAL_LEVEL_FRAME" is used for some mosaics.	**Valid Values** "SITE_FRAME" \ **Type** string(20) **Units** n/a **Location** ROVER_COORDINATE_SYSTEM (Group)	**Mode** Static Value **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a
Ops Keyword RELEASE_ID **Definition** Specifies the unique identifier associated with the release to the public of all or part of a data set. The release number is associated with the data set, not the mission.	**Valid Values** n/a **Type** string **Units** n/a	**Mode** User parameter input **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
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. The first release of a data set in the mission should have a value of "0001". For example, on MSL the first release of the SSI EDR data set on MSL will have RELEASE_ID = "0001". The next SSI EDR release will have RELEASE_ID = "0002".	**Location** IDENTIFICATION (Class)	
Ops Keyword REQUEST_ID **Definition** Specifies the Request ID value associated with the Data Product generation command. Unsigned integer.	**Valid Values** n/a **Type** string **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:RequestId" **Type** U16
Ops Keyword ROVER_MOTION_COUNTER **Definition** Specifies a set of integers which 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 which 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 which conform to the above definition, such as time or spacecraft clock values. For MSL, the motion counter consists of ten values. In order, they are "Site", "Drive", "Pose", "Arm", "CHIMRA", "Drill", "RSM", "HGA", "DRT", and "Inlet Cover Motion". 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	**Valid Values** n/a **Type** integer array[10] **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:RoverMotionCounter" **Type** U16

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
they increment. The Arm, RSM, and HGA increment whenever the corresponding articulation device moves. Arm, RSM and HGA increment independently of each other; they are reset to zero only when the SITE or DRIVE changes.		
Ops Keyword ROVER_MOTION_COUNTER_NAME **Definition** Specifies an array that provides the formal names identifying each integer in ROVER_MOTION_COUNTER.	**Valid Values** ("SITE", "DRIVE", "POSE", "ARM", "CHIMRA", "DRILL", "RSM", "HGA", "DRT", "IC") **Type** string array[10] **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** Static Values **Field as "<xml name>:[<element>]:[<element>]:<field>"** **Type** U16
Ops Keyword ^SCIENCE_TABLE **Definition** Specifies a pointer to the Science Table object. See chapter 14 of the PDS Standards Reference for more information on pointer usage.	**Valid Values** n/a **Type** NULL **Units** n/a **Location** POINTERS	**Mode** Calculation **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
Ops Keyword SEQUENCE_EXECUTION_COUNT **Definition** Set to 0 at RCE start-up and Incremented each time this sequence has executed since last RCE start-up. Unsigned integer.	**Valid Values** n/a **Type** integer **Units** n/a **Location** TELEMETRY (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata: SequenceExecutionCounter" **Type** n/a
Ops Keyword SEQUENCE_ID **Definition** Specifies an identification of the spacecraft sequence associated with the given product. This element replaces the older seq_id, which should no longer be used.	**Valid Values** "UNK" **Type** string(30) **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:SequenceId" **Type** n/a
Ops Keyword SEQUENCE_VERSION_ID **Definition** Specifies the version identifier for a particular observation sequence used during planning or data processing.	**Valid Values** "UNK" **Type** string(30) **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:SequenceVersion" **Type** n/a
Ops Keyword SOFTWARE_NAME	**Valid Values** "MSLEDRGEN", other	**Mode** Static Value

