Mars Atmosphere and Volatile Evolution (MAVEN) Mission

Imaging Ultraviolet Spectrograph

PDS Archive

Software Interface Specification

[Rev. 1.5, Nov 13, 2017]

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1 Introduction

This software interface specification (SIS) describes the format and content of the Imaging Ultraviolet Spectrograph (IUVS) Planetary Data System (PDS) data archive. It includes descriptions of the data products and associated metadata, and the archive format, content, and generation pipeline.

1.1 Distribution List

Table 1: Distribution list

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1.2 Document Change Log

Table 2: Document change log

Version	Change	Date	Affected portion
0.0	Initial template	2012-Aug-24	All
0.1	Updated template	2013-Feb-13	All
0.2	Updated template	2013-Apr-03	All
0.3	Updated template	2014-Jan-30	All
0.7	Initial review draft	2014-Aug-22	All
0.8	Second review draft	2015-Apr-17	All
1.0	1st PDS Release	2015-May-15	All
1.1	3rd PDS Release	2015-Nov-18	Sections 3 & 6
1.3	6th PDS Release, updated occultation campaign dates and echelle processed data format	2016-Aug-26	Section 5.2.1.11, Table 24 in Section 6.1.3
1.4	7th & 8th PDS Release, updated occultation campaign dates, collections, file formats	2017-Feb-17	Sections 5 & 6

1.3 TBD Items

Table 3 lists items that are not yet finalized.

Table 3: List of TBD items

Item	Section(s)	Page(s)

1.4 Abbreviations

Table 4: Abbreviations and their meaning

Abbreviation	Meaning
ASCII	American Standard Code for Information Interchange
Atmos	PDS Atmospheres Node (NMSU, Las Cruces, NM)
CCSDS	Consultative Committee for Space Data Systems
CDR	Calibrated Data Record
CFDP	CCSDS File Delivery Protocol
CK	C-matrix Kernel (NAIF orientation data)
CODMAC	Committee on Data Management, Archiving, and Computing
CRC	Cyclic Redundancy Check
CU	University of Colorado (Boulder, CO)
DAP	Data Analysis Product
DDR	Derived Data Record
DMAS	Data Management and Storage
DPF	Data Processing Facility
E&PO	Education and Public Outreach
EDR	Experiment Data Record
EUV	Extreme Ultraviolet; also used for the EUV Monitor, part of LPW (SSL)
FEI	File Exchange Interface
FOV	Field of View
FTP	File Transfer Protocol
GB	Gigabyte(s)
GSFC	Goddard Space Flight Center (Greenbelt, MD)
HK	Housekeeping

Abbreviation	Meaning
HTML	Hypertext Markup Language
ICD	Interface Control Document
IM	Information Model
ISO	International Standards Organization
ITF	Instrument Team Facility
IUVS	Imaging Ultraviolet Spectrograph (LASP)
JPL	Jet Propulsion Laboratory (Pasadena, CA)
LASP	Laboratory for Atmosphere and Space Physics (CU)
LID	Logical Identifier
LIDVID	Versioned Logical Identifer
LPW	Langmuir Probe and Waves instrument (SSL)
MAG	Magnetometer instrument (GSFC)
MAVEN	Mars Atmosphere and Volatile EvolutioN
MB	Megabyte(s)
MD5	Message-Digest Algorithm 5
MOI	Mars Orbit Insertion
MOS	Mission Operations System
MSA	Mission Support Area
NAIF	Navigation and Ancillary Information Facility (JPL)
NASA	National Aeronautics and Space Administration
NGIMS	Neutral Gas and Ion Mass Spectrometer (GSFC)
NMSU	New Mexico State University (Las Cruces, NM)
NSSDC	National Space Science Data Center (GSFC)
PCK	Planetary Constants Kernel (NAIF)
PDS	Planetary Data System
PDS4	Planetary Data System Version 4
PF	Particles and Fields (instruments)
PPI	PDS Planetary Plasma Interactions Node (UCLA)
RS	Remote Sensing (instruments)
SCET	Spacecraft Event Time

Abbreviation	Meaning
SDC	Science Data Center (LASP)
SCLK	Spacecraft Clock
SEP	Solar Energetic Particle instrument (SSL)
SIS	Software Interface Specification
SOC	Science Operations Center (LASP)
SPE	Solar Particle Event
SPICE	Spacecraft, Planet, Instrument, C-matrix, and Events (NAIF data format)
SPK	Spacecraft and Planetary ephemeris Kernel (NAIF)
SSL	Space Sciences Laboratory (UCB)
STATIC	Supra-Thermal And Thermal Ion Composition instrument (SSL)
SWEA	Solar Wind Electron Analyzer (SSL)
SWIA	Solar Wind Ion Analyzer (SSL)
TBC	To Be Confirmed
TBD	To Be Determined
UCB	University of California, Berkeley
UCLA	University of California, Los Angeles
URN	Uniform Resource Name
UV	Ultraviolet
XML	eXtensible Markup Language

1.5 Glossary

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

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

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

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

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

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

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

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

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

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

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

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

Manifest - A list of contents.

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

Non-Digital Object – An object which does not consist of digital data. Non-digital objects include both physical objects like instruments, spacecraft, and planets, and non-physical objects like missions, and institutions. Non-digital objects are labeled in PDS in order to define a unique identifier (LID) by which they may be referenced across the system.

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

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

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

Tagged Object – An entity categorized by the PDS Information Model, and described by a PDS label.

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

Repository – A place, room, or container where something is deposited or stored (often for safety).

XML – eXtensible Markup Language.

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

1.6 MAVEN Mission Overview

The MAVEN mission is scheduled to launch on an Atlas V between November 18 and December 7, 2013. After a ten-month ballistic cruise phase, Mars orbit insertion will occur on or after September 22, 2014. Following a 5-week transition phase, the spacecraft will orbit Mars at a 75° inclination, with a 4.5 hour period and periapsis altitude of 140-170 km (density corridor of 0.05-0.15 kg/km^3). Over a one-Earth-year period, periapsis will precess over a wide range of latitude and local time, while MAVEN obtains detailed measurements of the upper atmosphere, ionosphere, planetary corona, solar wind, interplanetary/Mars magnetic fields, solar EUV and solar energetic particles, thus defining the interactions between the Sun and Mars. MAVEN will explore down to the homopause during a series of five 5-day "deep dip" campaigns for which periapsis will be lowered to an atmospheric density of 2 kg/km^3 (~125 km altitude) in order to sample the transition from the collisional lower atmosphere to the collisionless upper atmosphere. These five campaigns will be interspersed though the mission to sample the subsolar region, the dawn and dusk terminators, the anti-solar region, and the north pole.

1.6.1 Mission Objectives

The primary science objectives of the MAVEN project will be to provide a comprehensive picture of the present state of the upper atmosphere and ionosphere of Mars and the processes controlling them and to determine how loss of volatiles to outer space in the present epoch varies with changing solar conditions. Knowing how these processes respond to the Sun's energy inputs will enable scientists, for the first time, to reliably project processes backward in time to study atmosphere and volatile evolution. MAVEN will deliver definitive answers to high-priority science questions about atmospheric loss (including water) to space that will greatly enhance our understanding of the climate history of Mars. Measurements made by MAVEN will allow us to determine the role that escape to space has played in the evolution of the Mars atmosphere, an essential component of the quest to "follow the water" on Mars. MAVEN will accomplish this by achieving science objectives that answer three key science questions:

- What is the current state of the upper atmosphere and what processes control it?
- What is the escape rate at the present epoch and how does it relate to the controlling processes?
- What has the total loss to space been through time?

MAVEN will achieve these objectives by measuring the structure, composition, and variability of the Martian upper atmosphere, and it will separate the roles of different loss mechanisms for both neutrals and ions. MAVEN will sample all relevant regions of the Martian atmosphere/ionosphere system—from the termination of the well-mixed portion of the atmosphere (the "homopause"), through the diffusive region and main ionosphere layer, up into the collisionless exosphere, and through the magnetosphere and into the solar wind and downstream tail of the planet where loss of neutrals and ionization occurs to space—at all relevant latitudes and local solar times. To allow a meaningful projection of escape back in time, measurements of escaping species will be made simultaneously with measurements of the energy drivers and the controlling magnetic field over a range of solar conditions. Together with measurements of the isotope ratios of major species, which constrain the net loss to space over time, this approach will allow thorough identification of the role that atmospheric escape plays today and to extrapolate to earlier epochs.

1.6.2 Payload

MAVEN will use the following science instruments to measure the Martian upper atmospheric and ionospheric properties, the magnetic field environment, the solar wind, and solar radiation and particle inputs:

- NGIMS Package:
  - Neutral Gas and Ion Mass Spectrometer (NGIMS) measures the composition, isotope ratios, and scale heights of thermal ions and neutrals.
- RS Package:
  - Imaging Ultraviolet Spectrograph (IUVS) remotely measures UV spectra in four modes: limb scans, planetary mapping, coronal mapping and stellar occultations. These measurements provide the global composition, isotope ratios, and structure of the upper atmosphere, ionosphere, and corona.
- PF Package:
  - Supra-Thermal and Thermal Ion Composition (STATIC) instrument measures the velocity distributions and mass composition of thermal and suprathermal ions from below escape energy to pickup ion energies.
  - Solar Energetic Particle (SEP) instrument measures the energy spectrum and angular distribution of solar energetic electrons (30 keV – 1 MeV) and ions (30 keV – 12 MeV).
  - Solar Wind Ion Analyzer (SWIA) measures solar wind and magnetosheath ion density, temperature, and bulk flow velocity. These measurements are used to determine the charge exchange rate and the solar wind dynamic pressure.
  - Solar Wind Electron Analyzer (SWEA) measures energy and angular distributions of 5 eV to 5 keV solar wind, magnetosheath, and auroral electrons, as well as ionospheric photoelectrons. These measurements are used to constrain

the plasma environment, magnetic field topology and electron impact ionization rate.
- Langmuir Probe and Waves (LPW) instrument measures the electron density and temperature and electric field in the Mars environment. The instrument includes an EUV Monitor that measures the EUV input into Mars atmosphere in three broadband energy channels.
- Magnetometer (MAG) measures the vector magnetic field in all regions traversed by MAVEN in its orbit.

1.7 SIS Content Overview

Section 2 describes the IUVS instrument. Section 3 gives an overview of data organization and data flow. Section 4 describes data archive generation, delivery, and validation. Section 5 describes the archive structure and archive production responsibilities. Section 6 describes the file formats used in the archive, including the data product record structures. Individuals involved with generating the archive volumes are listed in Appendix A. Appendix B contains a description of the MAVEN science data file naming conventions. Appendix C, Appendix D, and Appendix E contain sample PDS product labels. Appendix F describes IUVS archive product PDS deliveries formats and conventions.

1.8 Scope of this document

The specifications in this SIS apply to all IUVS products submitted for archive to the Planetary Data System (PDS), for all phases of the MAVEN mission. This document includes descriptions of archive products that are produced by both the IUVS team and by PDS.

1.9 Applicable Documents

[1] Planetary Data System Data Provider's Handbook, TBD.

[2] Planetary Data System Standards Reference, TBD.

[3] Planetary Science Data Dictionary Document, TBD.

[4] Planetary Data System (PDS) PDS4 Information Model Specification, Version 1.1.0.1.

[5] Mars Atmosphere and Volatile Evolution (MAVEN) Science Data Management Plan, Rev. C, doc. no.MAVEN-SOPS-PLAN-0068.

[6] King, T., and J. Mafi, Archive of MAVEN CDF in PDS4, July 16, 2013.

1.10 Audience

This document serves both as a SIS and Interface Control Document (ICD). It describes both the archiving procedure and responsibilities, and data archive conventions and format. It is designed to be used both by the instrument teams in generating the archive, and by those wishing to understand the format and content of the IUVS PDS data product archive collection. Typically, these individuals would include scientists, data analysts, and software engineers.

2 IUVS Instrument Description

2.1 Science Objectives

The MAVEN mission has four science goals that the on-board instrumentation will seek to address.

1. Determine the role that loss of volatiles from the Mars atmosphere to space has played through time.
2. Determine the current state of the upper atmosphere, ionosphere, and interactions with the solar wind.
3. Determine the current rates of escape of neutral gases and ions to space and the processes controlling them.
4. Determine the ratios of stable isotopes that will tell Mars' history of loss through time.

To address these four mission goals, the MAVEN IUVS has three measurements it will make during the primary mission. The three measurements, which encompass these goals, are as follows.

1. Profiles and column abundances of H, C, N, O, CO, N_2, and CO_2 from the homopause up to two scale heights (~1500 km for coronal H and O, ~24 km for CO_2) above the exobase with a vertical resolution of one scale height for each species and 25% accuracy.
2. Profiles and column abundances of C^+ and CO_2^+, from the ionospheric main peak up to the nominal ionopause with one O_2^+ scale height vertical resolution and 25% accuracy.
3. D/H ratio above the homopause with sufficient accuracy (~30%) to capture spatial/temporal variations (factor of 2) and compare with measured D/H in bulk atmosphere.

2.2 Detectors

IUVS is an imaging ultraviolet spectrograph which simultaneously images far ultraviolet (FUV) and middle ultraviolet (MUV) spectra onto paired Hamatsu V5180M image intensifiers with Cypress CYIH1SM1000AA-HHCS CMOS array detectors. Second order (110-190nm) light from the beamsplitter is measured by the FUV detector (with a CsI photocathode and MgF_2 window) while first-order (180-340 nm) light is transmitted to the MUV detector (with a CsTe photocathode and synthetic silica window). A spectral resolution of 0.6 nm and 1.2 nm is achieved for the FUV and MUV, respectively.

2.3 Electronics

IUVS is part of the MAVEN Remote Sensing Package. Controlling electronics are part of the Remote Sensing Data Processing Unit (RSDPU), which is located on the spacecraft bus and consists of a 69R000 microprocessor, serial detector interfaces for data and command transfers, dual-port SRAM for data storage, a MIL-STD 1553 spacecraft interface, and a high-speed serial data channel on a common backplane.

2.4 Measured Parameters

Each IUVS detector readout, independent of operational mode (see section 2.5), returns data in data numbers (DN) versus wavelength and position along the aperture. The binning of the detector readouts in the spectral and spatial domains varies with operational mode. Higher level processed and derived data products convert the measured data numbers to the quantity of spectral radiance in units of Rayleighs per nanometer (R/nm) and local column and volumetric densities for relevant species.

2.5 Operational Modes

The IUVS operates in four separate modes, limb scans, nadir planetary mapping, coronal scans, and stellar occultations. For the altitude scanning modes (limb scans and coronal scans), altitude profiles of emission brightness are produced at measured locations. The nadir looking planetary mapping produces maps of emission brightness across the disk of Mars. Stellar occultation observations produce vertical profiles based on the changing absorption of stellar flux by the Martian atmosphere.

2.6 Operational Considerations

The IUVS instrument is commanded off during the five Deep Dip campaigns that MAVEN undertakes in its nominal mission. This is taken as a precaution to avoid damage from the 6 kV high voltage supplied to the image intensifier.

2.7 Ground Calibration

Normal Mode: IUVS normal-mode radiometric sensitivity was measured using both detector standards (comparison of instrument response to that from a calibrated photodiode) and irradiance standards (calibrated lamps). Both approaches are traceable to National Institute of Standards and Technology (NIST) standards. In the former calibration approach we used a vacuum facility equipped with a 2.3-mfocal-length collimator that had a scanning monochromator positioned at its focal plane. The monochromator's exit slit was masked to 1 mm in height and the slit was adjusted to be less than 0.2 mm wide so that beam of light exiting the collimator had less than a 0.2 milliradian angular extent. A hollow cathode lamp using flowing H2, N2, O2, and CO2 was placed at the entrance slit provided spectra with both molecular emissions and isolated atomic emissions. A pair of photomultiplier tubes (PMTs) with pulse-amplifierdiscriminators and 2.54-mmsquare apertures were placed on a translation stage in the vacuum chamber and coaligned to the IUVS. One of these was equipped with a CsI photocathode and a MgF_2 window for FUV calibrations and the other with a CsTe photocathode and a fused silica window for MUV calibrations. The PMTs' quantum efficiencies were determined as a function of wavelength by comparing their outputs to a photodiode whose absolute quantum efficiency as a function of wavelength was measured by NIST (Canfield et al. 1973). This allowed us to determine a map of input beam irradiance (photons cm^{-2} sec^{-1}) as a function of position within the vacuum chamber by scanning the two PMTs in a raster pattern and measuring their outputs. IUVS responsivity, $R(\lambda_j, \theta_k)$ ($R = T_{Optics} \cdot Q_{ePc} \cdot G_{Det} \cdot G_{ADC}$) was determined at 20 discrete wavelengths and 7 heights along the slit. A measurement sequence for each wavelength and angle began setting the monochromator to an isolated atomic emission line and mapping the beam with the appropriate PMT. Once map was complete, the PMT was placed in the center of the raster and its count rate was recorded. Next the PMT was translated aside and the IUVS placed at the center of the raster and rotated in elevation to the measurement angle, θ_k, where the DN rate was measured. Finally the PMT was reinserted and its count rate was measured for a second time to determine lamp drift. (No more than a few percent drift was ever observed during a measurement sequence). Two separate measurement sequences were performed; one with the monochromator grating grooves parallel to those of IUVS and one with them perpendicular. These were averaged to account for polarization effects that may have been introduced because the monochromator grating acts as a polarizer and the IUVS grating acts as an analyzer. (The effects were only a few percent, probably because the IUVS grating operates very near the Littrow configuration (James & Sternberg 1969).) Care was taken to accurately account for parallax between the PMTs whose apertures were in one plane and the IUVS whose entrance pupil was in another.

The irradiance standards approach is performed at ambient pressure and can only be used for MUV. It employs lamps that have their spectral irradiance (i.e., photons cm^{-2} sec^{-1} nm^{-1}) directly traceable to NIST standard sources. In this approach a calibrated lamp (irradiance standard) is placed in front of a Spectrolon® screen providing an extended source with a radiance (i.e., photons cm^{-2} sec^{-1} nm^{-1} str^{-1}). Radiance is calculated from the product of lamp irradiance at the screen multiplied by screen reflectance (Georgiev and Butler 2007; Stiegman et al. 1993). When IUVS views a screen that is large enough to fill both its entrance pupil and its field of view the output DN rate from the MUV detector divided by the screen radiance is a direct measure of the quantity $A \cdot \lambda \cdot R(\lambda_j, \theta_k) \cdot \Omega(\theta_k)$. A measurement sequence includes observations of the screen followed by a dark measurement, obtained by closing the MUV electronic shutter. This is followed by a similar sequence with the screen by a black cloth. Assuming that the cloth reflectance is ≤4 % provides a good measure of the ambient backgrounds, which result when light from the lamp is reflected from walls and other objects within the lab into the IUVS field of view. Additionally, measurements are made at a range of instrument-screen separations in order to determine atmospheric absorption, which is small but significant, particularly for wavelengths 200 nm, and an FEL lamp (Walker et al. 1987), which was calibrated for $\lambda > 250$ nm, were used for IUVS. The different spectral properties of these lamps provide insight into the scattered light performance of the IUVS spectrograph.

Echelle Mode: The echelle mode responsivity was estimated before calibration to be 0.36 ∗ 0.56 ∗ 0.5 ~ 0.1 of the normal mode value. This is based on the echelle spectrograph beam filling factor of 0.36. (The effective echelle grating width is W ∗ cos(β) = 24.1 mm compared to w = 66.7 mm for the normal mode (Bottema 1981), the transmission of the MgF2 prism, which when used in double pass is 0.752 = 0.56, and the relative echelle grating/normal grating groove efficiency of 0.5 (Content et al. 1996).) This estimate was validated at 121.567 nm by taking images in normal and echelle modes while the IUVS viewed the vacuum collimator with the monochromator set to transmit H Lyman alpha emission from its hollow cathode lamp. The ratio of the total DNs within each of the two measured profiles was Total(Echelle)/Total(Normal mode) ~0.096. Thus responsivity of the echelle mode is ~1.3 DN/photon for 121.567 nm. The echelle mode signal for atmosphere emission is 66 times smaller because the etendue and optical throughput are 6.6 and 10 times less, respectively, than normal mode.

2.8 Inflight Calibration

Calibration of the IUVS instrument in flight utilizes UV bright stellar targets with well-established spectral fluxes (e.g. Alpha Crucis, Beta Centauri, Beta Canis Majoris, etc.). Two stellar calibration activities were performed during the cruise phase of the mission, with repeated observations being made on orbit to monitor potential changes in sensitivity. Analysis of this data, reconciliation with ground calibration, and application to airglow observations at Mars is ongoing. To reflect this, systematic uncertainties of 30% for the FUV channel and 25% for the MUV channel are currently being carried.

3 Data Overview

This section provides a high level description of archive organization under the PDS4 Information Model (IM) as well as the flow of the data from the spacecraft through delivery to PDS. Unless specified elsewhere in this document, the MAVEN IUVS archive conforms with version 1.1.0.1 of the PDS4 IM [4].

3.1 Data Processing Levels

A number of different systems may be used to describe data processing level. This document refers to data by their PDS4 processing level. Table 5 provides a description of these levels along with the equivalent designations used in other systems.

Table 5: Data processing level designations

PDS4 processing level	PDS4 processing level description	MAVEN Processing Level	CODMAC Level	IUVS Level
Raw	Original data from an instrument. If compression, reformatting, packetization*, or other translation has been applied to facilitate data transmission or storage, those processes are reversed so that the archived data are in a PDS approved archive format.	0	2	1A
Calibrated	Data converted to physical units entirely independent of the instrument.	2	3	1B
Derived	Results that have been distilled from one or more calibrated data products (for example, maps, gravity or magnetic fields, or ring particle size distributions). Supplementary data, such as calibration tables or tables of viewing geometry, used to interpret observational data should also be classified as 'derived' data if not easily matched to one of the other three categories.	3+	4+	1C+

* PDS does not accept packetized data (CODMAC level 1/NASA level 0) as fulfilling the requirement for the archive of raw data. The PDS/PPI node, however, has agreed to an exception for the MAVEN mission with the understanding that the MAVEN packetized data are not compressed, and may be described as fixed width binary tables. Typically the minimum reduction level accepted by PDS for "raw" data is CODMAC level 2, or NASA level 1A.

3.2 Products

A PDS product consists of one or more digital and/or non-digital objects, and an accompanying PDS label file. Labeled digital objects are data products (i.e. electronically stored files). Labeled non-digital objects are physical and conceptual entities which have been described by a PDS label. PDS labels provide identification and description information for labeled objects. The PDS label defines a Logical Identifier (LID) by which any PDS labeled product is referenced throughout the system. In PDS4 labels are XML formatted ASCII files. More information on the formatting of PDS labels is provided in Section 6.3. More information on the usage of LIDs and the formation of MAVEN LIDs is provided in Section 5.1.

3.3 Product Organization

The highest level of organization for PDS archive is the bundle. A bundle is a list of one or more related collection products that may be of different types. A collection is a list of one or more related basic products that are all of the same type. Figure 1 below illustrates these relationships.

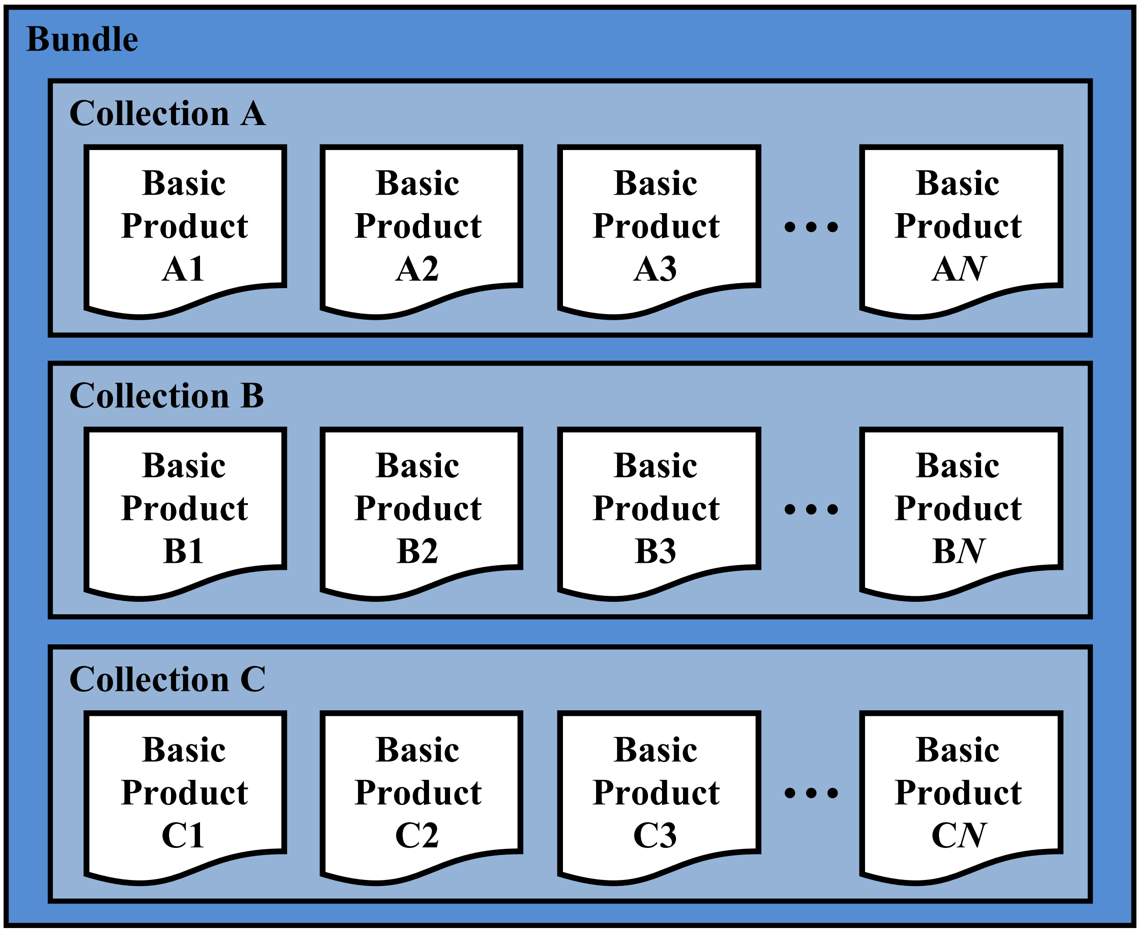


Figure 1: A graphical depiction of the relationship among bundles, collections, and basic products.

Bundles and collections are logical structures, not necessarily tied to any physical directory structure or organization. Bundle and collection membership is established by a member inventory list. Bundle member inventory lists are provided in the bundle product labels themselves. Collection member inventory lists are provided in separate collection inventory table files. Sample bundle and collection labels are provided in Appendix C and Appendix D, respectively.

3.3.1 Collection and Basic Product Types

Collections are limited to a single type of basic products. The types of archive collections that are defined in PDS4 are listed in Table 6.

Table 6: Collection product types

Collection Type	Description
Browse	Contains products intended for data characterization, search, and viewing, and not for scientific research or publication.
Calibration	Contains data and files necessary for the calibration of basic products.
Context	Contains products which provide for the unique identification of objects which form the context for scientific observations (*e.g.* spacecraft, observatories, instruments, targets, etc.).
Document	Contains electronic document products which are part of the PDS Archive.
Data	Contains scientific data products intended for research and publication.
SPICE	Contains NAIF SPICE kernels.
XML_Schema	Contains XML schemas and related products which may be used for generating and validating PDS4 labels.

3.4 Bundle Products

The IUVS data archive is organized into 4 bundles. A description of each bundle is provided in Table 7. A more detailed description of the contents and format of each bundle is provided in Section 5.2.

Table 7: IUVS Bundles

Bundle Logical Identifier	PDS4 Reduction Level	Description	Data Provider
urn:nasa:pds:maven.iuvs.raw	Raw	Raw instrument readouts in data numbers per bin. Includes engineering and geometric data derived from SPICE kernels.	SDC
urn:nasa:pds:maven.iuvs.calibrated	Calibrated	Calibrated instrument readouts in kR/nm, including background subtraction and ancillary data.	ITF
urn:nasa:pds:maven.iuvs.processed	Derived	Calibrated brightnesses that have been reduced by isolating emission features and spatial binning to facilitate processing.	ITF
urn:nasa:pds:maven.iuvs.derived	Derived	Column abundance, density profiles, and maps derived from measured brightnesses.	ITF

3.5 Data Flow

This section describes only those portions of the MAVEN data flow that are directly connected to archiving. A full description of MAVEN data flow is provided in the MAVEN Science Data Management Plan [5]. A graphical representation of the full MAVEN data flow is provided in Figure 2 below.

Reduced (MAVEN level 1) data will be produced by RS and NGIMS as an intermediate processing product, and are delivered to the SDC for archiving at the PDS, but will not be used by the MAVEN team.

All ITFs will produce calibrated products. Following an initial 2-month period at the beginning of the mapping phase, the ITFs will routinely deliver preliminary calibrated data products to the SDC for use by the entire MAVEN team within two weeks of ITF receipt of all data needed to generate those products. The SOC will maintain an active archive of all MAVEN science data, and will provide the MAVEN science team with direct access through the life of the MAVEN mission. After the end of the MAVEN project, PDS will be the sole long-term archive for all public MAVEN data.

Updates to calibrations, algorithms, and/or processing software are expected to occur regularly, resulting in appropriate production system updates followed by reprocessing of science data products by ITFs for delivery to SDC. Systems at the SOC, ITFs and PDS are designed to handle these periodic version changes.

Data bundles intended for the archive are identified in Table 7.

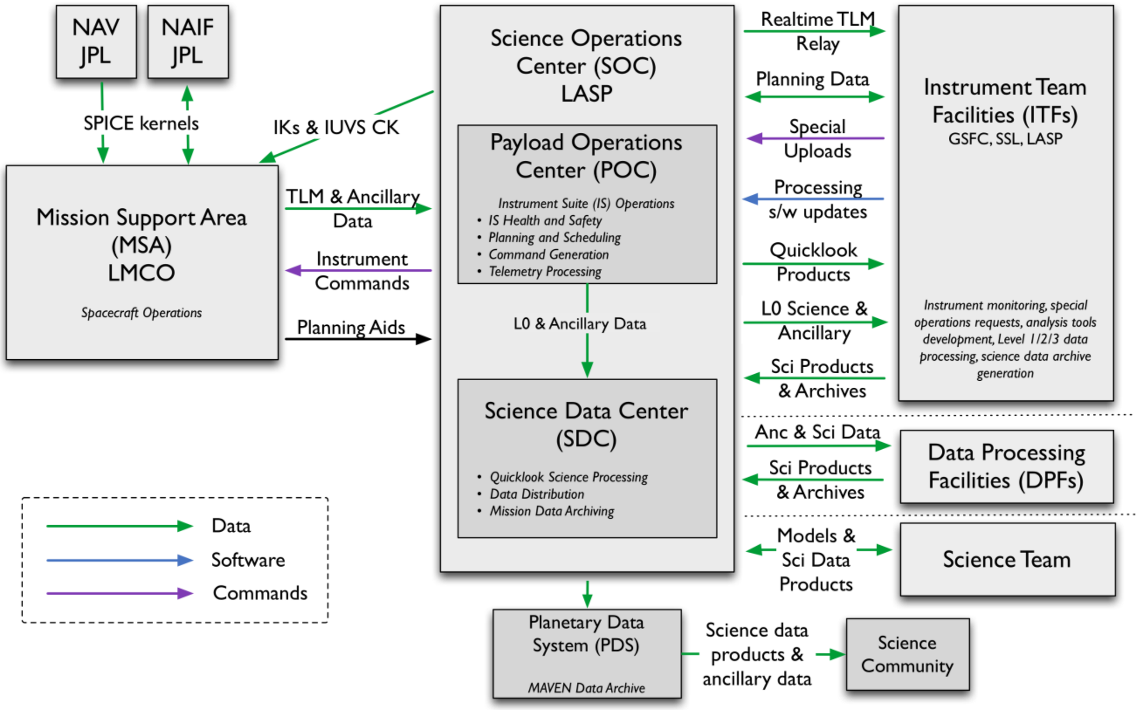


Figure 2: MAVEN Ground Data System responsibilities and data flow. Note that this figure includes portions of the MAVEN GDS which are not directly connected with archiving, and are therefore not described in Section 3.5 above.

4 Archive Generation

The IUVS archive products are produced by the IUVS instrument team in cooperation with the SDC, and with the support of the PDS Atmospheres Node at New Mexico State University. The archive volume creation process described in this section sets out the roles and responsibilities of each of these groups. The assignment of tasks has been agreed upon by all parties. Archived data received by the Atmos Node from the IUVS team are made available to PDS users electronically as soon as practicable but no later than two weeks after the delivery and validation of the data.

4.1 Data Processing and Production Pipeline

The following sections describe the process by which data products in each of the IUVS bundles listed in Table 7 are produced.

4.1.1 Raw Data Production Pipeline

Packets are received from the MAVEN SOC in the form of level 0 files. These files are parsed and individual packets are assembled into images. A sequence of images taken with the same instrument settings is considered a single "observation". There is one level 1A raw FITS file created for each observation for each channel. A raw file is also created for incomplete observations, where some but not all packets are present. A level 1A file is created for each observation taken, whether light or dark, and has exactly the same structure for any mode of instrument observation.

To create a level 1A file, packet data are decompressed, packets are assembled into images, and images into observations, which in general results in a 3D data array (2D if only one image is taken in the observation). This construction of images takes into account the detector binning settings in effect at the time the observation was taken.

A selection of engineering data necessary for calibrating the image is attached in the form of tables, but not converted into physical units. Geometry information is also calculated at this point. Details of the level 1A structure can be found in section 6.1.1.

Raw image production is done in the IDL language. Packets are indexed in a database so that when retransmitted packets are received, incomplete observations may be completed with a minimum amount of reprocessing. All processing is fully automatic and triggered by the arrival of new level 0 data at the SOC.

4.1.2 Calibrated Data Production Pipeline

The calibration pipeline converts images from engineering units to physical units, taking into account all necessary temperature and voltage measurements, subtracting dark images, and applying calibration curves constructed from pre-launch and in-flight calibration experiments. The system automatically pairs light images with the appropriate dark images and estimates the proper dark level to subtract from each image. A level 1B calibrated FITS file is constructed for each light 1A image, but not for dark images. Sufficient data are attached to the 1B file to reconstruct each step in the calibration process, for automatic or manual validation purposes.

The steps in the calibration process are as follows, done approximately in order:

1. The level 1A light image is opened and read into memory.
2. The temperature and intensifier voltage are converted from engineering to physical units, and the intensifier gain is calculated.

3. The background in each bin at each image time is estimated from the nearby dark image level 1A data and an estimate of scattered and other background light. This background is then subtracted.
4. The intensifier gain and integration time are used to convert from image DN values to photoevents per second.
5. The sensitivity curves (a function of wavelength and image pixel position) are used to convert photoevents per second into Rayleighs per nanometer in each image bin.
6. The level 1B file is created, with the primary image being this image in physical units. Attached calibration data are also stored in physical units where appropriate. Geometry is copied from the level 1A source file.

Details of the 1B structure are described in section 6.1.2.

Calibration is performed in the IDL language. The indexing system which identifies which 1A images to process or reprocess each time a new level 0 file comes in also decides which 1B files to process or reprocess.

4.1.3 Processed Data Production Pipeline

The processed data pipeline isolates spectral features and performs spatial binning using calibrated L1B images to produce L1C files. Unwanted backgrounds, such as solar continuum in airglow measurements, are also removed. This facilitates performing science in physical units, and is a necessary step before producing higher levels products. L1C files do not exist in a one-to-one ratio with L1B files, but aggregate information from multiple files produced for a given observation mode on a given orbit. This stage of processing is performed in the IDL language. It is triggered for each observation mode by the complete production of a series of L1B files for a given orbit. While all L1A and L1B data products have identical structure, this commonality diverges at L1C in a way that depends on the mode of observation.

The spectral and spatial processing may be carried out independently, and/or simultaneously depending on the observation mode. The distinct emission features that are isolated by spectral processing also differ from mode to mode. For example, many more spectral features are present in the limb scans than in the coronal scans. Spatial binning may be done on an altitude grid (limb scans and stellar occultations), or in latitude and longitude (disk imaging). Descriptions of the processing for various types of observation are given below. More details regarding the L1C structure for each mode are provided in Section 6.

Airglow: The production of L1C files for emission features from the limb and disk is somewhat complex, and warrants a detailed description here. The Martian UV dayglow spectrum represents a blended composite of many emission features, each of which are identified from their expected wavelength and spectral shape. The wavelength scale and dispersion relation are derived by fitting the composite blended spectrum to limb spectra near the airglow peak. The spectral shape of the features uses the IUVS point spread function, obtained from an IUVS observation of Lyman-α immediately after orbital insertion. The point spread function is fit with two Voigt profiles, where the widths of the profiles are adjusted to fit the brightest MUV features. The full width at half maximum of the point spread function is assumed to vary by 14% on the short wavelength edge compared to the long wavelength edge, consistent with what is measured in the laboratory.

1) The L1C periapse pipeline uses Multiple Linear Regression (MLR) to fit the spectral shape of all known FUV and MUV components. The MUV MLR components are the following (* indicates feature from which densities are retrieved): CO Cameron bands. CO Cameron band uses two temperature (800 K/6000K) to fit the IUVS observations. The temperatures are used to describe two different Bolztmann distributions that switch at the 20th rotational level.
2) O I 297.2 multiplet.
3) CO_2^+ Ultraviolet Doublet*
4) N_2 Vegard-Kaplan bands*
5) CO_2^+ Fox-Duffendack-Barker bands*
6) Mg^+ 280 nm multiplet*
7) Mg 285 nm doublet
8) Fe multiplets
9) Fe^+ multiplets
10) Solar continuum. This represents scattered light from the atmosphere and/or within the instrument, primarily at the lowest tangent altitudes. Here an IUVS observation of scattered sunlight from the Martian disk at apoapse is used.

These ten components are calculated at high spectral resolution (≤ 1 Å), smoothed with the point spread function and sampled according to the derived IUVS dispersion relation. The 10 emission features therefore yield independent vectors across the passband, each with its own spectral shape.

Each of the emission features is targeted in a wavelength window surrounding the feature. All blended emissions that contribute to the emission within the window are fit using MLR. Intensities of targeted features are inferred by subtracting all other contributions to the spectrum. To derive the brightness of given emissions, the fit spectrum is summed spectrally and spatially (along the slit) and binned at 5 km altitude bins producing 1d profiles. The parameter uncertainties are derived from the MLR for the residual spectrum at each altitude.

The FUV MLR components are the following (* indicates feature from which densities are retrieved):

1) H Lyman-α
2) O 130.4 multiplet. Relative intensities of the O I 130.4 are taken from Meier [Space Sci. Rev., 58,1-185, 1991]
3) O 135.6 multiplet*.
4) O 115.2 multiplet
5) CO Cameron bands.
6) CO Hopfield-Birge bands.
7) CO Fourth Positive bands*. CO 4PG fitting includes a total of 3 components: photodissociation of CO_2, split into an optically thick component (v"=0) and an optically thin component (v">0); and CO 4PG bands (v"=0) pumped by solar C IV photons at 155 nm.
8) N_2 Lyman-Birge-Hopfield bands*.
9) C 127.7 multiplet
10) C 165.7 multiplet*
11) C 160.3 multiplet
12) C 156.1 multiplet*

13) C 132.9 multiplet
14) C^+ 133.6 multiplet
15) C^+ 152.9 multiplet*
16) N 120.0 multiplet
17) N 149.3 multiplet
18) Solar continuum

Analogous to the MUV approach, the wavelength scale and the dispersion relation are derived by fitting all of the FUV components to limb spectra near the airglow peak. Each component is calculated at high spectral resolution (≤ 1 Å), smoothed with the IUVS point spread function and sampled according to the derived IUVS dispersion relation. The point spread function uses the same FUV observation of Lyman-α from the sunlit disk fit with two Voigt functions, whose widths are modified over the passband to fit the data as described above for the MUV. Each retrieved FUV feature is targeted in a narrow wavelength window that is specific to that feature.

Disk Imaging: The L1C files for disk imaging contain a spectral reflectance derived from MUV light reflected by the planet. For each spectral bin between 210-295 nm, the L1B brightness is divided by the synthetic solar flux calculated by an IUVS instrument simulator with the same instrumental settings and geometry as the observation.

Stellar Occultation: The L1C files for stellar occulations include an unocculted reference spectrum, a series of transmission spectra, and geometry data. The data to calculate the reference and transmission spectra are taken as DN (data number: from the `'detector_dark_subtracted'` HDU) in the corresponding L1B file. These data are already dark corrected but no not include background correction (e.g. scattered sunlight). Thus a background correction together with a correction of the Lyα and O_2 airglow for the FUV channel is performed before calculating the transmission spectra. The transmission spectra are obtained by dividing the attenuated spectrum at each recorded altitude by the reference spectrum. The reference spectrum is calculated as the mean value of the spectrum for altitudes well above the level at which absorption is measurable (typically ~ 170 km).

4.1.4 Derived Data Production Pipeline

The derived data pipeline converts the discrete feature brightnesses of L1C processed data into L2 files containing profiles and maps of densities and column abundances. There is a one-to-one correspondence between L1C and L2 files. Each observation mode has an independent software pipeline that uses a physical forward model and fitting routines to retrieve the atmospheric characteristics from the observed radiances.

This stage of processing involves multiple computer languages (e.g. FORTRAN, C++, IDL), but a master software driver in the IDL language controls all the pipelines. It is triggered by the production of L1C files for a given orbit.

A high level description of the processing performed for each observation mode is given below.

Limb Scans

Retrieval Algorithm: The Generalized Retrieval and ANalysis Tool (GRANT), developed by Computational Physics, Inc. (CPI), infers atmospheric composition from terrestrial and extraterrestrial dayglow observations. This tool merges CPI's Atmospheric Ultraviolet Radiance Integrated Code (AURIC) and OPTimal estimation (hereafter OPT) retrieval algorithms. The GRANT framework uses AURIC as a forward model driver for the optimal estimation routines in OPT, deriving an optimal atmospheric state solution by minimizing the difference between forward model calculations and measurements. The forward model calculations assume isotropy, which is a safe approximation for solar zenith angles below 60°.

Forward Model: The AURIC software package was developed by CPI for upper atmospheric radiance modeling from the FUV to the NIR. Many enhancements have been made to AURIC since its inception, including a more comprehensive chemistry model (for neutral and ionospheric species), new radiative transfer capabilities, the option of performing photoelectron energy degradation with or without vertical transport, updates to electron impact cross sections, and the addition of new emission features. Upgrades made to allow modeling of the Martian atmosphere include: 1-D Mars photochemistry and molecular transport; and the addition of the following molecular band systems: CO Cameron; CO Fourth Positive Group; CO_2^+ Fox–Duffendack–Barker; CO_2^+ UV Doublet; CO Hopfield-Birge (B-X); and CO^+ First Negative Group.

CO_2 Retrieval Algorithm: IUVS observations of the CO_2^+ UVD (B $^2\Pi_u^+ \rightarrow$ X $^2\Pi_g$) transition are used to retrieve CO_2 number densities in the Martian atmosphere. Fluorescent scattering of sunlight by CO_2^+ ignored as a source of emission since it contributes less than ten percent to the total UVD emission at altitudes below ~200 km. CO_2 density retrievals use a total of 20 parameters for each CO_2^+ UVD limb scan: 19 constituent densities on a fixed altitude grid (10 km from 80 to 170 km and an exponential grid up to 600 km) and a forward model brightness scale factor. Retrieved CO_2 densities reported in Level 2 FITS files are constrained to 130 – 193 km.

Temperature Profile Retrieval Algorithm: The algorithm first calculates a mean upper atmospheric temperature by inferring a scale height from retrieved CO_2 densities from 170 – 220 km. A geopotential altitude is use to account for changes in gravitational acceleration with altitude. The scale-height inferred temperature is then use to derive a temperature profile by integrating the hydrostatic equilibrium equation for CO_2 downward from the upper boundary to obtain the local partial pressure of CO_2. The temperature is then derived from the partial pressure using the ideal gas law. Retrieved temperatures reported in Level 2 FITS files are constrained to 130 – 193 km.

N_2 Retrieval Algorithm: We use IUVS MUV observations of the N_2 Vegard-Kaplan (A $^3\Sigma_u^+$ $\rightarrow$ X $^3\Sigma_g^+$) transition to retrieve N_2 number densities. The N_2 density retrievals use a total of 16 parameters for each N_2 VK limb scan: 15 constituent densities and a forward model brightness scale factor. The retrieval altitude grid is based on the N_2 scale height from 80 to ~220 km and an exponential grid up to 600 km. Retrieved N_2 densities reported in Level 2 FITS files are constrained to 125 – 217 km.

CO_2^+ Retrieval Algorithm: We use IUVS MUV observations of the CO_2^+ Fox-Duffendack-Barker (A $^2\Pi_u$ $\rightarrow$ X $^2\Pi_g$) transition to retrieve CO_2^+ number densities. The CO_2^+ density retrievals use a total of 20 parameters for each CO_2^+ FDB limb scan: 19 constituent densities on a fixed altitude grid (20 km from 80 to 120 km, 10 km from 120 to 140 km, and an exponential grid up to 600 km). Retrieved CO_2^+ densities reported in Level 2 FITS files are constrained to 155 – 290 km.

FUV Apoapse Disk Scans

CO/CO_2 Retrieval Algorithm: CO/CO_2 column density ratios are derived by comparing observed brightness ratios with a pre-computed theoretical lookup table containing brightness ratios mapped to column density ratios. The brightnesses used with the CO/CO_2 column density ratio algorithm are the sum of v"=0 bands and the sum of v">0 bands from the CO Fourth Positive Group (4PG) molecular band system. While there are multiple sources of CO 4PG emission from CO, CO_2, and CO_2^+, emissions resulting from transitions that terminate in the ground state (v"=0) are primarily diagnostic of variability in thermal CO molecules through self-absorption (regardless of the source of emission or excitation mechanism), whereas emissions from transitions terminating in v">0 are primarily diagnostic of changes in the CO_2 density through dissociative processes leading to CO 4PG emissions. The MLR CO 4PG v"=0 and v">0 templates assume vibrational populations appropriate for photodissociation of CO_2 producing CO 4PG, but are treated as representative of all sources of emission even though the vibrational populations differ across the various sources. Errors and biases in MLR retrievals of CO 4PG emissions introduced by an assumed vibrational population are considered to be small compared to errors and biases resulting from underdetermined MLR retrievals when using vibrational populations appropriate for each source of CO 4PG emission (i.e. when using two templates for each source, one each for v"=0 and v">0). It should be mentioned that the MLR template for solar C IV pumping of CO 4PG is not currently being used for deriving CO/CO_2 column density ratios.