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
Definition Specifies the name of data processing software such as a program or a program library.	**Type** string(60) **Units** n/a **Location** HISTORY (Class)	**Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a
Ops Keyword SOFTWARE_VERSION_ID **Definition** Specifies the version (development level) of a program or a program library.	**Valid Values** n/a **Type** string(20) **Units** n/a **Location** HISTORY (Class)	**Mode** Static Value **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a
Ops Keyword SOLAR_LONGITUDE **Definition** Specifies the value of the angle between the body_Sun line at the time of interest and the body_Sun line at the vernal equinox. This provides a measure of season on a target body, with values of 0 to 90 degrees representing northern spring, 90 to 180 degrees representing northern summer, 180 to 270 degrees representing northern autumn and 270 to 360 degrees representing northern winter. Example: For IRAS, the geocentric ecliptic longitude (B1950) of the Sun at the start of a scan.	**Valid Values** "0.0" to "359.99" "N/A" if any SPICE kernel is unavailable. **Type** float **Units** deg (<deg> unit tag required) **Location** IDENTIFICATION (Class)	**Mode** • Calculation: - SCLK Kernel - Landing Site Kernel - P Kernel **Field as "<xml name>:[<element>]:[<element>]:<field>"** • "MslEarthProductMetadata:MslProductMetadata:DvtCourse" • "MslEarthProductMetadata:MslProductMetadata:DvtFine" **Type** U32
Ops Keyword SPACECRAFT_CLOCK_CNT_PARTITION	**Valid Values** "1"	**Mode** Static Value

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
Definition Specifies the clock partition active for the SPACECRAFT_CLOCK_START_COUNT and SPACECRAFT_CLOCK_STOP_COUNT elements.	**Type** integer **Units** n/a **Location** IDENTIFICATION (Class)	**Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a
Ops Keyword SPACECRAFT_CLOCK_START_COUNT **Definition** Specifies the value of the spacecraft clock at the beginning of a time period of interest. Format is "sssssssss.mmm", stored as a floating point number where, "sssssssss" = seconds converted from clock's coarse counter "mmm" = milliseconds converted from clock's fine counter For MSL, the fractional component "mmm" is computed as: [DvtFine/ 65536] * 1000	**Valid Values** sssssssss.mmm **Type** string(30) **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** • "MslEarthProductMetadata:MslProductMetadata:DvtCoarse" • "MslEarthProductMetadata:MslProductMetadata:DvtFine" NOTES: • The DvtFine is a 16-bit truncated value from a 20-bit number. **Type** U32 U16
Ops Keyword SPACECRAFT_CLOCK_STOP_COUNT **Definition** Specifies the value of the spacecraft clock at the end of a time period of interest. Format is "sssssssss.mmm", stored as a floating point number where, "sssssssss" = seconds converted from clock's coarse counter	**Valid Values** sssssssss.mmm **Type** string(30) **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** • "MslEarthProductMetadata:MslProductMetadata:DvtCoarse" • "MslEarthProductMetadata:MslProductMetadata:DvtFine" NOTES: • The DvtFine is a 16-bit truncated value from a 20-bit number.

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
"mmm" = milliseconds converted from clock's fine counter For MSL, the fractional component "mmm" is computed as: [DvtFine/65536] * 1000		**Type** U32 U16
Ops Keyword SPICE_FILE_NAME **Definition** Specifies the names of the SPICE files used in processing the data. For Galileo, the SPICE files are used to determine navigation and lighting information.	**Valid Values** n/a **Type** string(180) **Units** n/a **Location** TELEMETRY (Class)	**Mode** User parameter input **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a
Ops Keyword START_TIME **Definition** Specifies 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.	**Valid Values** YYYY-MM-DDThh:mm:ss[.fff] NOTE: Value will be uncalibrated if SPICE kernels unavailable. **Type** string **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** • "MslEarthProductMetadata:MslProductMetadata:DvtCoarse" • "MslEarthProductMetadata:MslProductMetadata:DvtFine" NOTES: • The DvtFine is a 16-bit truncated value from a 20-bit number. **Type** U32 U16
Ops Keyword STOP_TIME	**Valid Values** YYYY-MM-DDThh:mm:ss[.fff]	**Mode** EMD in XML format