The pre-computed theoretical lookup table is generated using CPI's AURIC forward model. The forward model is run for a range of solar zenith angles and model atmospheres with different scale factors applied to the CO and CO_2 density profiles. The resulting set of solar zenith angles, brightness ratios, and column density ratios is first examined to ensure that the brightness ratio to column density ratio correspondence is unique, i.e. a given brightness ratio can only arise from an atmosphere with a particular column density ratio (with some associated uncertainty). The lookup table is constructed such that there is a grid of brightness ratios, one for each column density ratio at each solar zenith angle. The dimensionality of the table is first reduced by interpolating the model brightness ratios at the observed solar zenith angle, resulting in a curve of column density ratios as a function of model brightness ratios. It is then straightforward to interpolate on brightness ratio. Note that no extrapolation is done, so that column density ratios are not computed for observed brightness ratios outside the range of modeled brightness ratios. Furthermore, column density ratios are not computed for Level 1C pixels that are outside a pre-determined range of solar zenith and emission angles. The current range for both quantities is 0 – 75 degrees. The forward model runs used to construct the look tables assume an emission angle of 0 degrees. While sensitivity studies suggest there is little error introduced by neglecting emission angle effects, future versions of this algorithm are planned to include an emission angle dimension in the lookup table.

O/CO_2 Retrieval Algorithm: O/CO_2 column density ratios are derived by comparing observed O I 135.6 nm brightnesses with a pre-computed theoretical lookup table of model O I 135.6 nm brightnesses. As with the CO/CO_2 algorithm, the pre-computed theoretical lookup table is generated using CPI's AURIC forward model. The forward model is run for an assumed atmosphere and a range of solar zenith angles, emission angles, and total energy flux of the solar irradiance from 1–45 nm (hereafter Q_{EUV}). The lookup table is constructed such that there is a grid of brightness values, one for each solar zenith angle, emission angle, and Q_{EUV}. The dimensionality of the table is reduced by interpolating the model brightnesses at the observed solar zenith angle, emission angle, and Q_{EUV}. The assumed O number density, integrated in altitude to a reference CO_2 column density of 10^{16} cm^{-3}, is then multiplied by the ratio of the observed and modeled O I 135.6 nm brightnesses. Note that no extrapolation is done, so that column density ratios are not computed for observed brightnesses outside the range of predicted model values. Furthermore, column density ratios are not computed for Level 1C pixels that are outside a pre-determined range of Q_{EUV} and solar zenith and emission angles. The current range for both angles is 0 – 80 degrees.

Coronal Scans

The current L2 coronal scan files report a profile of atomic O column densities in units of cm^{-2} along the instrument line of sight. These are derived by applying a g-factor to the O I 130.4 nm brightnesses in the L1C files. This assumes that the emission is optically thin, which should be accurate for tangent altitudes > 400 km. Due to the weak signal of the coronal O I emission, these products are susceptible to artifacts due to cosmic ray hits on the detector and background from Ly-α photons scattered inside the instrument. The currently reported uncertainties do not accurately reflect the contributions from these sources of noise. A more robust pipeline is currently in development.

MUV Apoapse Disk Scans

L2 MUV apoapse files are produced according to a methodology inspired from the algorithm in use to process the Mars Express/SPICAM data (Perrier et al., JGR, 111, 2006). The final products contained in the L2 files are the ozone vertically-integrated column (micrometer-atmosphere), the vertically-integrated dust opacity in the MUV (unitless), and the MUV surface albedo (unitless). The first step is to generate spectral reflectance (L1C), which is explained earlier. The spectral reflectance is then fitted by a forward model using the SHDOM (Spherical Harmonics Discrete Ordinate Method) radiative transfer code (Evans, J. Atmos. Sci., 1998). This code takes into account the specific geometry for each spatial bin (ground elevation, solar zenith angle, phase angle, emission angle) as well as a model of atmosphere calculated by a GCM for the appropriate season and location. The pipeline then minimizes the chi-square deviation between the simulated and observed reflectance over all the spectral bins between 210-295 nm. The result is a best fit model for the ozone column, the dust opacity, and the surface albedo. The parameters uncertainties and goodness-of-fit are also provided.

The formation of ozone occurs through a three-body reaction that is favored by large atmospheric pressures. As a result, on Mars, the largest ozone concentrations are often found near the surface. In those conditions (all other things being equal), the ozone vertically-integrated column is positively correlated with the surface pressure and topography. This inverse relationship is particularly visible at polar latitudes in the high-resolution images obtained from IUVS, showing for instance distinct O_3 column maxima inside impact craters. The user of the

IUVS O_3 column data may want to filter out the effect of surface pressure/topography in order to study the other factors contributing to ozone variations, such as primarily the amount of water vapor. This is why for each of the IUVS O_3 column data point, is also provided the surface pressure p_s calculated by a GCM and a high-resolution terrain model. Thus, it is possible to scale the retrieved O_3 column to a reference pressure level p_{ref} (e.g., 6 hPa) by simply multiplying the O_3 column by p_s/p_{ref}.

Stellar Occultations

The L2 files for stellar occultations include the slant column densities for CO_2, O_2, and O_3 in cm^{-2} as well as the aerosol parameters (the Angstrom coefficient and the optical depth at 1000 nm). Furthermore these L2 files include the local number densities of CO_2, O_2, and O_3 in cm^{-3} together with the temperature in K and the atmospheric pressure in Pa.

The measured transmission spectrum given in the L1C file is fitted at each altitude using the Levenberg-Marquardt algorithm to retrieve the best-fit column densities and aerosol parameters. These column density profiles are inverted to get the corresponding local densities by using the Tikhonov regularization method. The obtained CO_2 number density is furthermore used to calculate the temperate and pressure profiles by applying the constraint of hydrostatic equilibrium to it. The altitude range with usable data is limited to the quality of the transmission spectrum and the success of the fit. `NaN` values in the number density, temperature, and pressure profiles indicate altitudes which could not be fit.

For PDS release v04 the O_2 is tied by a factor of 2 x 10^{-3} to the fitted CO_2 values at altitudes below 90 km (which represent the MUV channel). The combined FUV and MUV transmission spectrum in the transition region between 80 and 100 km shows high fluctuations that propagate in the temperature profiles and thus the uncertainties in this altitude range are increased. Problems with fitting aerosol contribution occur in most of the MUV transmission region, and so the temperature uncertainties at altitudes below 60 km are increased in the current release.

4.2 Data Validation

4.2.1 Instrument Team Validation

Data products generated from the automated pipeline described in 4.1 are spot-checked after every downlink by the IUVS ITF. A low-level data summary overview of the mission to date is also internally maintained to facilitate identification of anomalies. As the mission progresses and familiarity with the operational idiosyncrasies of the instrument advances, automated procedures for validating data products are being developed as appropriate.

4.2.2 MAVEN Science Team Validation

It is anticipated that individual scientists on the MAVEN Science Team will perform their own validation of the data after dissemination of the data products. The IUVS ITF welcomes input from these contributors to improve the automated data product processing pipeline and instrument team validation process.

4.2.3 PDS Peer Review

The Atmos node will conduct a full peer review of all of the data types that the IUVS team intends to archive. The review data will consist of fully formed bundles populated with candidate final versions of the data and other products and the associated metadata.

Table 8: MAVEN PDS review schedule

Date	Activity	Responsible Team
2014-May through 2014-Aug	Calibrated and derived data product, archive structure, and SIS peer review	SDC
2014-Nov-01	Start of Science Operations	
2015-Mar-02	Delivery #1 Due to PDS	ITF/SDC
2015-Mar through 2015-Apr	Calibrated and derived data peer review	PDS
2015-May-01	Delivery #1 Release to the Public (Start of Science Ops + 6 months)	PDS

Reviews will include a preliminary delivery of sample products for validation and comment by PDS Atmos and Engineering node personnel. The data provider will then address the comments coming out of the preliminary review, and generate a full archive delivery to be used for the peer review.

Reviewers will include MAVEN Project and IUVS team representatives, researchers from outside of the MAVEN project, and PDS personnel from the Engineering and Atmos nodes. Reviewers will examine the sample data products to determine whether the data meet the stated science objectives of the instrument and the needs of the scientific community and to verify that the accompanying metadata are accurate and complete. The peer review committee will identify any liens on the data that must be resolved before the data can be ‘certified’ by PDS, a process by which data are made public as minor errors are corrected.

In addition to verifying the validity of the review data, this review will be used to verify that the data production pipeline by which the archive products are generated is robust. Additional deliveries made using this same pipeline will be validated at the Atmos node, but will not require additional external review.

As expertise with the instrument and data develops the IUVS team may decide that changes to the structure or content of its archive products are warranted. Any changes to the archive products or to the data production pipeline will require an additional round of review to verify that the revised products still meet the original scientific and archival requirements or whether those criteria have been appropriately modified. Whether subsequent reviews require external reviewers will be decided on a case-by-case basis and will depend upon the nature of the changes. A comprehensive record of modifications to the archive structure and content is kept in the Modification_History element of the collection and bundle products.

The instrument team and other researchers are encouraged to archive additional IUVS products that cover specific observations or data-taking activities. The schedule and structure of any additional archives are not covered by this document and should be worked out with the Atmos node.

4.3 Data Transfer Methods and Delivery Schedule

The SOC is responsible for delivering data products to the PDS for long-term archiving. While ITFs are primarily responsible for the design and generation of calibrated and derived data archives, the archival process is managed by the SOC. The SOC (in coordination with the ITFs) will also be primarily responsible for the design and generation of the raw data archive. The first PDS delivery will take place within 6 months of the start of science operations. Additional deliveries will occur every following 3 months and one final delivery will be made after the end of the mission. Science data are delivered to the PDS within 6 months of its collection. If it becomes necessary to reprocess data which have already been delivered to the archive, the ITFs will reprocess the data and deliver them to the SDC for inclusion in the next archive delivery. A summary of this schedule is provided in Table 9 below.

Each delivery will comprise both data and ancillary data files organized into directory structures consistent with the archive design described in Section 5, and combined into a deliverable file(s) using file archive and compression software. When these files are unpacked at the Atmos Node in the appropriate location, the constituent files will be organized into the archive structure.

Archive deliveries are made in the form of a "delivery package". Delivery packages include all of the data being transferred along with a transfer manifest, which helps to identify all of the products included in the delivery, and a checksum manifest which helps to insure that integrity of the data is maintained through the delivery. The format of these files is described in Section 6.4.

Table 9: Archive bundle delivery schedule

Bundle Logical Identifier	First Delivery to PDS	Delivery Schedule	Estimated Delivery Size
urn:nasa:pds:maven.iuvs.raw	No later than 6 months after the start of science operations	Every 3 months	14 GB
urn:nasa:pds:maven.iuvs.calibrated	No later than 6 months after the start of science	Every 3 months	39 GB

	operations		
urn:nasa:pds:maven.iuvs.processed	No later than 6 months after the start of science operations	Every 3 months	5 GB
urn:nasa:pds:maven.iuvs.derived	No later than 6 months after the start of science operations	Every 3 months	6 GB

Data are transferred electronically (using the *sftp* protocol) from the SOC to an agreed upon location within the Atmos file system. Atmos will provide the SOC a user account for this purpose. Each delivery package is made in the form of a compressed *tar* or *zip* archive. Only those files that have changed since the last delivery are included. The Atmos operator will decompress the data, and verify that the archive is complete using the transfer and MD5 checksum manifests that were included in the delivery package. Archive delivery status will be tracked using a system defined by the Atmos node.

Following receipt of a data delivery, Atmos will reorganize the data into its PDS archive structure within its online data system. Atmos will also update any of the required files associated with a PDS archive as necessitated by the data reorganization. Newly delivered data are made available publicly through the Atmos online system once accompanying labels and other documentation have been validated. It is anticipated that this validation process will require no more than fourteen working days from receipt of the data by Atmos. However, the first few data deliveries may require more time for the Atmos Node to process before the data are made publicly available.

The MAVEN prime mission begins approximately 5 weeks following MOI and lasts for 1 Earth-year. Table 9 shows the data delivery schedule for the entire mission.

4.4 Data Product and Archive Volume Size Estimates

IUVS data products consist of files that span a sequence of images taken with the same instrument settings. Files vary in size depending on the observation mode (limb scan, coronal scan, disk imaging, stellar occultation) as well as the telemetry rate and allocation.

4.5 Data Validation

Routine data deliveries to the PDS are validated at the Atmos node to ensure that the delivery meets PDS standards, and that the data conform to the SIS as approved in the peer review. As long as there are no changes to the data product formats, or data production pipeline, no additional external review will be conducted.

4.6 Backups and duplicates

The Atmos Node keeps three copies of each archive product. One copy is the primary online archive copy, another is an onsite backup copy, and the final copy is an off-site backup copy. Once the archive products are fully validated and approved for inclusion in the archive, copies of the products are sent to the National Space Science Data Center (NSSDC) for long-term archive in a NASA-approved deep-storage facility. The Atmos Node may maintain additional copies of the archive products, either on or off-site as deemed necessary. The process for the dissemination and preservation of IUVS data is illustrated in Figure 3.

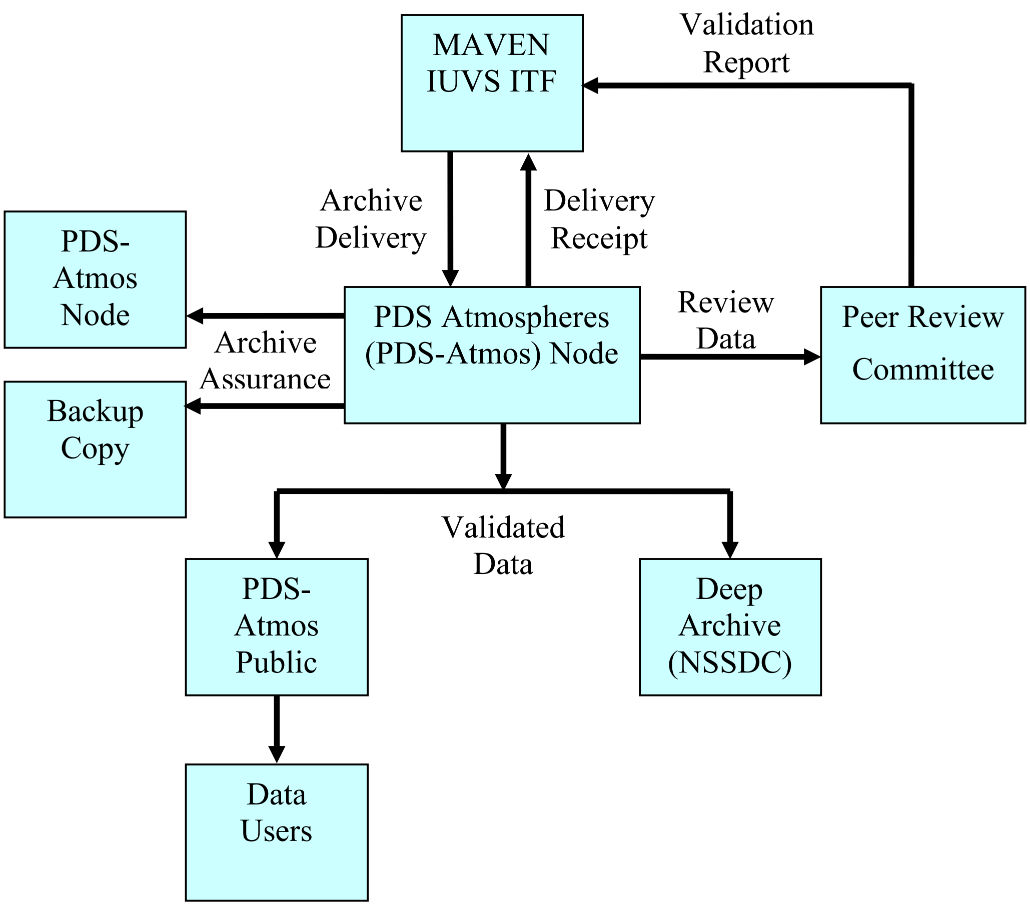


Figure 3: Duplication and dissemination of IUVS archive products at PDS/Atmos.

5 Archive organization and naming

This section describes the basic organization of an IUVS bundle, and the naming conventions used for the product logical identifiers, and bundle, collection, and basic product filenames.

5.1 Logical Identifiers

Every product in PDS is assigned an identifier which allows it to be uniquely identified across the system. This identifier is referred to as a Logical Identifier or LID. A LIDVID (Versioned Logical Identifier) includes product version information, and allows different versions of a specific product to be referenced uniquely. A product's LID and VID are defined as separate attributes in the product label. LIDs and VIDs are assigned by the entity generating the labels and are formed according to the conventions described in sections 5.1.1 and 5.1.2 below. The uniqueness of a product's LIDVID may be verified using the PDS Registry and Harvest tools.

5.1.1 LID Formation

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

MAVEN IUVS LIDs are formed according to the following conventions:

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

  urn:nasa:pds:maven.iuvs.<bundle ID>

  Since all PDS bundle LIDs are constructed this way, the combination of maven.IUVS.bundle must be unique across all products archived with the PDS.

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

  urn:nasa:pds:maven.iuvs.<bundle ID>:<collection ID>

  Since the collection LID is based on the bundle LID, which is unique across PDS, the only additional condition is that the collection ID must be unique across the bundle. Collection IDs correspond to the collection type (e.g. "browse", "data", "document", etc.).

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

  urn:nasa:pds:maven.iuvs.<bundle ID>:<collection ID>:<product ID>

  Since the product LID is based on the collection LID, which is unique across PDS, the only additional condition is that the product ID must be unique across the collection. See Appendix B for a detailed explanation of IUVS product ID descriptor conventions.

A list of IUVS bundle LIDs is provided in Table 7. Collection LIDs are listed in Table 14 through Table 15.

5.1.2 VID Formation

Product version ID's consist of major and minor components separated by a "." (M.n). Both components of the VID are integer values. The major component is initialized to a value of "1", and the minor component is initialized to a value of "0". The minor component resets to "0" when the major component is incremented.

5.2 IUVS Archive Contents

The IUVS archive includes the 4 bundles listed in Table 7. Each bundle corresponds to a data reduction level (raw, calibrated, processed, and derived). All data products have identical structure at the raw (L1A) and calibrated (L1B) reduction levels. Data product structure becomes unique for each observation mode at the processed (L1C) and derived (L2) reduction levels. The following sections describe the contents of each of these bundles in greater detail.

5.2.1 Common IUVS Collections

There are a number of collections that are common across multiple IUVS bundles. These include the documentation collection, along with a number of data collections. The data collections are distinguished by mission phase or observation target. These cover the cruise and transition phases of the MAVEN mission, as well as the five nominal science observation modes (limb, corona, echelle, disk, and occultation). Within each bundle, the data in these collections is of the appropriate reduction level. Descriptions of the nature of the data in each of these collections are provided below. Since these collections exist in multiple bundles, the generic identifier <bundle ID> is used in the LID descriptions.

Table 10 Common IUVS Collections

Collection LID	Description
urn:nasa:pds:maven.iuvs.<bundle ID>:cruise	FITS files with cruise phase data
urn:nasa:pds:maven.iuvs.<bundle ID>:transition	FITS files with transition phase data
urn:nasa:pds:maven.iuvs.<bundle ID>:limb	FITS files with limb scan data
urn:nasa:pds:maven.iuvs.<bundle ID>:corona	FITS files with coronal scan data
urn:nasa:pds:maven.iuvs.<bundle ID>:echelle	FITS files with echelle mode data
urn:nasa:pds:maven.iuvs.<bundle ID>:disk	FITS files with disk scan data
urn:nasa:pds:maven.iuvs.<bundle ID>:occultation	FITS files with stellar occultation data
urn:nasa:pds:maven.iuvs.<bundle ID>:phobos	FITS files with Phobos data
urn:nasa:pds:maven.iuvs.<bundle ID>:document	Documentation for the bundle
urn:nasa:pds:maven.iuvs.<bundle ID>:context	PDS context products referenced by products in the archive bundle.
urn:nasa:pds:maven.iuvs.<bundle ID>:xml_schema	XML schema and Schematron files referenced by products in the archive bundle.

5.2.1.1 Document Collection

The iuvs.<bundle ID>:document collection contains documents that are useful for understanding and using the IUVS data products. Table 11 contains a list of the documents included in this collection, along with the LID, and responsible group. Following this a brief description of each document is also provided.

Table 11: IUVS Science Data Documents

Document Name	LID	Responsibility
MAVEN Science Data Management Plan	urn:nasa:pds:maven:document:sdmp	MAVEN Project
MAVEN IUVS Archive SIS	urn:nasa:pds:maven.iuvs:document:sis	IUVS Team
MAVEN Mission Description	urn:nasa:pds:maven:document:mission.description	MAVEN Project
MAVEN Spacecraft Description	urn:nasa:pds:maven:document:spacecraft.description	MAVEN Project
IUVS Instrument Description	urn:nasa:pds:maven.iuvs:document: iuvs.instrument.description	IUVS Team
IUVS Calibration Description	urn:nasa:pds:maven.iuvs.calibrated:document:calibration.description	IUVS Team

MAVEN Science Data Management Plan – describes the data requirements for the MAVEN mission and the plan by which the MAVEN data system will meet those requirements

MAVEN IUVS Archive SIS – describes the format and content of the IUVS PDS data archive, including descriptions of the data products and associated metadata, and the archive format, content, and generation pipeline (this document)

MAVEN Mission Description – describes the MAVEN mission.

MAVEN Spacecraft Description – describes the MAVEN spacecraft.

IUVS Instrument Description – describes the MAVEN IUVS instrument.

IUVS Calibration Description – describes the algorithms and procedures used to apply the calibration performed on the data included in this bundle.

While responsibility for the individual documents varies, the document collection itself is managed by the PDS/Atmos node.

5.2.1.2 Context Collection

The iuvs.<bundle ID>:context collection contains a list of the context products describing objects referenced by products in the IUVS data bundle. Context products are used to define the LID's by which PDS4 data products identify the objects which form the context in which the scientific observations were made (e.g. spacecraft, instrument, target, etc.). These products are created and maintained by PDS and are listed here for reference only.

Table 12: IUVS Science Data Context Objects

Context Object	LID
MAVEN Mission	urn:nasa:pds:context:investigation:mission.maven
MAVEN Spacecraft	urn:nasa:pds:context:instrument_host:spacecraft.maven
MAVEN IUVS Instrument	urn:nasa:pds:context:instrument:iuvs.maven
Mars	urn:nasa:pds:context:target:planet.mars

5.2.1.3 XML_Schema Collection

The iuvs.<bundle ID>:xml_schema collection contains a list of the XML schema and Schematron documents which define the correct format and content for PDS4 metadata files.

The PDS4 master schema and Schematron are produced, managed, and provided to MAVEN by PDS. The MAVEN mission manages the MAVEN mission schema and Schematron which contain parameter definitions which are unique to the MAVEN project.

Table 13: IUVS Science Data XML_Schema Products

XML Document	Steward	Product LID
PDS Master Schema, v. 1.3.0.1	PDS	urn:nasa:pds:system_bundle:xml_schema:pds-xml_schema
PDS Master Schematron, v. 1.3.0.1	PDS	urn:nasa:pds:system_bundle:xml_schema:pds-xml_schema
PDS Display Schema, v. 1.0.0.4	PDS	urn:nasa:pds:system_bundle:xml_schema:pds-display
PDS Display Schematron, v. 1.0.0.4	PDS	urn:nasa:pds:system_bundle:xml_schema:pds-display

5.2.1.4 IUVS Cruise Collection

The iuvs.<bundle ID>:cruise collection contains data products from the IUVS observations made during the cruise phase of the MAVEN mission from Nov 18, 2013 through Sep 21, 2014. These include the initial instrument checkout, a campaign that attempted to observe comet C/2012 S1 (ISON) after periapsis, several months of observing interplanetary hydrogen, and two calibration sequences based on observations of stars and Mars.

5.2.1.5 IUVS Transition Collection

The iuvs.<bundle ID>:transition collection contains data products from the IUVS observations made during the transition phase of the MAVEN mission between Mars Orbital Insertion (MOI) on Sep 21, 2014 and the start of nominal science operations in November 2014. These include two APP calibration sequences, a 1 orbit campaign to observe comet C/2013 A1 (Siding Spring).

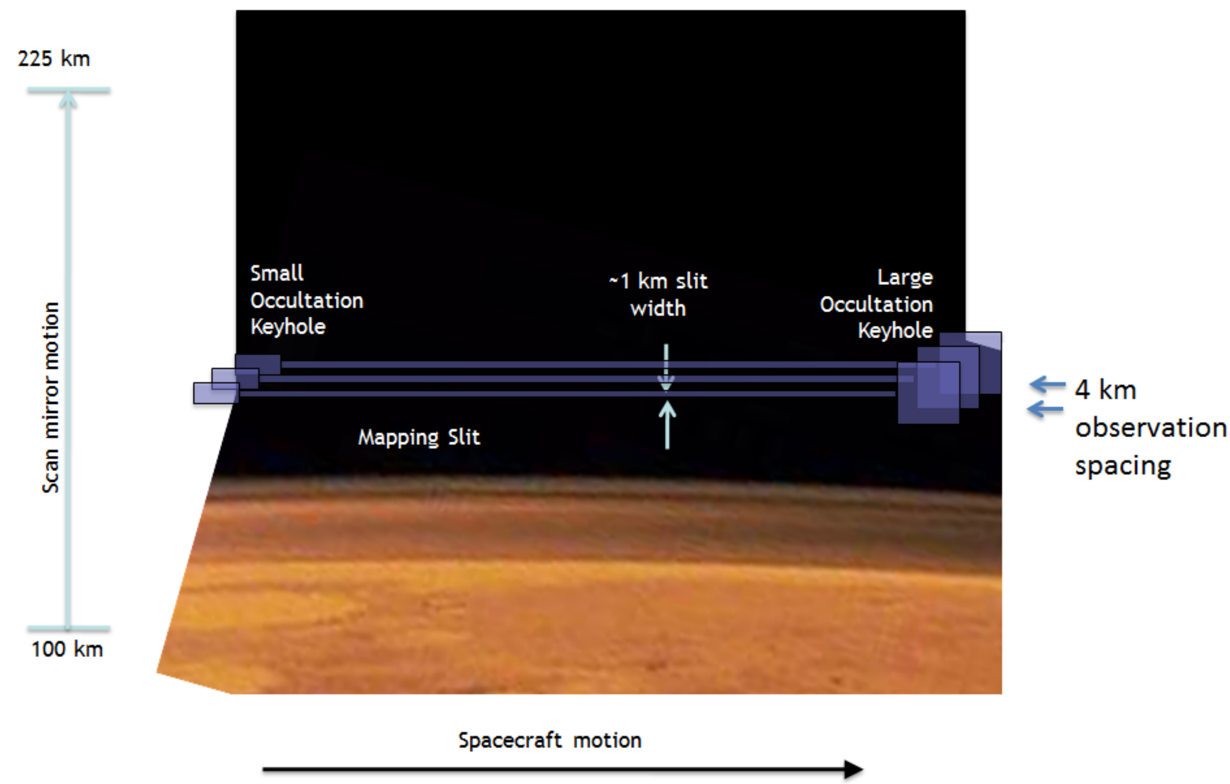
5.2.1.6 IUVS Calibration Activity Collection

The iuvs.<bundle ID>:calibration data collection contains data products for special calibration activities. These data expand, compliment, confirm, or track changes from the calibration activities performed during the cruise and transition period of the mission. The most common product is Ly-α centroid observations that monitor the detector wavelength scale after moving the echelle grating.

5.2.1.7 IUVS Limb Collection

The iuvs.<bundle ID>:limb data collection contains data products for limb scan observations of the Martian thermosphere. Each limb scan is composed of multiple integrations from the IUVS. At periapsis there are twelve vertical limb scan profiles during orbits where IUVS has pointing priority. An additional limb scan is obtained during the outbound side segment of the MAVEN orbit. Each limb scan aims to include the range of 100-200 km, with a vertical resolution of at least 4 km.

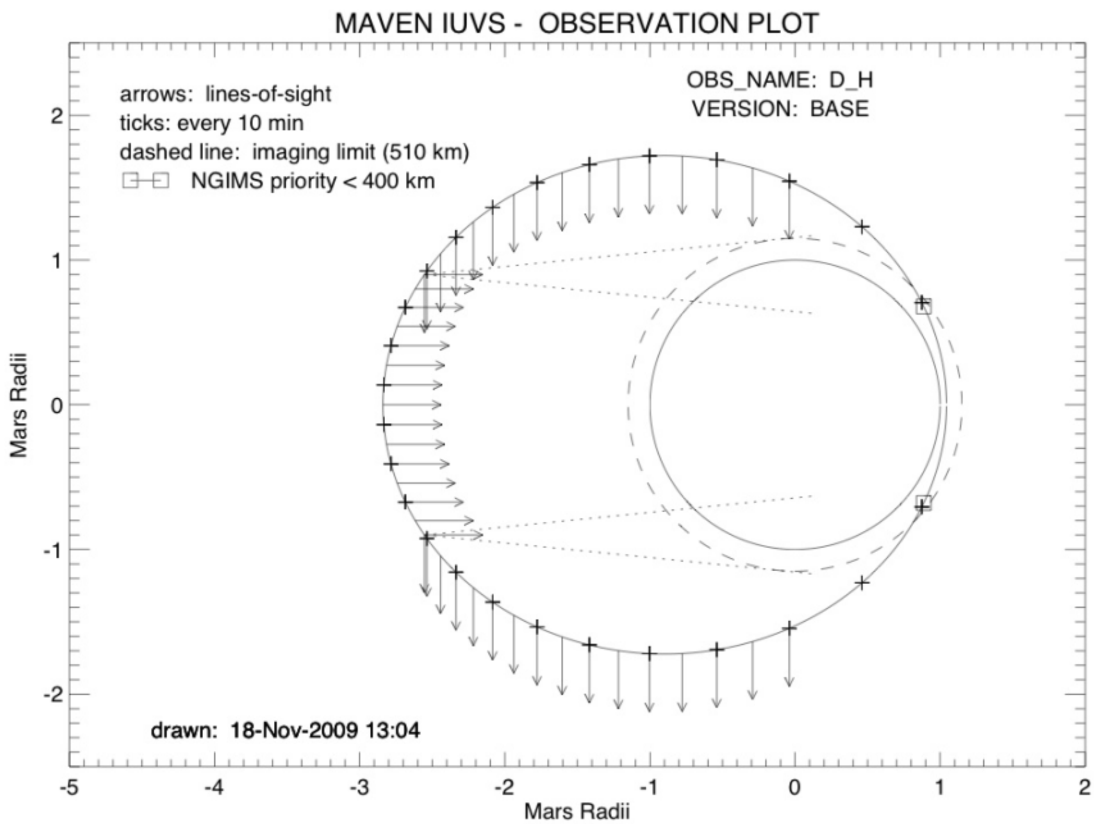
Figure 4 Limb scan observation geometry



5.2.1.8 IUVS Corona Collection

The iuvs.<bundle ID>:corona data collection contains data products for coronal scans of the extended Martian atmosphere during the side segments of the MAVEN orbit when IUVS has pointing priority. From orbit to orbit when IUVS has priority, it alternates between the low spectral resolution coronal scan mode described here, and the echelle mode described in the next section. The coronal scans have three distinct components: scanning while outbound above the Martian limb, inbound above the limb, and inbound below the limb (when the planet intersects the instrument line-of-sight projected backward).

Figure 5 Coronal scan observation geometry



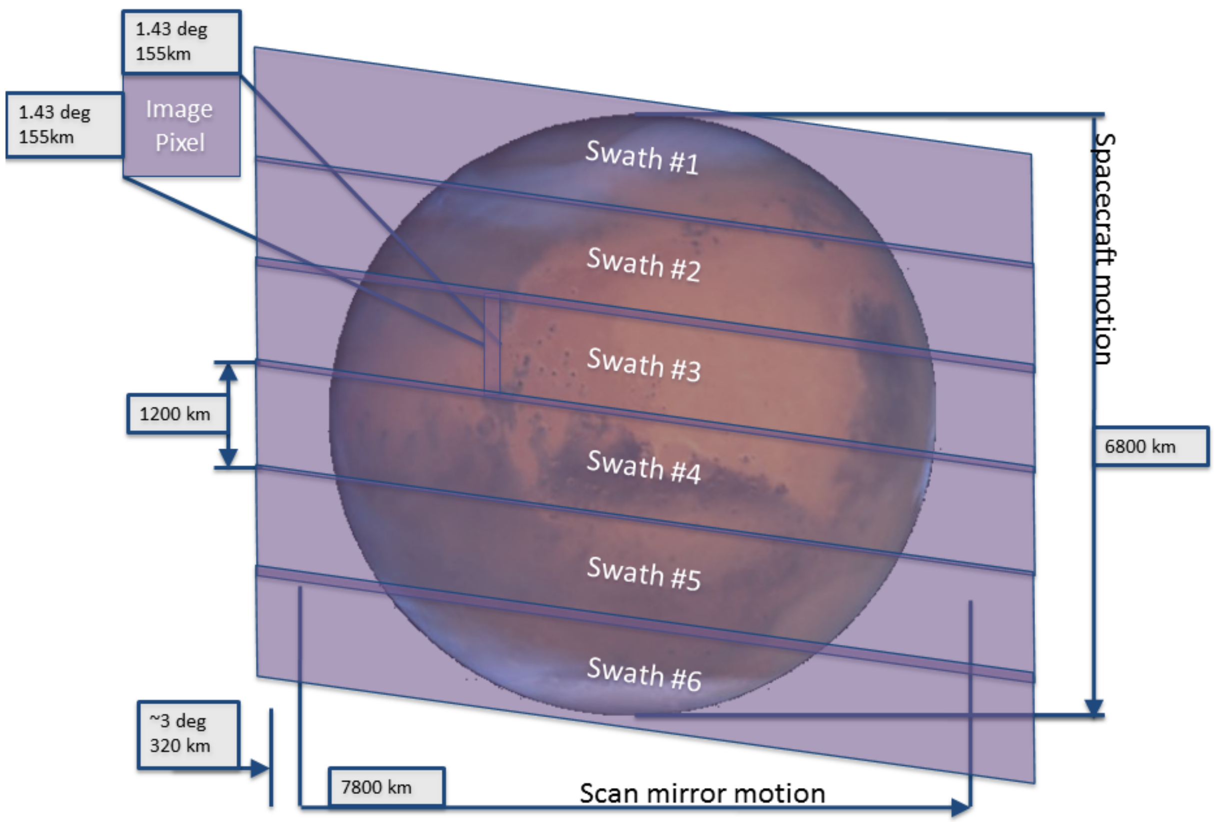
5.2.1.9 IUVS Echelle Collection

The iuvs.<bundle ID>:echelle data collection contains data products for scans taken during the side segments of the MAVEN orbit when IUVS has pointing priority. From orbit to orbit when IUVS has priority, it alternates between the echelle mode described here, and the low spectral resolution corona mode described in the previous section. The coronal scans have three distinct components: scanning while outbound above the Martian limb, inbound above the limb, and inbound below the limb (when the planet intersects the instrument line-of-sight projected backward).

5.2.1.10 IUVS Disk Collection

The iuvs.<bundle ID>:disk data collection contains data products for imaging of the Martian disk. During the apoapse segment of MAVEN's orbit the IUVS scan mirror traces out eight swaths that cover the entire disk and above the limb to 500 km or higher. A single swath is also taken during the outbound side segment of the orbit while IUVS is pointing at the disk.

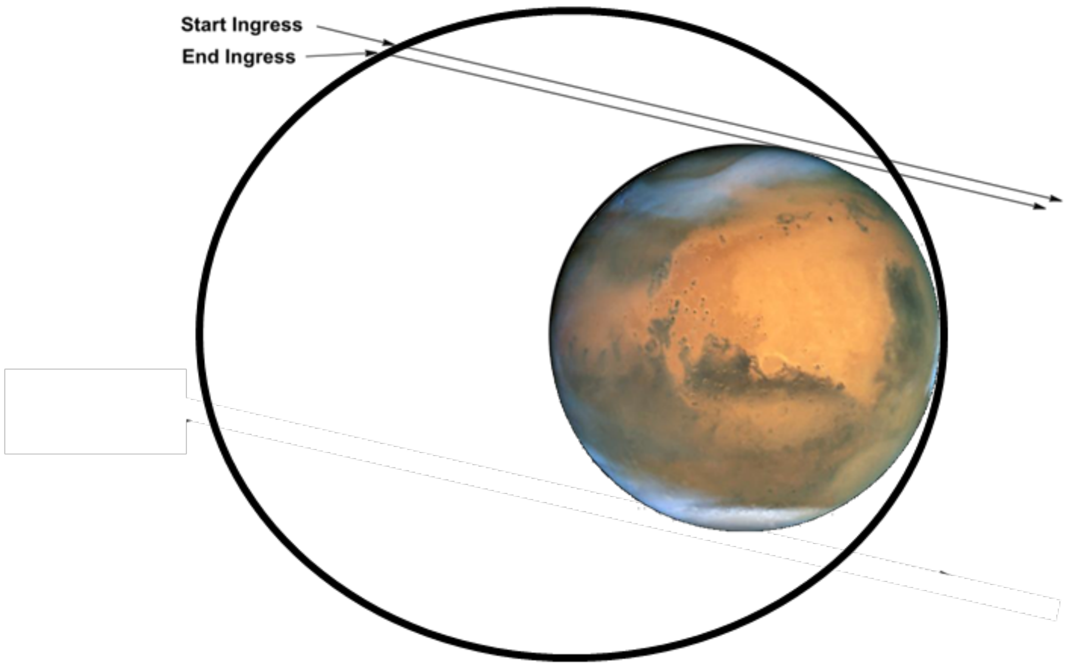
Figure 6 Apoapse disk imaging observation geometry (actual observations have 8 swaths)



5.2.1.11 IUVS Stellar Occultation Collection

The iuvs.<bundle ID>:occultation data collection contains data products for stellar occultation by the Martian atmosphere. Occultation campaigns composed of many individual occultations are preformed roughly every two months during the MAVEN mission and nominally occur over either 5 or 10 orbits. Occultation campaigns were executed on the following dates: 2015-03-24, 2015-05-17, 2015-08-01, 2015-11-03, 2016-01-18, 2016-03-17, 2016-07-14, and 2016,-09-21.

Figure 7 Stellar occultation observation geometry



5.2.1.12 IUVS Phobos Collection

The iuvs.<bundle ID>:phobos data collection contains data products containing observations of the Martian moon Phobos in a targeted close fly-by performed by MAVEN. Only raw and calibrated products exist for these observations, which were acquired on 2015-11-10 and 2015-11-22.

5.2.2 IUVS Raw Data Bundle

The iuvs.raw bundle contains the raw data numbers collected by the IUVS instrument along with supporting documentation. Observations are typically taken as a series of integrations with identical instrument settings, producing a series of 2D detector images composed of raw data numbers (DN). This data is stored as a 3D image series in the primary image block of a single L1A file. Data from the FUV and MUV detectors are stored in separate files at this level.

Table 14: IUVS Raw Collections

Collection LID	Description
urn:nasa:pds:maven.iuvs.raw:cruise	L1A FITS files with raw cruise phase data
urn:nasa:pds:maven.iuvs.raw:transition	L1A FITS files with raw transition phase data
urn:nasa:pds:maven.iuvs.raw:calibration	L1A FITS files with raw calibration activity data
urn:nasa:pds:maven.iuvs.raw:limb	L1A FITS files with raw limb scan data

Collection LID	Description
urn:nasa:pds:maven.iuvs.raw:corona	L1A FITS files with raw coronal scan data
urn:nasa:pds:maven.iuvs.raw:echelle	L1A FITS files with raw echelle mode data
urn:nasa:pds:maven.iuvs.raw:disk	L1A FITS files with raw disk scan data
urn:nasa:pds:maven.iuvs.raw:occultation	L1A FITS files with raw stellar occultation data
urn:nasa:pds:maven.iuvs.raw:phobos	L1A FITS files with raw Phobos data
urn:nasa:pds:maven.iuvs.raw:document	Documentation for the iuvs.raw bundle.
urn:nasa:pds:maven.iuvs.raw:context	PDS context products referenced by products in the IUVS.raw archive bundle.
urn:nasa:pds:maven.iuvs.calibrated:XML_Schema	XML schema and Schematron files referenced by products in the IUVS.raw archive bundle.

5.2.3 IUVS Calibrated Data Bundle

The iuvs.calibrated bundle contains spectral radiance data calibrated to kilorayleighs/nanometer, along with ancillary data on the calibration process and supporting documentation. The calibrated data for a series of integrations is stored as a 3D image series in the primary image block of a single L1B file, paralleling the organization of raw data in L1A files. Data from the FUV and MUV detectors are stored in separate files at this level.

Table 15: IUVS Calibrated Collections

Collection LID	Description
urn:nasa:pds:maven.iuvs.calibrated:cruise	L1B FITS files with calibrated cruise phase data
urn:nasa:pds:maven.iuvs.calibrated:transition	L1B FITS files with calibrated transition phase data
urn:nasa:pds:maven.iuvs.calibrated:calibration	L1B FITS files and ancillary data relevant to calibration activities
urn:nasa:pds:maven.iuvs.calibrated:limb	L1B FITS files with calibrated limb scan data
urn:nasa:pds:maven.iuvs.calibrated:corona	L1B FITS files with calibrated coronal scan data
urn:nasa:pds:maven.iuvs.calibrated:echelle	L1B FITS files with calibrated echelle mode data
urn:nasa:pds:maven.iuvs.calibrated:disk	L1B FITS files with calibrated disk scan data
urn:nasa:pds:maven.iuvs.calibrated:occultation	L1B FITS files with calibrated stellar occultation data
urn:nasa:pds:maven.iuvs.calibrated:phobos	L1B FITS files with calibrated Phobos data
urn:nasa:pds: maven.iuvs.calibrated:document	Documentation for the iuvs.calibrated bundle.
urn:nasa:pds: maven.iuvs.calibrated:context	PDS context products referenced by products in the iuvs.calibrated archive bundle.
urn:nasa:pds: maven.iuvs.calibrated:xml_schema	XML schema and Schematron files referenced by products in the iuvs.calibrated archive bundle.

5.2.4 IUVS Processed Data Bundle

The iuvs.processed bundle contains radiance data binned spectrally and/or spatially, along with supporting documentation. While lower reduction level data products have identical structure, the processed L1C FITS files are unique to each observation mode.

Table 16: IUVS Processed Collections

Collection LID	Description
urn:nasa:pds:maven.iuvs.processed:cruise	L1C FITS files with processed cruise phase data
urn:nasa:pds:maven.iuvs.processed:transition	L1C FITS files with processed transition phase data
urn:nasa:pds:maven.iuvs.processed:limb	L1C FITS files with processed limb scan data
urn:nasa:pds:maven.iuvs.processed:corona	L1C FITS files with processed coronal scan data
urn:nasa:pds:maven.iuvs.processed:echelle	L1C FITS files with processed echelle mode data
urn:nasa:pds:maven.iuvs.processed:disk	L1C FITS files with processed disk scan data
urn:nasa:pds:maven.iuvs.processed:occultation	L1C FITS files with processed stellar occultation data
urn:nasa:pds: maven.iuvs.processed:document	Documentation for the iuvs. processed bundle.
urn:nasa:pds: maven.iuvs.processed:context	PDS context products referenced by products in the iuvs. processed archive bundle.
urn:nasa:pds: maven.iuvs.processed:xml_schema	XML schema and Schematron files referenced by products in the iuvs. processed archive bundle.

5.2.5 IUVS Derived Data Bundle

The iuvs.derived bundle contains column abundances and densities as altitude profiles and surface map projections, along with supporting documentation. The structures of these data products are unique to each observation mode.

Table 17: IUVS Derived Collections

Collection LID	Description
urn:nasa:pds:maven.iuvs.derived:cruise	L1C FITS files with derived cruise phase data
urn:nasa:pds:maven.iuvs derived:transition	L1C FITS files with derived transition phase data
urn:nasa:pds:maven.iuvs.derived:limb	L1C FITS files with derived limb scan data
urn:nasa:pds:maven.iuvs.derived:corona	L1C FITS files with derived coronal scan data
urn:nasa:pds:maven.iuvs.derived:echelle	L1C FITS files with derived echelle mode data
urn:nasa:pds:maven.iuvs.derived:disk	L1C FITS files with derived disk scan data
urn:nasa:pds:maven.iuvs.derived:occultation	L1C FITS files with derived stellar occultation data
urn:nasa:pds: maven.iuvs.derived:document	Documentation for the iuvs.derived bundle.
urn:nasa:pds: maven.iuvs.derived:context	PDS context products referenced by products in the iuvs.derived archive bundle.

Collection LID	Description
urn:nasa:pds: maven.iuvs.derived:xml_schema	XML schema and Schematron files referenced by products in the iuvs.derived archive bundle.

6 Archive product formats

Data that comprise the IUVS archives are formatted in accordance with PDS specifications [see *Planetary Science Data Dictionary* [4], *PDS Data Provider's Handbook* [2], and *PDS Standards Reference* [3]. This section provides details on the formats used for each of the products included in the archive.

6.1 Data File Formats

This section describes the format and record structure of each of the data file types.

Field data types are:

Int16/32 – signed integer of 16 or 32 bit length

UInt16/32 – unsigned integer of 16 or 32 bit length. FITS only supports signed integers, so these are done according to FITS specification section 5.2.5 (BZERO keyword and TZEROn keyword). These are the only cases where BZERO is used.

Float32 – IEEE754 single-precision floating point number, encoded in 32 bits

Float64 – IEEE754 double-precision floating point number, encoded in 64 bits

String – ASCII English string. Many fields are enumerated, meaning that the value is one of a small finite set of strings. In these cases the possible values are enumerated in the Units field. This type is also used for UTC dates in the form YYYY/DOY Mon Day HH:MM:SS.SSSSSUTC, for example 2014/057 Feb 26 23:45:52.66265UTC. All string dates are encoded in this form, and all fields have a fixed width, padded with zeros on the left as necessary. The seconds field is in decimal, but given with sufficient precision to give each subsecond a unique value.