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
Definition Specifies the date and time of the end of an event or observation (whether it be a spacecraft, ground-based, or system event) in UTC system format.	NOTE: Value will be uncalibrated if SPICE kernels unavailable. **Type** string **Units** n/a **Location** IDENTIFICATION (Class)	**Field as "<xml name>:[<element>]:[<element>]:<field>"** • "MslEarthProductMetadata:MslProductMetadata:DvtCoarse" • "MslEarthProductMetadata:MslProductMetadata:DvtFine" NOTES: • The DvtFine is a 16-bit truncated value from a 20-bit number. **Type** U32 U16
Ops Keyword TARGET_NAME **Definition** Specifies a target. The target may be a planet, satellite, ring, region, feature, asteroid or comet. See TARGET_TYPE.	**Valid Values** "MARS", TBD **Type** string(30) **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** Calculation: • "MARS" or TBD LUT in database **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a
Ops Keyword TARGET_TYPE **Definition** Specifies the type of a named target.	**Valid Values** "PLANET", TBD **Type** string **Units** n/a **Location** IDENTIFICATION (Class)	**Mode** "PLANET" or TBD LUT in database **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
Ops Keyword TELEMETRY_PROVIDER_ID **Definition** Specifies the provider and version of the telemetry data used in the generation of this data.	**Valid Values** "MPCS_MSL_DP" **Type** string **Units** n/a **Location** TELEMETRY (Class)	**Mode** User parameter input **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a
Ops Keyword TELEMETRY_SOURCE_CHECKSUM **Definition** File checksum is an unsigned add of each byte in the data areas of the DPOs in the product. This does not include the DPO headers.	**Valid Values** n/a **Type** string **Units** n/a **Location** TELEMETRY (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:SessionInformation:ProductChecksum" **Type** n/a
Ops Keyword TELEMETRY_SOURCE_HOST_NAME **Definition** Specifies the name of the host venue that provides the telemetry source used in creation of this data set. For MSL, example is "mslmstbgds1". See also TELEMETRY_SOURCE_NAME.	**Valid Values** n/a **Type** string **Units** n/a **Location** TELEMETRY (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:SessionInformation:Venue:Host" **Type** n/a

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
Ops Keyword TELEMETRY_SOURCE_NAME **Definition** Specifies the name of the telemetry source used in creation of this data set. See also TELEMETRY_SOURCE_HOST_NAME.	**Valid Values** n/a **Type** string **Units** n/a **Location** TELEMETRY (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:DataFileName" **Type** n/a
Ops Keyword TELEMETRY_SOURCE_SIZE **Definition** Specifies the length of the Data Product in bytes. This value is *not* a "less one" value; that is, the field value is the exact length of the user data within the data product.	**Valid Values** "DATA PRODUCT" **Type** integer **Units** n/a **Location** TELEMETRY (Class)	**Mode** User parameter input **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:ProductFileSize" **Type** n/a
Ops Keyword TELEMETRY_SOURCE_TYPE **Definition** Specifies the classification of the source of the telemetry used in creating this data set.	**Valid Values** "DATA PRODUCT" **Type** string(12) **Units** n/a **Location** TELEMETRY (Class)	**Mode** User parameter input **Field as "<xml name>:[<element>]:[<element>]:<field>"** n/a **Type** n/a

OUTPUT METADATA (PRODUCT LABEL)		INPUT METADATA (SOURCE)
• Ops Keyword • PDS-Compliant Keyword (listed if different than Ops) • Definition	• Valid Values (quoted) • Type • Units • Keyword Location in Label	• Mode • Metadata Field • Type
Ops Keyword TRANSMISSION_PATH **Definition** Routing status at time of MPDU (Metadata PDU) generation. Indicates the actual transmission paths (routes) of the Data Product.	**Valid Values** n/a **Type** string **Units** n/a **Location** TELEMETRY (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata: TransmissionStatus" **Type** n/a
Ops Keyword VIRTUAL_CHANNEL_ID **Definition** The Virtual Channel Identifier is used by MSL to identify the RCE string generating the Transfer Frame, and to indicate the type of data flowing in the telemetry virtual channel. RCE String A is indicated by all Virtual Channel Identifier values having a '0' as the high bit (e.g., virtual channels 0 to 31); RCE String B is indicated by all Virtual Channel Identifier values having a '1' for the high bit (e.g., virtual channels 32 to 63).	**Valid Values** n/a **Type** integer **Units** n/a **Location** TELEMETRY (Class)	**Mode** EMD in XML format **Field as "<xml name>:[<element>]:[<element>]:<field>"** "MslEarthProductMetadata:MslProductMetadata:Vcid" **Type** n/a