Header – ASCII English string stored in one line of header part of the appropriate HDU and has variable type 'header', meaning the data is in a string with 'FIELD = value' format. Header fields may also contain enumerated or date strings as specified above. Header values may contain comments according to FITS specification

6.1.1 Raw data file data structure

Raw products are stored in the Flexible Image Transport System (FITS) format, following FITS specification 3.0 (July 2008). This format is specified and maintained by NASA/Goddard Space Flight Center FITS Support Office. The format is self-descriptive, in that all information necessary to pull any piece of data out of the file is included in the file itself.

FITS files consist of a number of Header/Data Units (HDUs), each of which may describe an image or a table. The first HDU is called the Primary HDU, and always encodes an image. Each subsequent HDU is named according the FITS specification section 4.4.2.6 (EXTNAME keyword).

As used in Maven/IUVS data products, an image is one multi-dimensional array, not necessarily 2D. Each image HDU encodes one and only one image. A table is a 1D set of rows, each of which is composed of named fields, each of which may be either a scalar or an array of any size and dimension. If a field is an array, the field will have the same size and dimension across all rows in the table.

Maven/IUVS raw FITS files will contain several HDUs, with both images and tables. The location of images in a FITS data product is completely specified by the HDU name. The location of table fields is completely specified by the HDU name, followed by the field name. In the lists that follow, this is specified as HDU/FIELD (referred to as a 'path'). Extra information in the header part of the HDU above and beyond that required by the FITS format is specified as HDU_HEADER/FIELD.

Maven/IUVS FITS files use the specified mechanisms for including the names, types, and array dimension (if applicable) of table fields, array dimension of images, and units of fields and images. The description of each image and field is included in the HDU header comments.

The table and image size specifications below include the special values 'spectral', 'spatial', and 'integrations' which refer to the number of transmitted spectral bins, transmitted spatial bins, and integrations in the observation represented by this data product. These sizes are encoded in the file implicitly as the size of the primary image. Tables, being sets of rows, have a size as well. All tables in this product either have one row, representing the entire observation, or as many rows as there are integrations, with one row representing each integration.

Being a raw product, many fields are direct copies of telemetry produced by the instrument, unconverted in any form. The units for such fields are called DN (Data Number) and may represent ADC counts, encoder steps, discrete time intervals, and so on.

Table 18: Raw data file structure.

Field Name	Data Type	Unit	Frame	Description
PRIMARY	int32 [Spectral, Spatial, Integrations]			
INTEGRATION	Table [Integrations]			
INTEGRATION/TIMESTAMP	double64	SCLK seconds		Time that the integration began according to S/C clock (uncorrected)
INTEGRATION/ET	double64	ET s		Time that the integration began (corrected for SCLK errors by SCLK kernel)
INTEGRATION/UTC	string	UTC date string		Time that the integration began (corrected for SCLK errors by SCLK kernel)

INTEGRATION/MIRROR_DN	uint16	DN		Mirror position at beginning of this integration
INTEGRATION/MIRROR_DEG	float32	deg		Mirror position at beginning of this integration
INTEGRATION/FOV_DEG	float32	deg		Instrument field of view center position at beginning of integration (=MIRROR_THIS_DEG*2)
INTEGRATION/LYA_CENTROID	int16	pixel		Shift of wavelength scale calculated from centroid
INTEGRATION/CASE_TEMP	uint16	DN		
INTEGRATION/DET_TEMP	uint16	DN		
ENGINEERING	Table[1]			
ENGINEERING/ SCI_PKT_CKSUM	int16			
ENGINEERING/ SCI_ERR_FLAGS	int16			
ENGINEERING/XUV	string	FUV/ MUV		Which channel this is
ENGINEERING/LENGTH	int64	byte		Length of entire science image to which this segment belongs
ENGINEERING/ IMAGE_NUMBER	int32			Series number of this image
ENGINEERING/AVERAGE	int32	DN		Average DN value of last packet of observation, not significant
ENGINEERING/CHECKSUM	int32			Checksum of last packet of observation, not significant, not being checked
ENGINEERING/START_TIME	int64	s		Time when image set containing this segment was initiated
ENGINEERING/ START_TIME__SUB	int32	1/65536 s		Time when image set containing this segment was initiated
ENGINEERING/CADENCE	int32	ms		Image cadence parameter for this image set
ENGINEERING/NUMBER	int32			Total number of commanded images for this set (equal to number of integrations)
ENGINEERING/INT_TIME	int32	ms		Image integration time parameter for this image set
ENGINEERING/MIRROR_POS	int32	DN		Position of mirror when image set began
ENGINEERING/STEP_NUM	int32	DN		Value of mirror step number when this image was initiated

ENGINEERING/STEP_SIZE	int16	DN		Value of mirror step size when this image was initiated
ENGINEERING/STEP_INT	int16	DN		Value of mirror step interval when this image was initiated
ENGINEERING/BIN_SHIFT	int16	pixel		Offset between expected lyman alpha line and calculated
ENGINEERING/OBS_ID	int32			Value of Obs ID telemetry point when this image was initiated
ENGINEERING/ FUV_BAD_PIXEL_MASK	int16			Each detector has a list of pixels that are bad and those pixels are never included in the binned data. This bad pixel masking can be disabled, in which case all pixels are used.
ENGINEERING/ MUV_BAD_PIXEL_MASK	int16			Each detector has a list of pixels that are bad and those pixels are never included in the binned data. This bad pixel masking can be disabled, in which case all pixels are used.
ENGINEERING/ DATA_COMPRESSION	int16			If data compression is on, all detector data will be sent in 16 bit pixels. If compression is off, the data can be up to 32 bits wide and it will be different for each bin. Compression should always be enabled unless taking a full frame image.
ENGINEERING/ TEST_PATTERN	int16			There are two types of test patterns that can be produced. The 16 bit pattern rolls over at 65535 and the 12 bit pattern rolls over at 4095. This indicates which type will be used for the next test pattern image.
ENGINEERING/ ON_CHIP_WINDOWING	int16			In linear bin mode, the Detector FPGA can read the entire array into SRAM and bin it from there, or it can only read out the pixels in the defined window. Running with the window enabled can save readout time.
ENGINEERING/BIN_TYPE	string			There are two types of binning, linear and non-linear. This indicates which the detector will use for the next set of images.
ENGINEERING/SCAN_MODE	string			The detector can peform three different types of readouts, in addition to generating a test pattern. This indicates which

				readout will be used for the next set of images.
ENGINEERING/MODE	string			
ENGINEERING/TIME_FLAG	string			Indicates if time was sync'd when this packet was logged (may be Synced/Freewheel)
ENGINEERING/ BIN_SHIFT_DIR	int16			
ENGINEERING/ SHUTTER_ON	int32	ms		Shutter cycle on time for this image set
ENGINEERING/ SHUTTER_OFF	int32	ms		Shutter cycle off time for this image set
ENGINEERING/ SHUTTER_NUM	int16			Shutter cycle number for this image set
ENGINEERING/SET_TOTAL	int32			It is possible that not all commanded images are received in the SDRAM. This is the actual number received, out of the commanded
ENGINEERING/BIN_X_ROW	int16			Image bin table for this image set
ENGINEERING/BIN_Y_ROW	int16			Image bin table row for this image set
ENGINEERING/MCP_GAIN	int32	DN		MCP value when this image set was initiated. (Commanded value, use that DN conversion)
ENGINEERING/ SCI_SEG_TOTAL	int32			Series number of this segment (eg 1 out of 4)
ENGINEERING/ SCI_SEG_LENGTH	int32	byte		Length of this segment of the science image
ENGINEERING/ SCI_SEG_NUM	int32			Number of segments for this image
ENGINEERING/ PROCESS_DATE	string			
BINNING	Table[1]			
BINNING/SPABINWIDTH	int16[Spatial]			Width of each spatial bin in pixels, one entry for each bin, transmitted or not
BINNING/SPABINTRANSMIT	int16[Spatial]			1 if bin is transmitted, 0 if not. Total number of 1 entries set equals the number of spatial bins in the file
BINNING/SPEBINWIDTH	int16 [Spectral]			Width of each spectral bin in pixels, one entry for each bin, transmitted or not
BINNING/SPEBINTRANSMIT	int16			1 if bin is transmitted, 0 if not.

	[Spectral]			Total number of 1 entries set equals the number of spatial bins in the file
BINNING/SPAPIXLO	int16[Spatial]			Lowest numbered pixel in each transmitted spatial bin
BINNING/SPAPIXHI	int16[Spatial]			Highest numbered pixel in each transmitted spatial bin
BINNING/SPEPIXLO	int16 [Spectral]			Lowest numbered pixel in each transmitted spectral bin
BINNING/SPEPIXHI	int16 [Spectral]			Highest numbered pixel in each transmitted spectral bin
BINNING/BINTABLENAME	string			
PIXELGEOMETRY	Table [Integrations]			
PIXELGEOMETRY/ PIXEL_VEC	double64 [5,Spatial,3]	unit vector	IAU_MARS	Unit vector from spacecraft along lines of sight for 4 corners and center of each spatial bin
PIXELGEOMETRY/ PIXEL_CORNER_RA	double64 [5,Spatial]	deg	J2000	Right ascension of line of sight of 4 corners and center of each spatial bin
PIXELGEOMETRY/ PIXEL_CORNER_DEC	double64 [5,Spatial]	deg	J2000	Declination of line of sight of 4 corners and center of each spatial bin
PIXELGEOMETRY/ PIXEL_CORNER_LAT	double64 [5,Spatial]	deg	IAU_MARS	Geodetic Latitude of tangent or impact point of line of sight with Mars ellipsoid, for 4 corners and center of each spatial bin
PIXELGEOMETRY/ PIXEL_CORNER_LON	double64 [5,Spatial]	deg	IAU_MARS	East Longitude of tangent or impact point of line of sight with Mars ellipsoid, for 4 corners and center of each spatial bin
PIXELGEOMETRY/ PIXEL_CORNER_MRH_ALT	double64 [5,Spatial]	km		Altitude of tangent point, or zero if line of sight hits ellipsoid, for 4 corners and center of each spatial bin
PIXELGEOMETRY/ PIXEL_CORNER_MRH_ALT_ RATE	double64 [5,Spatial]	km/s		Time rate of change of altitude of tangent point
PIXELGEOMETRY/ PIXEL_CORNER_LOS	double64 [5,Spatial]	km		Distance from spacecraft to tangent or impact point
PIXELGEOMETRY/ PIXEL_SOLAR_ZENITH_ANG LE	double64 [Spatial]	deg		Angle between surface normal and vector to Sun, at tangent or impact point
PIXELGEOMETRY/ PIXEL_EMISSION_ANGLE	double64 [Spatial]	deg		Angle between surface normal and vector to spacecraft, at tangent or impact point

PIXELGEOMETRY/ PIXEL_ZENITH_ANGLE	double64 [Spatial]	deg		Angle between pixel look direction and spacecraft zenith (90deg plus lookdown angle)
PIXELGEOMETRY/ PIXEL_PHASE_ANGLE	double64 [Spatial]	deg		Angle between spacecraft and sun as seen from tangent or impact point
PIXELGEOMETRY/ PIXEL_LOCAL_TIME	double64 [Spatial]	hours		Local time at tangent or impact point. Varies from 0=midnight, through 6 which is about sunrise, through 12=noon, through 18 which is about sunset, to almost 24 towards midnight again
SPACECRAFTGEOMETRY	Table [Integrations]			
SPACECRAFTGEOMETRY/ SUB_SPACECRAFT_LAT	double64	deg		Geodetic Latitude of subspacecraft point
SPACECRAFTGEOMETRY/ SUB_SPACECRAFT_LON	double64	deg		East Longitude of subspacecraft point
SPACECRAFTGEOMETRY/ SUB_SOLAR_LAT	double64	deg		Geodetic Latitude of subsolar point
SPACECRAFTGEOMETRY/ SUB_SOLAR_LON	double64	deg		East Longitude of subsolar point
SPACECRAFTGEOMETRY/ SPACECRAFT_ALT	double64	km		Altitude of spacecraft above reference Mars ellipsoid
SPACECRAFTGEOMETRY/ V_SPACECRAFT	double64[3]	km	IAU_MARS	Position of spacecraft relative to Mars center of mass
SPACECRAFTGEOMETRY/ V_SPACECRAFT_RATE	double64[3]	km/s	IAU_MARS	Velocity of spacecraft
SPACECRAFTGEOMETRY/ V_SUN	double64[3]	km	IAU_MARS	Position of Sun relative to Mars center of mass
SPACECRAFTGEOMETRY/ V_SUN_RATE	double64[3]	km/s	IAU_MARS	Velocity of Sun
SPACECRAFTGEOMETRY/ VX_SPACECRAFT	double64[3]	unit vector	IAU_MARS	Direction of spacecraft X axis
SPACECRAFTGEOMETRY /VY_SPACECRAFT	double64[3]	unit vector	IAU_MARS	Direction of spacecraft Y axis
SPACECRAFTGEOMETRY/ VZ_SPACECRAFT	double64[3]	unit vector	IAU_MARS	Direction of spacecraft Z axis
SPACECRAFTGEOMETRY/ VX_INSTRUMENT	double64[3]	unit vector	IAU_MARS	Direction of instrument field of view X axis, including scan mirror rotation. This is the instrument spatial direction.
SPACECRAFTGEOMETRY/ VY_INSTRUMENT	double64[3]	unit vector	IAU_MARS	Direction of instrument field of view Y axis, including scan mirror rotation. This is the instrument scan direction

SPACECRAFTGEOMETRY/ VZ_INSTRUMENT	double64[3]	unit vector	IAU_MARS	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
SPACECRAFTGEOMETRY/ V_SPACECRAFT_MSO	double64[3]	km	MAVEN_MSO	Position of spacecraft relative to Mars center of mass
SPACECRAFTGEOMETRY/ V_SPACECRAFT_RATE_MSO	double64[3]	km/s	MAVEN_MSO	Velocity of spacecraft
SPACECRAFTGEOMETRY/ V_SPACECRAFT_INERTIAL	double64[3]	km	Inertial	Position of spacecraft relative to Mars center of mass
SPACECRAFTGEOMETRY/ V_SPACECRAFT_RATE_INERTIAL	double64[3]	km/s	Inertial	Velocity of spacecraft
SPACECRAFTGEOMETRY/ V_SPACECRAFT_INERTIAL_FRAME	string			Spice name of inertial frame
SPACECRAFTGEOMETRY/ V_SPACECRAFT_INERTIAL_CENTER	string			Spice name of inertial center of mass
SPACECRAFTGEOMETRY/ V_SUN_MSO	double64[3]	km	MAVEN_MSO	Position of Sun relative to Mars center of mass
SPACECRAFTGEOMETRY/ V_SUN_RATE_MSO	double64[3]	km/s	MAVEN_MSO	Velocity of Sun
SPACECRAFTGEOMETRY/ VX_SPACECRAFT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of spacecraft X axis
SPACECRAFTGEOMETRY/ VY_SPACECRAFT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of spacecraft Y axis
SPACECRAFTGEOMETRY/ VZ_SPACECRAFT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of spacecraft Z axis
SPACECRAFTGEOMETRY/ VX_INSTRUMENT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of instrument field of view X axis, including scan mirror rotation. This is the instrument spatial direction.
SPACECRAFTGEOMETRY/ VY_INSTRUMENT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of instrument field of view Y axis, including scan mirror rotation. This is the instrument scan direction
SPACECRAFTGEOMETRY/ VZ_INSTRUMENT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
SPACECRAFTGEOMETRY/ VX_SPACECRAFT_INERTIAL	double64[3]	unit vector	Inertial	Direction of spacecraft X axis
SPACECRAFTGEOMETRY/ VY_SPACECRAFT_INERTIAL	double64[3]	unit vector	Inertial	Direction of spacecraft Y axis
SPACECRAFTGEOMETRY/	double64[3]	unit	Inertial	Direction of spacecraft Z axis

VZ_SPACECRAFT_INERTIAL		vector		
SPACECRAFTGEOMETRY/ VX_INSTRUMENT_ INERTIAL	double64[3]	unit vector	Inertial	Direction of instrument field of view X axis, including scan mirror rotation. This is the instrument spatial direction.
SPACECRAFTGEOMETRY/ VY_INSTRUMENT_INERTIA L	double64[3]	unit vector	Inertial	Direction of instrument field of view Y axis, including scan mirror rotation. This is the instrument scan direction
SPACECRAFTGEOMETRY/ VZ_INSTRUMENT_INERTIAL	double64[3]	unit vector	Inertial	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
SPACECRAFTGEOMETRY/ INST_SUN_ANGLE	double64	deg		Angle between instrument boresight (taking into account mirror position) and Sun, deg
OBSERVATION	Table[1]			
OBSERVATION/ PRODUCT_ID	string			Original filename of this product
OBSERVATION/ COLLECTION_ID	string			PDS collection ID (currently unused)
OBSERVATION/BUNDLE_ID	string			PDS bundle ID (currently unused)
OBSERVATION/ CODE_SVN_REVISION	string			SVN revision number of code used to produce this product
OBSERVATION/ ANC_SVN_REVISION	string			SVN revision number of ancillary data used to produce this product
OBSERVATION/ PRODUCT_CREATION_DATE	string	UTC		Product creation date
OBSERVATION/ OBSERVATION_TYPE	string			Observation type string
OBSERVATION/ MISSION_PHASE	string			Mission phase string
OBSERVATION/ TARGET_NAME	string			Target name string
OBSERVATION/ ORBIT_SEGMENT	int16			Orbit segment (periapse, apoapse, corona etc, currently 0)
OBSERVATION/ ORBIT_NUMBER	int16			Orbit number (MOI is start of orbit 1, orbit number changes 30min before each periapse)
OBSERVATION/ SOLAR_LONGITUDE	float32	deg		Solar longitude, 0deg=Martian spring equinox, 90deg=solstice, etc
OBSERVATION/ GRATING_SELECT	string			Grating select (one of 'ECHELLE'/'LOWRES')
OBSERVATION/	string			Keyhole select (one of

KEYHOLE_SELECT				'LARGE'/'SMALL'/'NEITHER')
OBSERVATION/ BIN_PATTERN_INDEX	string			Name of linear or nonlinear binning table used for this observation.
OBSERVATION/CADENCE	double64			
OBSERVATION/INT_TIME	double64			
OBSERVATION/ DUTY_CYCLE	double64			
OBSERVATION/CHANNEL	string			
OBSERVATION/ WAVELENGTH	double64 [Spectral, Spatial]	nm		Wavelength of center of each bin
OBSERVATION/ WAVELENGTH_WIDTH	double64 [Spectral, Spatial]	nm		Wavelength width of each bin
OBSERVATION/KERNELS	string[*]			

6.1.2 Calibrated data file structure

Calibrated products are also stored in the Flexible Image Transport System (FITS) format, and are similar in structure to the raw products described above. The essential difference is that the primary image contains a calibrated spectral radiance in units of kilorayleighs/nm, along with estimates of uncertainty. In addition, engineering telemetry has been translated from DN to physical units (e.g. detector temperature, MCP voltage, etc.)

Table 19: Calibrated data file structure.

Field Name	Data Type	Unit	Frame	Description
PRIMARY	float32 [Spectral, Spatial, Integrations]	kR/nm		Detector image in calibrated units
RANDOM_DN_UNC	float32 [Spectral, Spatial, Integrations]	DN		Random uncertainty of detector image in raw DN
RANDOM_PHY_UNC	float32 [Spectral, Spatial, Integrations]	kR/nm		Random uncertainty of detector image in physical units
SYSTEMATIC_PHY_UNC	float32 [Spectral, Spatial, Integrations]	kR/nm		Systematic uncertainty of detector image in physical units

DETECTOR_RAW	int32 [Spectral, Spatial, Integrations]			Raw detector image in DN
DETECTOR_DARK_SUBTRACTED	float32[Spectral, Spatial, Integrations]			Raw light image that has had dark subtraction applied
QUALITY_FLAG	int16 [Spectral, Spatial, Integrations]			Quality flag (TBD)
BACKGROUND_DARK	float32 [Spectral, Spatial, Integrations]			Image used for subtraction of background dark current
DARK_INTEGRATION	Table[4]			One entry for each integration of each dark observation used. There is most commonly two dark observations, each with two integrations, giving a total of four.
DARK_INTEGRATION/ TIMESTAMP	double64	SCLK seconds		Time that the integration began according to S/C clock (uncorrected)
DARK_INTEGRATION/ET	double64	ET s		Time that the integration began (corrected for SCLK errors by SCLK kernel)
DARK_INTEGRATION/UTC	string	UTC date string		Time that the integration began (corrected for SCLK errors by SCLK kernel)
DARK_INTEGRATION/ MIRROR_DN	uint16	DN		Mirror position at beginning of this integration
DARK_INTEGRATION/ MIRROR_DEG	float32	deg		Mirror position at beginning of this integration
DARK_INTEGRATION/ FOV_DEG	float32	deg		Instrument field of view center position at beginning of integration (=MIRROR_THIS_DEG*2)
DARK_INTEGRATION /LYA_CENTROID	int16	pixel		Shift of wavelength scale calculated from centroid
DARK_INTEGRATION/ DET_TEMP_C	double64	degC		Case temperature
DARK_INTEGRATION/ CASE_TEMP_C	double64	degC		Case temperature
DARK_ENGINEERING	Table[2]			A copy of the Engineering HDU from each dark observation used to correct this image
DARK_ENGINEERING/	int16			

SCI_PKT_CKSUM				
DARK_ENGINEERING/ SCI_ERR_FLAGS	int16			
DARK_ENGINEERING/ XUV	string			Which channel this is
DARK_ENGINEERING/ LENGTH	int64			Length of entire science image to which this segment belongs
DARK_ENGINEERING /IMAGE_NUMBER	int32			Series number of this image
DARK_ENGINEERING/ AVERAGE	int32			Average DN value of last packet of observation, not significant
DARK_ENGINEERING/ CHECKSUM	int32			Checksum of last packet of observation, not significant, not being checked
DARK_ENGINEERING/ START_TIME	int64			Time when image set containing this segment was initiated
DARK_ENGINEERING/ START_TIME__SUB	int32			Time when image set containing this segment was initiated
DARK_ENGINEERING/ CADENCE	int32			Image cadence parameter for this image set
DARK_ENGINEERING/ NUMBER	int32			Total number of commanded images for this set (equal to number of integrations)
DARK_ENGINEERING/ INT_TIME	int32			Image integration time parameter for this image set
DARK_ENGINEERING/ MIRROR_POS	int32			Position of mirror when image set began
DARK_ENGINEERING/ STEP_NUM	int32			Value of mirror step number when this image was initiated
DARK_ENGINEERING/ STEP_SIZE	int16			Value of mirror step size when this image was initiated
DARK_ENGINEERING/ STEP_INT	int16			Value of mirror step interval when this image was initiated
DARK_ENGINEERING /BIN_SHIFT	int16			Offset between expected lyman alpha line and calculated
DARK_ENGINEERING/ OBS_ID	int32			Value of Obs ID telemetry point when this image was initiated
DARK_ENGINEERING/ FUV_BAD_PIXEL_MASK	int16			Each detector has a list of pixels that are bad and those pixels are never included in the binned data. This bad pixel masking can be disabled, in which case all pixels are used.
DARK_ENGINEERING/ MUV_BAD_PIXEL_MASK	int16			Each detector has a list of pixels that are bad and those pixels are

				never included in the binned data. This bad pixel masking can be disabled, in which case all pixels are used.
DARK_ENGINEERING/ DATA_COMPRESSION	int16			If data compression is on, all detector data will be sent in 16 bit pixels. If compression is off, the data can be up to 32 bits wide and it will be different for each bin. Compression should always be enabled unless taking a full frame image.
DARK_ENGINEERING/ TEST_PATTERN	int16			There are two types of test patterns that can be produced. The 16 bit pattern rolls over at 65535 and the 12 bit pattern rolls over at 4095. This indicates which type will be used for the next test pattern image.
DARK_ENGINEERING/ ON_CHIP_WINDOWING	int16			In linear bin mode, the Detector FPGA can read the entire array into SRAM and bin it from there, or it can only read out the pixels in the defined window. Running with the window enabled can save readout time.
DARK_ENGINEERING/ BIN_TYPE	string			There are two types of binning, linear and non-linear. This indicates which the detector will use for the next set of images.
DARK_ENGINEERING/ SCAN_MODE	string			The detector can peform three different types of readouts, in addition to generating a test pattern. This indicates which readout will be used for the next set of images.
DARK_ENGINEERING/ MODE	string			
DARK_ENGINEERING/ TIME_FLAG	string			Indicates if time was sync'd when this packet was logged (may be Synced/Freewheel)
DARK_ENGINEERING/ BIN_SHIFT_DIR	int16			
DARK_ENGINEERING/ SHUTTER_ON	int32			Shutter cycle on time for this image set
DARK_ENGINEERING/ SHUTTER_OFF	int32			Shutter cycle off time for this image set
DARK_ENGINEERING/ SHUTTER_NUM	int16			Shutter cycle number for this image set

DARK_ENGINEERING/ SET_TOTAL	int32			It is possible that not all commanded images are received in the SDRAM. This is the actual number received, out of the commanded
DARK_ENGINEERING/ BIN_X_ROW	int16			Image bin table for this image set
DARK_ENGINEERING/BIN _Y_ROW	int16			Image bin table row for this image set
DARK_ENGINEERING/ MCP_GAIN	int32			MCP value when this image set was initiated. (Commanded value, use that DN conversion)
DARK_ENGINEERING/ SCI_SEG_TOTAL	int32			Series number of this segment (eg 1 out of 4)
DARK_ENGINEERING/ SCI_SEG_LENGTH	int32			Length of this segment of the science image
DARK_ENGINEERING/ SCI_SEG_NUM	int32			Number of segments for this image
DARK_ENGINEERING/ PROCESS_DATE	string			
DARK_ENGINEERING/ SCI_IMG_DATA_LENGTH_	int32			
DARK_OBSERVATION	Table[2]			A copy of the Observation HDU from each dark observation used to correct this image
DARK_OBSERVATION/ PRODUCT_ID	string			Original filename of this product
DARK_OBSERVATION/ COLLECTION_ID	string			PDS collection ID (currently unused)
DARK_OBSERVATION/ BUNDLE_ID	string			PDS bundle ID (currently unused)
DARK_OBSERVATION/ CODE_SVN_REVISION	string			SVN revision number of code used to produce this product
DARK_OBSERVATION/ ANC_SVN_REVISION	string			SVN revision number of ancillary data used to produce this product
DARK_OBSERVATION/ PRODUCT_CREATION_DA TE	string			Product creation date
DARK_OBSERVATION/ OBSERVATION_TYPE	string			Observation type string
DARK_OBSERVATION/ MISSION_PHASE	string			Mission phase string
DARK_OBSERVATION/ TARGET_NAME	string			Target name string
DARK_OBSERVATION/	int16			Orbit segment (periapse, apoapse,

ORBIT_SEGMENT				corona etc, currently 0)
DARK_OBSERVATION/ ORBIT_NUMBER	int16			Orbit number (MOI is start of orbit 1, orbit number changes 30min before each periapse)
DARK_OBSERVATION/ SOLAR_LONGITUDE	float32			Solar longitude, 0deg=Martian spring equinox, 90deg=solstice, etc
DARK_OBSERVATION/ GRATING_SELECT	string			Grating select (one of 'ECHELLE'/'LOWRES')
DARK_OBSERVATION/ KEYHOLE_SELECT	string			Keyhole select (one of 'LARGE'/'SMALL'/'NEITHER')
DARK_OBSERVATION/ BIN_PATTERN_INDEX	string			Name of linear or nonlinear binning table used for this observation.
DARK_OBSERVATION/ CADENCE	double64			
DARK_OBSERVATION /INT_TIME	double64			
DARK_OBSERVATION/ DUTY_CYCLE	double64			
DARK_OBSERVATION/ CHANNEL	string			
DARK_OBSERVATION/ WAVELENGTH	double64 [Spectral, Spatial]			Wavelength of center of each bin
DARK_OBSERVATION/WAVELENGTH_WIDTH	double64 [Spectral, Spatial]			Wavelength width of each bin
DARK_OBSERVATION/ KERNELS	string[*]			
DETECTOR_DARK	int32 [Spectral, Spatial,4]			Raw dark images used to estimate dark correction for each calibrated image
INTEGRATION	Table[Integrations]			
INTEGRATION/ TIMESTAMP	double64	SCLK seconds		Time that the integration began according to S/C clock (uncorrected)
INTEGRATION/ET	double64	ET s		Time that the integration began (corrected for SCLK errors by SCLK kernel)
INTEGRATION/UTC	string	UTC date string		Time that the integration began (corrected for SCLK errors by SCLK kernel)
INTEGRATION/ MIRROR_DN	uint16	DN		Mirror position at beginning of this integration

INTEGRATION/ MIRROR_DEG	float32	deg		Mirror position at beginning of this integration
INTEGRATION/FOV_DEG	float32	deg		Instrument field of view center position at beginning of integration (=MIRROR_THIS_DEG*2)
INTEGRATION/ LYA_CENTROID	int16	pixel		Shift of wavelength scale calculated from centroid
INTEGRATION/ DET_TEMP_C	double64	degC		
INTEGRATION/ CASE_TEMP_C	double64	degC		
ENGINEERING	Table[1]			
ENGINEERING/XUV	string	FUV/M UV		Which channel this is
ENGINEERING/LENGTH	int64	byte		Length of entire science image to which this segment belongs
ENGINEERING/ IMAGE_NUMBER	int32			Series number of this image
ENGINEERING/AVERAGE	int32	DN		Average DN value of last packet of observation, not significant
ENGINEERING/ CHECKSUM	int32			Checksum of last packet of observation, not significant, not being checked
ENGINEERING/ START_TIME	int64	s		Time when image set containing this segment was initiated
ENGINEERING/ START_TIME__SUB	int32	1/65536 s		Time when image set containing this segment was initiated
ENGINEERING/CADENCE	int32	ms		Image cadence parameter for this image set
ENGINEERING/NUMBER	int32			Total number of commanded images for this set (equal to number of integrations)
ENGINEERING/INT_TIME	int32	ms		Image integration time parameter for this image set
ENGINEERING/ MIRROR_POS	int32	DN		Position of mirror when image set began
ENGINEERING/STEP_NUM	int32	DN		Value of mirror step number when this image was initiated
ENGINEERING/STEP_SIZE	int16	DN		Value of mirror step size when this image was initiated
ENGINEERING/STEP_INT	int16	DN		Value of mirror step interval when this image was initiated
ENGINEERING/BIN_SHIFT	int16	pixel		Offset between expected lyman alpha line and calculated

ENGINEERING/OBS_ID	int32			Value of Obs ID telemetry point when this image was initiated
ENGINEERING/ FUV_BAD_PIXEL_MASK	int16			Each detector has a list of pixels that are bad and those pixels are never included in the binned data. This bad pixel masking can be disabled, in which case all pixels are used.
ENGINEERING/ MUV_BAD_PIXEL_MASK	int16			Each detector has a list of pixels that are bad and those pixels are never included in the binned data. This bad pixel masking can be disabled, in which case all pixels are used.
ENGINEERING/ DATA_COMPRESSION	int16			If data compression is on, all detector data will be sent in 16 bit pixels. If compression is off, the data can be up to 32 bits wide and it will be different for each bin. Compression should always be enabled unless taking a full frame image.
ENGINEERING/ TEST_PATTERN	int16			There are two types of test patterns that can be produced. The 16 bit pattern rolls over at 65535 and the 12 bit pattern rolls over at 4095. This indicates which type will be used for the next test pattern image.
ENGINEERING/ ON_CHIP_WINDOWING	int16			In linear bin mode, the Detector FPGA can read the entire array into SRAM and bin it from there, or it can only read out the pixels in the defined window. Running with the window enabled can save readout time.
ENGINEERING/BIN_TYPE	string			There are two types of binning, linear and non-linear. This indicates which the detector will use for the next set of images.
ENGINEERING/ SCAN_MODE	string			The detector can peform three different types of readouts, in addition to generating a test pattern. This indicates which readout will be used for the next set of images.
ENGINEERING/MODE	string			
ENGINEERING/ TIME_FLAG	string			Indicates if time was sync'd when this packet was logged (may be Synced/Freewheel)
ENGINEERING/	int16			

BIN_SHIFT_DIR				
ENGINEERING/SHUTTER_ON	int32	ms		Shutter cycle on time for this image set
ENGINEERING/ SHUTTER_OFF	int32	ms		Shutter cycle off time for this image set
ENGINEERING/ SHUTTER_NUM	int16			Shutter cycle number for this image set
ENGINEERING/ SET_TOTAL	int32			It is possible that not all commanded images are received in the SDRAM. This is the actual number received, out of the commanded
ENGINEERING/ BIN_X_ROW	int16			Image bin table for this image set
ENGINEERING/ BIN_Y_ROW	int16			Image bin table row for this image set
ENGINEERING/MCP_GAIN	int32	DN		MCP value when this image set was initiated. (Commanded value, use that DN conversion)
ENGINEERING/ SCI_SEG_TOTAL	int32			Series number of this segment (eg 1 out of 4)
ENGINEERING/ SCI_SEG_LENGTH	int32	byte		Length of this segment of the science image
ENGINEERING/ SCI_SEG_NUM	int32			Number of segments for this image
ENGINEERING/ PROCESS_DATE	string			
BINNING	Table[1]			
BINNING/SPABINWIDTH	int16 [Spatial]			Width of each spatial bin in pixels, one entry for each bin, transmitted or not
BINNING/SPABINTRANSMIT	int16 [Spatial]			1 if bin is transmitted, 0 if not. Total number of 1 entries set equals the number of spatial bins in the file
BINNING/SPEBINWIDTH	int16 [Spectral]			Width of each spectral bin in pixels, one entry for each bin, transmitted or not
BINNING/ SPEBINTRANSMIT	int16 [Spectral]			1 if bin is transmitted, 0 if not. Total number of 1 entries set equals the number of spatial bins in the file
BINNING/SPAPIXLO	int16 [Spatial]			Lowest numbered pixel in each transmitted spatial bin
BINNING/SPAPIXHI	int16			Highest numbered pixel in each

	[Spatial]			transmitted spatial bin
BINNING/SPEPIXLO	int16 [Spectral]			Lowest numbered pixel in each transmitted spectral bin
BINNING/SPEPIXHI	int16 [Spectral]			Highest numbered pixel in each transmitted spectral bin
BINNING/BINTABLENAME	string			
SPACECRAFTGEOMETRY	Table [Integrations]			
SPACECRAFTGEOMETRY/ SUB_SPACECRAFT_LAT	double64	deg		Geodetic Latitude of subspacecraft point
SPACECRAFTGEOMETRY/ SUB_SPACECRAFT_LON	double64	deg		East Longitude of subspacecraft point
SPACECRAFTGEOMETRY/ SUB_SOLAR_LAT	double64	deg		Geodetic Latitude of subsolar point
SPACECRAFTGEOMETRY/ SUB_SOLAR_LON	double64	deg		East Longitude of subsolar point
SPACECRAFTGEOMETRY/ SPACECRAFT_ALT	double64	km		Altitude of spacecraft above reference Mars ellipsoid
SPACECRAFTGEOMETRY/ V_SPACECRAFT	double64[3]	km	IAU_MARS	Position of spacecraft relative to Mars center of mass
SPACECRAFTGEOMETRY/ V_SPACECRAFT_RATE	double64[3]	km/s	IAU_MARS	Velocity of spacecraft
SPACECRAFTGEOMETRY/ V_SUN	double64[3]	km	IAU_MARS	Position of Sun relative to Mars center of mass
SPACECRAFTGEOMETRY/ V_SUN_RATE	double64[3]	km/s	IAU_MARS	Velocity of Sun
SPACECRAFTGEOMETRY/ VX_SPACECRAFT	double64[3]	unit vector	IAU_MARS	Direction of spacecraft X axis
SPACECRAFTGEOMETRY/ VY_SPACECRAFT	double64[3]	unit vector	IAU_MARS	Direction of spacecraft Y axis
SPACECRAFTGEOMETRY/ VZ_SPACECRAFT	double64[3]	unit vector	IAU_MARS	Direction of spacecraft Z axis
SPACECRAFTGEOMETRY/ VX_INSTRUMENT	double64[3]	unit vector	IAU_MARS	Direction of instrument field of view X axis, including scan mirror rotation. This is the instrument spatial direction.
SPACECRAFTGEOMETRY/ VY_INSTRUMENT	double64[3]	unit vector	IAU_MARS	Direction of instrument field of view Y axis, including scan mirror rotation. This is the instrument scan direction
SPACECRAFTGEOMETRY/ VZ_INSTRUMENT	double64[3]	unit vector	IAU_MARS	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.

SPACECRAFTGEOMETRY/ V_SPACECRAFT_MSO	double64[3]	km	MAVEN_MSO	Position of spacecraft relative to Mars center of mass
SPACECRAFTGEOMETRY/ V_SPACECRAFT_RATE_M SO	double64[3]	km/s	MAVEN_MSO	Velocity of spacecraft
SPACECRAFTGEOMETRY/ V_SPACECRAFT_INERTIA L	double64[3]	km	Inertial	Position of spacecraft relative to Mars center of mass
SPACECRAFTGEOMETRY/ V_SPACECRAFT_RATE_IN ERTIAL	double64[3]	km/s	Inertial	Velocity of spacecraft
SPACECRAFTGEOMETRY/ V_SPACECRAFT_INERTIA L_FRAME	string			Spice name of inertial frame
SPACECRAFTGEOMETRY/ V_SPACECRAFT_INERTIA L_CENTER	string			Spice name of inertial center of mass
SPACECRAFTGEOMETRY/ V_SUN_MSO	double64[3]	km	MAVEN_MSO	Position of Sun relative to Mars center of mass
SPACECRAFTGEOMETRY/ V_SUN_RATE_MSO	double64[3]	km/s	MAVEN_MSO	Velocity of Sun
SPACECRAFTGEOMETRY/ VX_SPACECRAFT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of spacecraft X axis
SPACECRAFTGEOMETRY/ VY_SPACECRAFT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of spacecraft Y axis
SPACECRAFTGEOMETRY/ VZ_SPACECRAFT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of spacecraft Z axis
SPACECRAFTGEOMETRY/ VX_INSTRUMENT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of instrument field of view X axis, including scan mirror rotation. This is the instrument spatial direction.
SPACECRAFTGEOMETRY/ VY_INSTRUMENT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of instrument field of view Y axis, including scan mirror rotation. This is the instrument scan direction
SPACECRAFTGEOMETRY/ VZ_INSTRUMENT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
SPACECRAFTGEOMETRY/ VX_SPACECRAFT_INERTI AL	double64[3]	unit vector	Inertial	Direction of spacecraft X axis
SPACECRAFTGEOMETRY/ VY_SPACECRAFT_INERTI AL	double64[3]	unit vector	Inertial	Direction of spacecraft Y axis
SPACECRAFTGEOMETRY/ VZ_SPACECRAFT_INERTI	double64[3]	unit	Inertial	Direction of spacecraft Z axis

AL		vector		
SPACECRAFTGEOMETRY/ VX_INSTRUMENT_INERTIAL	double64[3]	unit vector	Inertial	Direction of instrument field of view X axis, including scan mirror rotation. This is the instrument spatial direction.
SPACECRAFTGEOMETRY/ VY_INSTRUMENT_INERTIAL	double64[3]	unit vector	Inertial	Direction of instrument field of view Y axis, including scan mirror rotation. This is the instrument scan direction
SPACECRAFTGEOMETRY/ VZ_INSTRUMENT_INERTIAL	double64[3]	unit vector	Inertial	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
SPACECRAFTGEOMETRY/INST_SUN_ANGLE	double64	deg		Angle between instrument boresight (taking into account mirror position) and Sun, deg
PIXELGEOMETRY	Table [Integrations]			
PIXELGEOMETRY/ PIXEL_VEC	double64 [5,Spatial,3]	unit vector	IAU_MARS	Unit vector from spacecraft along lines of sight for 4 corners and center of each spatial bin
PIXELGEOMETRY/ PIXEL_CORNER_RA	double64 [5,Spatial]	deg	J2000	Right ascension of line of sight of 4 corners and center of each spatial bin
PIXELGEOMETRY/ PIXEL_CORNER_DEC	double64 [5,Spatial]	deg	J2000	Declination of line of sight of 4 corners and center of each spatial bin
PIXELGEOMETRY/ PIXEL_CORNER_LAT	double64 [5,Spatial]	deg	IAU_MARS	Geodetic Latitude of tangent or impact point of line of sight with Mars ellipsoid, for 4 corners and center of each spatial bin
PIXELGEOMETRY/ PIXEL_CORNER_LON	double64 [5,Spatial]	deg	IAU_MARS	East Longitude of tangent or impact point of line of sight with Mars ellipsoid, for 4 corners and center of each spatial bin
PIXELGEOMETRY/PIXEL_CORNER_MRH_ALT	double64 [5,Spatial]	km		Altitude of tangent point, or zero if line of sight hits ellipsoid, for 4 corners and center of each spatial bin
PIXELGEOMETRY/ PIXEL_CORNER_MRH_ALT_RATE	double64 [5,Spatial]	km/s		Time rate of change of altitude of tangent point
PIXELGEOMETRY/ PIXEL_CORNER_LOS	double64 [5,Spatial]	km		Distance from spacecraft to tangent or impact point
PIXELGEOMETRY/ PIXEL_SOLAR_ZENITH_ANGLE	double64 [Spatial]	deg		Angle between surface normal and vector to Sun, at tangent or impact point

PIXELGEOMETRY/ PIXEL_EMISSION_ANGLE	double64 [Spatial]	deg		Angle between surface normal and vector to spacecraft, at tangent or impact point
PIXELGEOMETRY/ PIXEL_ZENITH_ANGLE	double64 [Spatial]	deg		Angle between pixel look direction and spacecraft zenith (90deg plus lookdown angle)
PIXELGEOMETRY/ PIXEL_PHASE_ANGLE	double64 [Spatial]	deg		Angle between spacecraft and sun as seen from tangent or impact point
PIXELGEOMETRY/ PIXEL_LOCAL_TIME	double64 [Spatial]	hours		Local time at tangent or impact point. Varies from 0=midnight, through 6 which is about sunrise, through 12=noon, through 18 which is about sunset, to almost 24 towards midnight again
OBSERVATION	Table[1]			
OBSERVATION/ PRODUCT_ID	string			Original filename of this product
OBSERVATION/ COLLECTION_ID	string			PDS collection ID (currently unused)
OBSERVATION/ BUNDLE_ID	string			PDS bundle ID (currently unused)
OBSERVATION/ CODE_SVN_REVISION	string			SVN revision number of code used to produce this product
OBSERVATION/ ANC_SVN_REVISION	string			SVN revision number of ancillary data used to produce this product
OBSERVATION/ PRODUCT_CREATION_ DATE	string	UTC		Product creation date
OBSERVATION/ OBSERVATION_TYPE	string			Observation type string
OBSERVATION/ MISSION_PHASE	string			Mission phase string
OBSERVATION/ TARGET_NAME	string			Target name string
OBSERVATION/ ORBIT_SEGMENT	int16			Orbit segment (periapse, apoapse, corona etc, currently 0)
OBSERVATION/ ORBIT_NUMBER	int16			Orbit number (MOI is start of orbit 1, orbit number changes 30min before each periapse)
OBSERVATION/ SOLAR_LONGITUDE	float32	deg		Solar longitude, 0deg=Martian spring equinox, 90deg=solstice, etc
OBSERVATION/ GRATING_SELECT	string			Grating select (one of 'ECHELLE'/'LOWRES')
OBSERVATION/	string			Keyhole select (one of

KEYHOLE_SELECT				'LARGE'/'SMALL'/'NEITHER')
OBSERVATION/KEYHOLE_SELECT	string			Keyhole select (one of 'LARGE'/'SMALL'/'NEITHER')
OBSERVATION/BIN_PATTERN_INDEX	string			Name of linear or nonlinear binning table used for this observation.
OBSERVATION/CADENCE	double64			
OBSERVATION/INT_TIME	double64			
OBSERVATION/ DUTY_CYCLE	double64			
OBSERVATION/CHANNEL	string			
OBSERVATION/ WAVELENGTH	double64 [Spectral, Spatial]	nm		Wavelength of center of each bin
OBSERVATION/ WAVELENGTH_WIDTH	double64 [Spectral, Spatial]	nm		Wavelength width of each bin
OBSERVATION/KERNELS	string[*]			
OBSERVATION/ MCP_VOLT	float32			
OBSERVATION/MCP_GAIN	double64			
OBSERVATION/ DARK_METHOD	string			
OBSERVATION/ DARK_FILES	string[2]			
OBSERVATION/ CALIBRATION_VERSION	int16			

6.1.3 Processed data file structure

IUVS processed data files will also be archived with PDS as FITS. Unlike the raw and calibrated files, the contents of the IUVS processed data files vary between observation modes. At this data reduction level, spectral radiances are integrated spectrally into discrete emission features and binned spatially in altitude or latitude and longitude, as appropriate. Much of the low-level engineering data present in the raw and calibrated products are omitted. The file structure for each observation mode is described in a separate table below.

Table 20: Limb processed data file structure.

Field Name	Data Type	Unit	Frame	Description
EMISSION_FEATURES	Table[Emissions]			

EMISSION_FEATURES/EMISSION	string			Name of emission feature
EMISSION_FEATURES/FIT_TEMPLATE	double64[Spectral]			Spectra template for the given emission
EMISSION_FEATURES/START	float32	nm		Start value of wavelength for the multilinear fit for the given emission
EMISSION_FEATURES/STOP	float32	nm		Stop value of wavelength for the multilinear fit for the given emission
EMISSION_FEATURES/DOF	float32			Degree of freedom for regression fitted emision features.
SPECTRUM_NOALTBIN	Table[Observations]			
SPECTRUM_NOALTBIN/MUV	double64[Spectral,Spatial,Integrations]	kR/nm		Spectrum in native L1B MUV format, cleaned for solar cont. background
SPECTRUM_NOALTBIN/FUV	double64[Spectral,Spatial,Integrations]	kR/nm		Spectrum in native L1B FUV format
SPECTRUM_NOALTBIN/RANDOM_UNC_MUV	double64[Spectral,Spatial,Integrations]	kR/nm		Random uncertainty in FUV spectrum
SPECTRUM_NOALTBIN/RANDOM_UNC_FUV	double64[Spectral,Spatial,Integrations]	kR/nm		Random uncertainty in MUV spectrum
SPECTRUM_NOALTBIN/SYSTEMATIC_UNC_MUV	double64[Spectral,Spatial,Integrations]	kR/nm		Systematic uncertainty in MUV spectrum
SPECTRUM_NOALTBIN/SYSTEMATIC_UNC_FUV	double64[Spectral,Spatial,Integrations]	kR/nm		Systematic uncertainty in FUV spectrum
SPECTRUM_ALTBIN	Table[Observations]			
SPECTRUM_ALTBIN/PROFILE_FUV	double64[Spectral,Altitudes]	kR/nm		Altitudinally binned limb spectrum in FUV
SPECTRUM_ALTBIN/PROFILE_MUV	double64[Spectral,Altitudes]	kR/nm		Altitudinally binned limb spectrum in MUV
SPECTRUM_ALTBIN/RANDOM_UNC_FUV	double64[Spectral,Altitudes]	kR/nm		Random uncertainty in altitudinally binned limb radiance in FUV
SPECTRUM_ALTBIN/SYSTEMATIC_UNC_FUV	double64[Spectral,Altitudes]	kR/nm		Systematic uncertainty in altitudinally binned limb radiance in FUV
SPECTRUM_ALTBIN/RANDOM_UNC_MUV	double64[Spectral,Altitudes]	kR/nm		Random uncertainty in altitudinally binned limb radiance in MUV
SPECTRUM_ALTBIN/SYSTEMATIC_UNC_MUV	double64[Spectral,Altitudes]	kR/nm		Systematic uncertainty in altitudinally binned limb radiance in MUV

RADIANCE_ALTBIN	Table[Observations]			
RADIANCE_ALTBIN/PROFILE	double64[Emissions,Altitudes]	kR		Radiance of multilinear fitted emissions
RADIANCE_ALTBIN/RANDOM_UNC	double64[Emissions,Altitudes]	kR		Random uncertainty in the radiance of fitted emissions
RADIANCE_ALTBIN/SYSTEMATIC_UNC	double64[Emissions,Altitudes]	kR		Systematic uncertainty in the radiance of fitted emissions
RADIANCE_NOALTBIN	Table[Observations]			
RADIANCE_NOALTBIN/PROFILE	double64[Emissions,Spatial,Integrations]	kR		Radiance of multilinear fitted emissions with native geometry
RADIANCE_NOALTBIN/RANDOM_UNC	double64[Emissions,Spatial,Integrations]	kR		Random uncertainty in the radiance of fitted emissions with native geometry
RADIANCE_NOALTBIN/SYSTEMATIC_UNC	double64[Emissions,Spatial,Integrations]	kR		Systematic uncertainty in the radiance of fitted emissions with native geometry
RADIANCE_NOALTBIN/BASELINE_MUV	double64[Spatial,Integrations]			Value of constant for regression fit of CO Cameron band in MUV channel.
RADIANCE_NOALTBIN/BASELINE_FUV	double64[Spatial,Integrations]			Values of constant for regression fit of CO Fourth Positive band in FUV channel.
RADIANCE_NOALTBIN/CHI_SQUARE_MUV	double64[Spatial,Integrations]			Chi square for regression fit of CO Cameron band in MUV channel.
RADIANCE_NOALTBIN/CHI_SQUARE_FUV	double64[Spatial,Integrations]			Chi square for regression fit of CO Fourth Positive band in FUV channel.
RADIANCE_NOALTBIN/WAVELENGTH_OFFSET_FUV	double64[Spatial]			Wavelength offset in FUV channel
RADIANCE_NOALTBIN/WAVELENGTH_OFFSET_MUV	double64[Spatial]			Wavelength offset in MUV channel
GEOMETRY_ALTBIN	Table[Observations]			
GEOMETRY_ALTBIN/TANGENT_ALT	double64[Altitudes]	km	IAU_MARS	Mean altitude of binned tangent point
GEOMETRY_ALTBIN/TANGENT_LAT	double64[Altitudes]	deg	IAU_MARS	Mean geodetic Latitude of binned tangent or impact point of line of sight with Mars ellipsoid
GEOMETRY_ALTBIN/TANGENT_LON	double64[Altitudes]	deg	IAU_MARS	East Longitude of tangent point of line of sight
GEOMETRY_ALTBIN/LOOKDOWN	double64[Altitudes]	deg	IAU_MARS	Angle between spacecraft normal and tangent point
GEOMETRY_ALTBIN/TAN	double64[Alti	deg	IAU_MARS	Angle (azimuth) between true north at

GENT_AZ	tudes]			spacecraft and tangent point
GEOMETRY_ALTBIN/TANGENT_DIST	double64[Altitudes]	km	IAU_MARS	Distance between tangent point and spacecraft
GEOMETRY_ALTBIN/SPACECRAFT_ALT	double64[Altitudes]	km	IAU_MARS	Mean altitude of the spacecraft during observation above reference Mars ellipsoid
GEOMETRY_ALTBIN/SUB_SPACECRAFT_LAT	double64[Altitudes]	deg	IAU_MARS	Mean Geodetic Latitude of subspacecraft point
GEOMETRY_ALTBIN/SUB_SPACECRAFT_LON	double64[Altitudes]	deg	IAU_MARS	Mean Geodetic Longitude of subspacecraft point
GEOMETRY_ALTBIN/SZA	double64[Altitudes]	deg		Mean angle between surface normal and vector to Sun, at binned tangent or impact point
GEOMETRY_ALTBIN/PHASE_ANGLE	double64[Altitudes]	deg		Angle between spacecraft and sun as seen from tangent or impact point
GEOMETRY_ALTBIN/LOCAL_TIME	double64[Altitudes]	decimal hour		Local time at the location of tangent point
INTEGRATION	Table[Observations]			
INTEGRATION/TIMESTAMP	double64[Integrations]	SCLK seconds		Time that the integration began according to S/C clock (uncorrected)
INTEGRATION/ET	double64[Integrations]	ET s		Time that the integration began (corrected for SCLK errors by SCLK kernel)
INTEGRATION/UTC	string[Integrations]	UTC date string		Time that the integration began (corrected for SCLK errors by SCLK kernel)
INTEGRATION/MIRROR_DN	double64[Integrations]	DN		Mirror position at beginning of this integration
INTEGRATION/MIRROR_DEG	double64[Integrations]	deg		Mirror position at beginning of this integration
INTEGRATION/FOV_DEG	double64[Integrations]	deg		Instrument field of view center position at beginning of integration (=MIRROR_THIS_DEG*2)
INTEGRATION/LYA_CENTROID	double64[Integrations]	pixel		Shift of wavelength scale calculated from centroid
SPACECRAFTGEOMETRY	Table[Observations]			
SPACECRAFTGEOMETRY/SUB_SPACECRAFT_LAT	double64[Integrations]	deg		Geodetic Latitude of subspacecraft point
SPACECRAFTGEOMETRY/SUB_SPACECRAFT_LON	double64[Integrations]	deg		East Longitude of subspacecraft point
SPACECRAFTGEOMETRY/SUB_SOLAR_LAT	double64[Integrations]	deg		Geodetic Latitude of subsolar point

SPACECRAFTGEOMETRY/ SUB_SOLAR_LON	double64[Integrations]	deg		East Longitude of subsolar point
SPACECRAFTGEOMETRY/ SPACECRAFT_ALT	double64[Integrations]	km		Altitude of spacecraft above reference Mars ellipsoid
SPACECRAFTGEOMETRY/ V_SPACECRAFT	double64[Integrations,3]	km	IAU_MARS	Position of spacecraft relative to Mars center of mass
SPACECRAFTGEOMETRY/ V_SPACECRAFT_RATE	double64[Integrations,3]	km/s	IAU_MARS	Velocity of spacecraft
SPACECRAFTGEOMETRY/ V_SUN	double64[Integrations,3]	km	IAU_MARS	Position of Sun relative to Mars center of mass
SPACECRAFTGEOMETRY/ V_SUN_RATE	double64[Integrations,3]	km/s	IAU_MARS	Velocity of Sun
SPACECRAFTGEOMETRY/ VX_SPACECRAFT	double64[Integrations,3]	unit vector	IAU_MARS	Direction of spacecraft X axis
SPACECRAFTGEOMETRY/ VY_SPACECRAFT	double64[Integrations,3]	unit vector	IAU_MARS	Direction of spacecraft Y axis
SPACECRAFTGEOMETRY/ VZ_SPACECRAFT	double64[Integrations,3]	unit vector	IAU_MARS	Direction of spacecraft Z axis
SPACECRAFTGEOMETRY/ VX_INSTRUMENT	double64[Integrations,3]	unit vector	IAU_MARS	Direction of instrument field of view X axis, including scan mirror rotation. This is the instrument spatial direction.
SPACECRAFTGEOMETRY/ VY_INSTRUMENT	double64[Integrations,3]	unit vector	IAU_MARS	Direction of instrument field of view Y axis, including scan mirror rotation. This is the instrument scan direction
SPACECRAFTGEOMETRY/ VZ_INSTRUMENT	double64[Integrations,3]	unit vector	IAU_MARS	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
SPACECRAFTGEOMETRY/ V_SPACECRAFT_MSO	double64[Integrations,3]	km	MAVEN_MSO	Position of spacecraft relative to Mars center of mass
SPACECRAFTGEOMETRY/ V_SPACECRAFT_RATE_MSO	double64[Integrations,3]	km/s	MAVEN_MSO	Velocity of spacecraft
SPACECRAFTGEOMETRY/ V_SPACECRAFT_INERTIAL	double64[Integrations,3]	km	Inertial	Position of spacecraft relative to Mars center of mass
SPACECRAFTGEOMETRY/ V_SPACECRAFT_RATE_INERTIAL	double64[Integrations,3]	km/s	Inertial	Velocity of spacecraft
SPACECRAFTGEOMETRY/ V_SUN_MSO	double64[Integrations,3]	km	MAVEN_MSO	Position of Sun relative to Mars center of mass
SPACECRAFTGEOMETRY/ V_SUN_RATE_MSO	double64[Integrations,3]	km/s	MAVEN_MSO	Velocity of Sun
SPACECRAFTGEOMETRY/ VX_SPACECRAFT_MSO	double64[Integrations,3]	unit vector	MAVEN_MSO	Direction of spacecraft X axis

SPACECRAFTGEOMETRY/VY_SPACECRAFT_MSO	double64[Integrations,3]	unit vector	MAVEN_MSO	Direction of spacecraft Y axis
SPACECRAFTGEOMETRY/VZ_SPACECRAFT_MSO	double64[Integrations,3]	unit vector	MAVEN_MSO	Direction of spacecraft Z axis
SPACECRAFTGEOMETRY/VX_INSTRUMENT_MSO	double64[Integrations,3]	unit vector	MAVEN_MSO	Direction of instrument field of view X axis, including scan mirror rotation. This is the instrument spatial direction.
SPACECRAFTGEOMETRY/VY_INSTRUMENT_MSO	double64[Integrations,3]	unit vector	MAVEN_MSO	Direction of instrument field of view Y axis, including scan mirror rotation. This is the instrument scan direction
SPACECRAFTGEOMETRY/VZ_INSTRUMENT_MSO	double64[Integrations,3]	unit vector	MAVEN_MSO	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
SPACECRAFTGEOMETRY/VX_SPACECRAFT_INERTIAL	double64[Integrations,3]	unit vector	Inertial	Direction of spacecraft X axis
SPACECRAFTGEOMETRY/VY_SPACECRAFT_INERTIAL	double64[Integrations,3]	unit vector	Inertial	Direction of spacecraft Y axis
SPACECRAFTGEOMETRY/VZ_SPACECRAFT_INERTIAL	double64[Integrations,3]	unit vector	Inertial	Direction of spacecraft Z axis
SPACECRAFTGEOMETRY/VX_INSTRUMENT_INERTIAL	double64[Integrations,3]	unit vector	Inertial	Direction of instrument field of view X axis, including scan mirror rotation. This is the instrument spatial direction.
SPACECRAFTGEOMETRY/VY_INSTRUMENT_INERTIAL	double64[Integrations,3]	unit vector	Inertial	Direction of instrument field of view Y axis, including scan mirror rotation. This is the instrument scan direction
SPACECRAFTGEOMETRY/VZ_INSTRUMENT_INERTIAL	double64[Integrations,3]	unit vector	Inertial	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
SPACECRAFTGEOMETRY/INST_SUN_ANGLE	double64[Integrations]	deg		Angle between instrument boresight (taking into account mirror position) and Sun, deg
PIXELGEOMETRY	Table[Observations]			
PIXELGEOMETRY/PIXEL_VEC	double64[Integrations,5,Spatial,3]	unit vector	IAU_MARS	Unit vector from spacecraft along lines of sight for 4 corners and center of each spatial bin
PIXELGEOMETRY/PIXEL_CORNER_RA	double64[Integrations,5,Spatial]	deg	J2000	Right ascension of line of sight of 4 corners and center of each spatial bin
PIXELGEOMETRY/PIXEL_CORNER_DEC	double64[Integrations,5,Spatial]	deg	J2000	Declination of line of sight of 4 corners and center of each spatial bin

PIXELGEOMETRY/PIXEL_CORNER_LAT	double64[Integrations,5,Spatial]	deg	IAU_MARS	Geodetic Latitude of tangent or impact point of line of sight with Mars ellipsoid, for 4 corners and center of each spatial bin
PIXELGEOMETRY/PIXEL_CORNER_LON	double64[Integrations,5,Spatial]	deg	IAU_MARS	East Longitude of tangent or impact point of line of sight with Mars ellipsoid, for 4 corners and center of each spatial bin
PIXELGEOMETRY/PIXEL_CORNER_MRH_ALT	double64[Integrations,5,Spatial]	km		Altitude of tangent point, or zero if line of sight hits ellipsoid, for 4 corners and center of each spatial bin
PIXELGEOMETRY/PIXEL_CORNER_MRH_ALT_RATE	double64[Integrations,5,Spatial]	km/s		Time rate of change of altitude of tangent point
PIXELGEOMETRY/PIXEL_CORNER_LOS	double64[Integrations,5,Spatial]	km		Distance from spacecraft to tangent or impact point
PIXELGEOMETRY/PIXEL_INCIDENCE_ANGLE	double64[Integrations,Spatial]	deg		Angle between surface normal and vector to Sun, at tangent or impact point
PIXELGEOMETRY/PIXEL_EMISSION_ANGLE	double64[Integrations,Spatial]	deg		Angle between surface normal and vector to spacecraft, at tangent or impact point
PIXELGEOMETRY/LOCAL_TIME	double64[Integrations,Spatial]	decimal hour		Local time at the location of tangent point
PIXELGEOMETRY/PIXEL_PHASE_ANGLE	double64[Integrations,Spatial]	deg		Angle between spacecraft and sun as seen from tangent or impact point
OBSERVATION	Table[1]			
OBSERVATION/WAVELENGTH_FUV	double64[Spectral,Spatial, Observations]	nm		Wavelength of center of each bin for FUV channel
OBSERVATION/WAVELENGTH_MUV	double64[Spectral,Spatial, Observations]	nm		Wavelength of center of each bin for MUV channel
OBSERVATION/L1B_FUV	string[Observations]			Name of L1B FUV files used in L1C
OBSERVATION/L1B_MUV	string[Observations]			Name of L1B MUV files used in L1C
OBSERVATION/PRODUCT_ID	string			Original filename of this product
OBSERVATION/COLLECTION_ID	string			PDS collection ID (currently unused)
OBSERVATION/BUNDLE_ID	string			PDS bundle ID (currently unused)

OBSERVATION/CODE_SVN_REVISION	string			SVN revision number of code used to produce this product
OBSERVATION/ANC_SVN_REVISION	string			SVN revision number of ancillary data used to produce this product
OBSERVATION/PRODUCT_CREATION_DATE	string	UTC		Product creation date
OBSERVATION/OBSERVATION_TYPE	string			Observation type string
OBSERVATION/CALIBRATION_VERSION	int16			
OBSERVATION/MISSION_PHASE	string			Mission phase string
OBSERVATION/TARGET_NAME	string			Target name string
OBSERVATION/ORBIT_SEGMENT	float32			Orbit segment (periapse, apoapse, corona etc, currently 0)
OBSERVATION/ORBIT_NUMBER	float32			Orbit number (MOI is start of orbit 1, orbit number changes 30min before each periapse)
OBSERVATION/SOLAR_LONGITUDE	float32	deg		Solar longitude, 0deg=Martian spring equinox, 90deg=solstice, etc
OBSERVATION/GRATING_SELECT	string			Grating select (one of 'ECHELLE'/'LOWRES')
OBSERVATION/KEYHOLE_SELECT	string			Keyhole select (one of 'LARGE'/'SMALL'/'NEITHER')
OBSERVATION/BIN_PATTERN_INDEX	string			Name of linear or nonlinear binning table used for this observation.
OBSERVATION/CADENCE	float32			
OBSERVATION/INT_TIME	float32			
OBSERVATION/DUTY_CYCLE	float32			
OBSERVATION/CHANNEL	string			
OBSERVATION/KERNELS	string[*]			
OBSERVATION/MCP_VOLT_MUV	float32			
OBSERVATION/MCP_GAIN_MUV	float32			
OBSERVATION/MCP_VOLT_	float32			

FUV				
OBSERVATION/MCP_GAIN_FUV	float32			
OBSERVATION/WAVELENGTH_FUV_WIDTH	double64[Spectral,Spatial]	nm		Wavelength width of each bin for FUV channel

Table 21: Corona processed data file structure.

Field Name	Data Type	Unit	Frame	Description
EMISSION_FEATURES	Table[2]			
EMISSION_FEATURES/ID	string			Name of emission feature
EMISSION_FEATURES/BINRANGE	uint16[2]			Beginning and ending contributing spectral bins from L1B
EMISSION_FEATURES/LYA_CONT	float32			Fraction of Lyman alpha signal contributing to background
EMISSION_FEATURES/SCALE	float32			Scale factor to derive total brightness from binned brightness
OUTBOUND_ABOVE_LIMB	Table[Integrations]			
OUTBOUND_ABOVE_LIMB/RADIANCE	float32[2]	kR		Outbound scan emission feature radiance
OUTBOUND_ABOVE_LIMB/RADIANCE_UNC	float32[2]	kR		Outbound scan radiance uncertainty
OUTBOUND_ABOVE_LIMB/RADIANCE_SYSTEMATIC_UNC	float32[2]	kR		Outbound scan radiance systematic uncertainty due to calibration uncertainty
OUTBOUND_ABOVE_LIMB/TANGENT_ALT	double64	km		Altitude of tangent point, or zero if line of sight hits ellipsoid
OUTBOUND_ABOVE_LIMB/TANGENT_LOS	double64	km		Distance from spacecraft to tangent or impact point
OUTBOUND_ABOVE_LIMB/TANGENT_LAT	double64	deg		Geodetic Latitude of tangent or impact point of line of sight with Mars ellipsoid
OUTBOUND_ABOVE_LIMB/TANGENT_LON	double64	deg		East Longitude of tangent or impact point of line of sight with Mars ellipsoid
OUTBOUND_ABOVE_LIMB/RA	double64	deg	J2000	Right ascension of line of sight
OUTBOUND_ABOVE_LIMB/DEC	double64	deg	J2000	Declination of line of sight

OUTBOUND_ABOVE_LIMB/ V_TANGENT	double64[3]	km	IAU_MARS	Position of tangent point, or NaNs if line of sight hits ellipsoid
OUTBOUND_ABOVE_LIMB/ V_TANGENT_MSO	double64[3]	km	MAVEN_MSO	Position of tangent point, or NaNs if line of sight hits ellipsoid
OUTBOUND_ABOVE_LIMB/ VZ_INSTRUMENT	double64[3]	unit vector	IAU_MARS	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
OUTBOUND_ABOVE_LIMB/ VZ_INSTRUMENT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
OUTBOUND_ABOVE_LIMB/ VZ_INSTRUMENT_DOPPLER	float32	km/s		Doppler shift along the line of sight
OUTBOUND_ABOVE_LIMB/S PACECRAFT_ALT	double64	km		Altitude of spacecraft above reference Mars ellipsoid
OUTBOUND_ABOVE_LIMB/S UB_SPACECRAFT_LAT	double64	deg		Geodetic Latitude of subspacecraft point
OUTBOUND_ABOVE_LIMB/S UB_SPACECRAFT_LON	double64	deg		East Longitude of subspacecraft point
OUTBOUND_ABOVE_LIMB/ V_SPACECRAFT	double64[3]	km	IAU_MARS	Position of spacecraft relative to Mars center of mass
OUTBOUND_ABOVE_LIMB/ V_SPACECRAFT_MSO	double64[3]	km	MAVEN_MSO	Position of spacecraft relative to Mars center of mass
OUTBOUND_ABOVE_LIMB/S UB_SOLAR_LAT	double64	deg		Geodetic Latitude of subsolar point
OUTBOUND_ABOVE_LIMB/S UB_SOLAR_LON	double64	deg		East Longitude of subsolar point
OUTBOUND_ABOVE_LIMB/ V_SUN	double64[3]	km	IAU_MARS	Position of Sun relative to Mars center of mass
OUTBOUND_ABOVE_LIMB/ V_SUN_MSO	double64[3]	km	MAVEN_MSO	Position of Sun relative to Mars center of mass
OUTBOUND_ABOVE_LIMB/ ET	double64	ET s		Time that the integration began (corrected for SCLK errors by SCLK kernel)
OUTBOUND_ABOVE_LIMB/ UTC	string	UTC date string		Time that the integration began (corrected for SCLK errors by SCLK kernel)
INBOUND_ABOVE_LIMB	Table[Integ rations]			
INBOUND_ABOVE_LIMB/RA DIANCE	float32[2]	kR		Inbound scan emission feature radiance
INBOUND_ABOVE_LIMB/RA DIANCE_UNC	float32[2]	kR		Inbound scan radiance uncertainty
INBOUND_ABOVE_LIMB/RA	float32[2]	kR		Inbound scan radiance systematic

DIANCE_SYSTEMATIC_UNC				uncertainty due to calibration uncertainty
INBOUND_ABOVE_LIMB/TANGENT_ALT	double64	km		Altitude of tangent point
INBOUND_ABOVE_LIMB/TANGENT_LOS	double64	km		Distance from spacecraft to tangent or impact point
INBOUND_ABOVE_LIMB/TANGENT_LAT	double64	deg		Geodetic Latitude of tangent point of line of sight
INBOUND_ABOVE_LIMB/TANGENT_LON	double64	deg		East Longitude of tangent point of line of sight
INBOUND_ABOVE_LIMB/RA	double64	deg	J2000	Right ascension of line of sight
INBOUND_ABOVE_LIMB/DEC	double64	deg	J2000	Declination of line of sight
INBOUND_ABOVE_LIMB/V_TANGENT	double64[3]	km	IAU_MARS	Position of tangent point
INBOUND_ABOVE_LIMB/V_TANGENT_MSO	double64[3]	km	MAVEN_MSO	Position of tangent point
INBOUND_ABOVE_LIMB/VZ_INSTRUMENT	double64[3]	unit vector	IAU_MARS	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
INBOUND_ABOVE_LIMB/VZ_INSTRUMENT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
INBOUND_ABOVE_LIMB/VZ_INSTRUMENT_DOPPLER	float32	km/s		Doppler shift along the line of sight
INBOUND_ABOVE_LIMB/SPACECRAFT_ALT	double64	km		Altitude of spacecraft above reference Mars ellipsoid
INBOUND_ABOVE_LIMB/SUB_SPACECRAFT_LAT	double64	deg		Geodetic Latitude of subspacecraft point
INBOUND_ABOVE_LIMB/SUB_SPACECRAFT_LON	double64	deg		East Longitude of subspacecraft point
INBOUND_ABOVE_LIMB/V_SPACECRAFT	double64[3]	km	IAU_MARS	Position of spacecraft relative to Mars center of mass
INBOUND_ABOVE_LIMB/V_SPACECRAFT_MSO	double64[3]	km	MAVEN_MSO	Position of spacecraft relative to Mars center of mass
INBOUND_ABOVE_LIMB/SUB_SOLAR_LAT	double64	deg		Geodetic Latitude of subsolar point
INBOUND_ABOVE_LIMB/SUB_SOLAR_LON	double64	deg		East Longitude of subsolar point
INBOUND_ABOVE_LIMB/V_SUN	double64[3]	km	IAU_MARS	Position of Sun relative to Mars center of mass
INBOUND_ABOVE_LIMB/V_	double64[3	km	MAVEN_MSO	Position of Sun relative to Mars

SUN_MSO	]			center of mass
INBOUND_ABOVE_LIMB/ET	double64	ET s		Time that the integration began (corrected for SCLK errors by SCLK kernel)
INBOUND_ABOVE_LIMB/UTC	string	UTC date string		Time that the integration began (corrected for SCLK errors by SCLK kernel)
INBOUND_BELOW_LIMB	Table[Integrations_below]			
INBOUND_BELOW_LIMB/RADIANCE	float32[2]	kR		Inbound scan emission feature radiance
INBOUND_BELOW_LIMB/RADIANCE_UNC	float32[2]	kR		Inbound scan radiance uncertainty
INBOUND_BELOW_LIMB/RADIANCE_SYSTEMATIC_UNC	float32[2]	kR		Inbound scan radiance systematic uncertainty due to calibration uncertainty
INBOUND_BELOW_LIMB/RA	double64	deg	J2000	Right ascension of line of sight
INBOUND_BELOW_LIMB/DEC	double64	deg	J2000	Declination of line of sight
INBOUND_BELOW_LIMB/VZ_INSTRUMENT	double64[3]	unit vector	IAU_MARS	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
INBOUND_BELOW_LIMB/VZ_INSTRUMENT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
INBOUND_BELOW_LIMB/VZ_INSTRUMENT_DOPPLER	float32	km/s		Doppler shift along the line of sight relative to solar system barycenter
INBOUND_BELOW_LIMB/SPACECRAFT_ALT	double64	km		Altitude of spacecraft above reference Mars ellipsoid
INBOUND_BELOW_LIMB/SUB_SPACECRAFT_LAT	double64	deg		Geodetic Latitude of subspacecraft point
INBOUND_BELOW_LIMB/SUB_SPACECRAFT_LON	double64	deg		East Longitude of subspacecraft point
INBOUND_BELOW_LIMB/V_SPACECRAFT	double64[3]	km	IAU_MARS	Position of spacecraft relative to Mars center of mass
INBOUND_BELOW_LIMB/V_SPACECRAFT_MSO	double64[3]	km	MAVEN_MSO	Position of spacecraft relative to Mars center of mass
INBOUND_BELOW_LIMB/SUB_SOLAR_LAT	double64	deg		Geodetic Latitude of subsolar point
INBOUND_BELOW_LIMB/SUB_SOLAR_LON	double64	deg		East Longitude of subsolar point
INBOUND_BELOW_LIMB/V_	double64[3	km	IAU_MARS	Position of Sun relative to Mars

SUN	]			center of mass
INBOUND_BELOW_LIMB/V_SUN_MSO	double64[3]	km	MAVEN_MSO	Position of Sun relative to Mars center of mass
INBOUND_BELOW_LIMB/ET	double64	ET s		Time that the integration began (corrected for SCLK errors by SCLK kernel)
INBOUND_BELOW_LIMB/UTC	string	UTC date string		Time that the integration began (corrected for SCLK errors by SCLK kernel)
OBSERVATION	Table[1]			
OBSERVATION/PRODUCT_ID	string			Original filename of this product
OBSERVATION/COLLECTION_ID	string			PDS collection ID (currently unused)
OBSERVATION/BUNDLE_ID	string			PDS bundle ID (currently unused)
OBSERVATION/L1B_OUTBOUND	string			
OBSERVATION/L1B_INBOUND	string			
OBSERVATION/CODE_SVN_REVISION	string			SVN revision number of code used to produce this product
OBSERVATION/ANC_SVN_REVISION	string			SVN revision number of ancillary data used to produce this product
OBSERVATION/PRODUCT_CREATION_DATE	string	UTC		Product creation date
OBSERVATION/OBSERVATION_TYPE	string			Observation type string
OBSERVATION/CALIBRATION_VERSION	int16			
OBSERVATION/MISSION_PHASE	string			Mission phase string
OBSERVATION/TARGET_NAME	string			Target name string
OBSERVATION/ORBIT_SEGMENT	int16			Orbit segment (periapse, apoapse, corona etc, currently 0)
OBSERVATION/ORBIT_NUMBER	int16			Orbit number (MOI is start of orbit 1, orbit number changes 30min before each periapse)
OBSERVATION/SOLAR_LONGITUDE	float32	deg		Solar longitude, 0deg=Martian spring equinox, 90deg=solstice, etc
OBSERVATION/GRATING_SELECT	string			Grating select (one of 'ECHELLE'/'LOWRES')
OBSERVATION/KEYHOLE_S	string			Keyhole select (one of

ELECT				'LARGE'/'SMALL'/'NEITHER')
OBSERVATION/BIN_PATTERN_INDEX	string			Name of linear or nonlinear binning table used for this observation.
OBSERVATION/CADENCE	float32			
OBSERVATION/INT_TIME	float32			
OBSERVATION/DUTY_CYCLE	float32			
OBSERVATION/CHANNEL	string			
OBSERVATION/KERNELS	string[8]			
OBSERVATION/MCP_VOLT	float32			
OBSERVATION/MCP_GAIN	float32			

Table 22: Disk processed data file structure.

Field Name	Data Type	Unit	Frame	Description
EMISSION_FEATURES_FUV	Table[Emissions]			
EMISSION_FEATURES_FUV/EMISSION	string			Name of emission feature
EMISSION_FEATURES_FUV/FIT_TEMPLATE	double64[Spectral_FUV]			Spectra template for the given emission
EMISSION_FEATURES_FUV/START	float32	nm		Start value of wavelength for the multilinear fit for the given emission
EMISSION_FEATURES_FUV/STOP	float32	nm		Stop value of wavelength for the multilinear fit for the given emission
EMISSION_FEATURES_FUV/DOF	float32			
REFLECTANCE_MUV	Table[1]			
REFLECTANCE_MUV/REFLECTANCE	double64[Latitudes,Longitudes,Spectral_MUV]			MUV reflectance
REFLECTANCE_MUV/RANDOM_UNC	double64[Latitudes,Longitudes,Spectral_MUV]			Random uncertainty (1-sigma) on MUV reflectance
REFLECTANCE_MUV/SYSTEMATIC_UNC	double64[Latitudes,Longitudes,Spectral_MUV]			Systematic uncertainty on MUV reflectance

BRIGHTNESS_FUV	Table[1]			
BRIGHTNESS_FUV/BRIGHTNESS	double64[Latitudes,Longitudes,Emissions]	kR		FUV brightmess
BRIGHTNESS_FUV/RANDOM_UNC	double64[Latitudes,Longitudes,Emissions]	kR		Random uncertainty (1-sigma) on FUV brightness
BRIGHTNESS_FUV/SYSTEMATIC_UNC	double64[Latitudes,Longitudes,Emissions]	kR		Systematic uncertainty on FUV brightness
SIMULATED_SOLAR_FLUX	float32[Latitudes,Longitudes,Spectral_MUV]	kR/nm		Simulated solar flux at Mars
APOAPSE_GEOMETRY	Table[1]			
APOAPSE_GEOMETRY/LATITUDE	float32[Latitudes]	deg		Latitude
APOAPSE_GEOMETRY/LONGITUDE	float32[Longitudes]	deg		Longitude, counted east positive
APOAPSE_GEOMETRY/LOCAL_TIME	float32[Latitudes,Longitudes]	decimal hour		Local time
APOAPSE_GEOMETRY/SOLAR_ZENITH_ANGLE	float32[Latitudes,Longitudes]	deg		Solar zenith angle
APOAPSE_GEOMETRY/PHASE_ANGLE	float32[Latitudes,Longitudes]	deg		Phase angle
APOAPSE_GEOMETRY/EMISSION_ANGLE	float32[Latitudes,Longitudes]	deg		Angle between normal and spacecraft
INTEGRATION	Table[Swaths]			
INTEGRATION/TIMESTAMP	double64[Integrations]	SCLK seconds		Time that the integration began according to S/C clock (uncorrected)
INTEGRATION/ET	double64[Integrations]	ET s		Time that the integration began (corrected for SCLK errors by SCLK kernel)
INTEGRATION/MIRROR_DN	double64[Integrations]	DN		Mirror position at beginning of this integration
INTEGRATION/MIRROR_DEG	double64[Integrations]	deg		Mirror position at beginning of this integration

INTEGRATION/FOV_DEG	double64[Integrations]	deg		Instrument field of view center position at beginning of integration (=MIRROR_THIS_DEG*2)
INTEGRATION/LYA_CENTROID	double64[Integrations]	pixel		Shift of wavelength scale calculated from centroid
SPACECRAFTGEOMETRY	Table[Swaths]			
SPACECRAFTGEOMETRY/SUB_SPACECRAFT_LAT	double64[Integrations]	deg		Geodetic Latitude of subspacecraft point
SPACECRAFTGEOMETRY/SUB_SPACECRAFT_LON	double64[Integrations]	deg		East Longitude of subspacecraft point
SPACECRAFTGEOMETRY/SUB_SOLAR_LAT	double64[Integrations]	deg		Geodetic Latitude of subsolar point
SPACECRAFTGEOMETRY/SUB_SOLAR_LON	double64[Integrations]	deg		East Longitude of subsolar point
SPACECRAFTGEOMETRY/SPACECRAFT_ALT	double64[Integrations]	km		Altitude of spacecraft above reference Mars ellipsoid
SPACECRAFTGEOMETRY/V_SPACECRAFT	double64[Integrations,3]	km	IAU_MARS	Position of spacecraft relative to Mars center of mass
SPACECRAFTGEOMETRY/V_SPACECRAFT_RATE	double64[Integrations,3]	km/s	IAU_MARS	Velocity of spacecraft
SPACECRAFTGEOMETRY/V_SUN	double64[Integrations,3]	km	IAU_MARS	Position of Sun relative to Mars center of mass
SPACECRAFTGEOMETRY/V_SUN_RATE	double64[Integrations,3]	km/s	IAU_MARS	Velocity of Sun
SPACECRAFTGEOMETRY/VX_SPACECRAFT	double64[Integrations,3]	unit vector	IAU_MARS	Direction of spacecraft X axis
SPACECRAFTGEOMETRY/VY_SPACECRAFT	double64[Integrations,3]	unit vector	IAU_MARS	Direction of spacecraft Y axis
SPACECRAFTGEOMETRY/VZ_SPACECRAFT	double64[Integrations,3]	unit vector	IAU_MARS	Direction of spacecraft Z axis
SPACECRAFTGEOMETRY/VX_INSTRUMENT	double64[Integrations,3]	unit vector	IAU_MARS	Direction of instrument field of view X axis, including scan mirror rotation. This is the instrument spatial direction.
SPACECRAFTGEOMETRY/VY_INSTRUMENT	double64[Integrations,3]	unit vector	IAU_MARS	Direction of instrument field of view Y axis, including scan mirror rotation. This is the instrument scan direction
SPACECRAFTGEOMETRY/VZ_INSTRUMENT	double64[Integrations,3]	unit vector	IAU_MARS	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
SPACECRAFTGEOMETRY/V_	double64[Inte	km	MAVEN_MSO	Position of spacecraft relative to

SPACECRAFT_MSO	grations,3]			Mars center of mass
SPACECRAFTGEOMETRY/V_ SPACECRAFT_RATE_MSO	double64[Inte grations,3]	km/s	MAVEN_MSO	Velocity of spacecraft
SPACECRAFTGEOMETRY/V_ SPACECRAFT_INERTIAL	double64[Inte grations,3]	km	Inertial	Position of spacecraft relative to Mars center of mass
SPACECRAFTGEOMETRY/V_ SPACECRAFT_RATE_INERTI AL	double64[Inte grations,3]	km/s	Inertial	Velocity of spacecraft
SPACECRAFTGEOMETRY/V_ SUN_MSO	double64[Inte grations,3]	km	MAVEN_MSO	Position of Sun relative to Mars center of mass
SPACECRAFTGEOMETRY/V_ SUN_RATE_MSO	double64[Inte grations,3]	km/s	MAVEN_MSO	Velocity of Sun
SPACECRAFTGEOMETRY/V X_SPACECRAFT_MSO	double64[Inte grations,3]	unit vector	MAVEN_MSO	Direction of spacecraft X axis
SPACECRAFTGEOMETRY/V Y_SPACECRAFT_MSO	double64[Inte grations,3]	unit vector	MAVEN_MSO	Direction of spacecraft Y axis
SPACECRAFTGEOMETRY/V Z_SPACECRAFT_MSO	double64[Inte grations,3]	unit vector	MAVEN_MSO	Direction of spacecraft Z axis
SPACECRAFTGEOMETRY/V X_INSTRUMENT_MSO	double64[Inte grations,3]	unit vector	MAVEN_MSO	Direction of instrument field of view X axis, including scan mirror rotation. This is the instrument spatial direction.
SPACECRAFTGEOMETRY/V Y_INSTRUMENT_MSO	double64[Inte grations,3]	unit vector	MAVEN_MSO	Direction of instrument field of view Y axis, including scan mirror rotation. This is the instrument scan direction
SPACECRAFTGEOMETRY/V Z_INSTRUMENT_MSO	double64[Inte grations,3]	unit vector	MAVEN_MSO	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
SPACECRAFTGEOMETRY/V X_SPACECRAFT_INERTIAL	double64[Inte grations,3]	unit vector	Inertial	Direction of spacecraft X axis
SPACECRAFTGEOMETRY/V Y_SPACECRAFT_INERTIAL	double64[Inte grations,3]	unit vector	Inertial	Direction of spacecraft Y axis
SPACECRAFTGEOMETRY/V Z_SPACECRAFT_INERTIAL	double64[Inte grations,3]	unit vector	Inertial	Direction of spacecraft Z axis
SPACECRAFTGEOMETRY/V X_INSTRUMENT_INERTIAL	double64[Inte grations,3]	unit vector	Inertial	Direction of instrument field of view X axis, including scan mirror rotation. This is the instrument spatial direction.
SPACECRAFTGEOMETRY/V Y_INSTRUMENT_INERTIAL	double64[Inte grations,3]	unit vector	Inertial	Direction of instrument field of view Y axis, including scan mirror rotation. This is the instrument scan direction
SPACECRAFTGEOMETRY/V Z_INSTRUMENT_INERTIAL	double64[Inte grations,3]	unit vector	Inertial	Direction of instrument field of view Z axis, including scan

				mirror rotation. This is the instrument boresight.
SPACECRAFTGEOMETRY/INST_SUN_ANGLE	double64[Integrations]	deg		Angle between instrument boresight (taking into account mirror position) and Sun, deg
OBSERVATION	Table[1]			
OBSERVATION/PRODUCT_ID	string			Original filename of this product
OBSERVATION/COLLECTION_ID	string			PDS collection ID (currently unused)
OBSERVATION/BUNDLE_ID	string			PDS bundle ID (currently unused)
OBSERVATION/CODE_SVN_REVISION	string			SVN revision number of code used to produce this product
OBSERVATION/ANC_SVN_REVISION	string			SVN revision number of ancillary data used to produce this product
OBSERVATION/PRODUCT_CREATION_DATE	string	UTC		Product creation date
OBSERVATION/OBSERVATION_TYPE	string			Observation type string
OBSERVATION/CALIBRATION_VERSION	int16			
OBSERVATION/MISSION_PHASE	string			Mission phase string
OBSERVATION/TARGET_NAME	string			Target name string
OBSERVATION/ORBIT_SEGMENT	int16			Orbit segment (periapse, apoapse, corona etc, currently 0)
OBSERVATION/ORBIT_NUMBER	int16			Orbit number (MOI is start of orbit 1, orbit number changes 30min before each periapse)
OBSERVATION/SOLAR_LONGITUDE	float32	deg		Solar longitude, 0deg=Martian spring equinox, 90deg=solstice, etc
OBSERVATION/GRATING_SELECT	string			Grating select (one of 'ECHELLE'/'LOWRES')
OBSERVATION/KEYHOLE_SELECT	string			Keyhole select (one of 'LARGE'/'SMALL'/'NEITHER')
OBSERVATION/BIN_PATTERN_INDEX	string			Name of linear or nonlinear binning table used for this observation.
OBSERVATION/CADENCE	float32			
OBSERVATION/INT_TIME	float32			

OBSERVATION/DUTY_CYCLE	float32			
OBSERVATION/CHANNEL	string			
OBSERVATION/KERNELS	string[*]			
OBSERVATION/MCP_VOLT_MUV	float32			
OBSERVATION/MCP_GAIN_MUV	float32			
OBSERVATION/MCP_VOLT_FUV	float32			
OBSERVATION/MCP_GAIN_FUV	float32			
OBSERVATION/WAVELENGTH_MUV	double64[Spectral_MUV,Spatial,Swaths*2]	nm		Wavelength of center of each bin for MUV channel
OBSERVATION/WAVELENGTH_FUV	double64[Spectral_FUV,Spatial,Swaths*2]	nm		Wavelength of center of each bin for FUV channel
OBSERVATION/L1B_MUV	string[Swaths*2]			Name of L1B MUV files used in L1C
OBSERVATION/L1B_FUV	string[Swaths*2]			Name of L1B FUV files used in L1C

Table 23: Occultation processed data file structure.

Field Name	Data Type	Unit	Frame	Description
REFERENCE_SPECTRUM	Table[1]			
REFERENCE_SPECTRUM/FUV	double64[Spectral]	DN		FUV reference spectrum
REFERENCE_SPECTRUM/FUV_UNCERTAINTY	double64[Spectral]	DN		Uncertainty of the FUV reference spectrum
REFERENCE_SPECTRUM/FUV_PHOTON	double64[Spectral]	photon cm-2 s-1 nm-1		FUV reference spectrum in photon cm-2 s-1 nm-1
REFERENCE_SPECTRUM/FUV_UNCERTAINTY_PHOTON	double64[Spectral]	photon cm-2 s-1 nm-1		Unertainty of the FUV reference spectrum in photon cm-2 s-1 nm-1
REFERENCE_SPECTRUM/MUV	float32	DN		MUV reference spectrum
REFERENCE_SPECTRUM/MUV_UNCERTAINTY	float32	DN		Uncertainty of the MUV reference spectrum
REFERENCE_SPECTRUM/MUV_PHOTON	float32	photon cm-2 s-1 nm-1		MUV reference spectrum in photon cm-2 s-1 nm-1
REFERENCE_SPECTRUM/MUV_UNCERTAINTY_PHOTON	float32	photon cm-2 s-		Unertainty of the MUV reference spectrum in photon

		1 nm-1		cm-2 s-1 nm-1
TRANSMISSION_SPECTRUM	Table[1]			
TRANSMISSION_SPECTRUM /FUV	float32[Specral,Integrations]			FUV transmission spectrum
TRANSMISSION_SPECTRUM /FUV_UNCERTAINTY	float32[Specral,Integrations]			Uncertainty of the FUV transmission spectrum
TRANSMISSION_SPECTRUM /MUV	float32			MUV transmission spectrum
TRANSMISSION_SPECTRUM /MUV_UNCERTAINTY	float32			Uncertainty of the MUV transmission spectrum
OCCULTATION_GEOMETRY	Table[Integrations]			
OCCULTATION_GEOMETRY /ALTITUDE	double64	km		tangent altitude of the nearpoint for each integration
OCCULTATION_GEOMETRY /RADIAL_DISTANCE	double64	km		
OCCULTATION_GEOMETRY /UTC_TIME	string	UTC		UTC time when the integraiton began
OCCULTATION_GEOMETRY /ET_TIME	string	ET s		time when the integration began (corrected for SCLK errors by SCLK kernel)
OCCULTATION_GEOMETRY /LONGITUDE_PG	double64	deg		
OCCULTATION_GEOMETRY /LATITUDE_PG	double64	deg		
OCCULTATION_GEOMETRY /LONGITUDE_PC	double64	deg		
OCCULTATION_GEOMETRY /LATITUDE_PC	double64	deg		
OCCULTATION_GEOMETRY /SZA	double64	deg		Solar zenith angle
OCCULTATION_GEOMETRY /LOCAL_TIME	double64	decimal hour		Local time
HLP_GEOMETRY	Table[1]			
HLP_GEOMETRY/HLP_LON_PG	float32			
HLP_GEOMETRY/HLP_LAT_PG	float32			
HLP_GEOMETRY/HLP_LON_PC	float32			
HLP_GEOMETRY/HLP_LAT_PC	float32			
HLP_GEOMETRY/HLP_SZA	float32			
HLP_GEOMETRY/HLP_LT	float32			
INTEGRATION	Table[Integrations]			
INTEGRATION/TIMESTAMP	double64	SCLK seconds		Time that the integration began according to S/C clock (uncorrected)
INTEGRATION/ET	double64	ET s		Time that the integration began (corrected for SCLK errors by

				SCLK kernel)
INTEGRATION/UTC	string	UTC date string		Time that the integration began (corrected for SCLK errors by SCLK kernel)
INTEGRATION/MIRROR_DN	uint16	DN		Mirror position at beginning of this integration
INTEGRATION/MIRROR_DEG	float32	deg		Mirror position at beginning of this integration
INTEGRATION/FOV_DEG	float32	deg		Instrument field of view center position at beginning of integration (=MIRROR_THIS_DEG*2)
INTEGRATION/LYA_CENTROID	int16	pixel		Shift of wavelength scale calculated from centroid
INTEGRATION/DET_TEMP_C	double64			
INTEGRATION/CASE_TEMP_C	double64			
SPACECRAFTGEOMETRY	Table[Integrations]			
SPACECRAFTGEOMETRY/SUB_SPACECRAFT_LAT	double64	deg		Geodetic Latitude of subspacecraft point
SPACECRAFTGEOMETRY/SUB_SPACECRAFT_LON	double64	deg		East Longitude of subspacecraft point
SPACECRAFTGEOMETRY/SUB_SOLAR_LAT	double64	deg		Geodetic Latitude of subsolar point
SPACECRAFTGEOMETRY/SUB_SOLAR_LON	double64	deg		East Longitude of subsolar point
SPACECRAFTGEOMETRY/SPACECRAFT_ALT	double64	km		Altitude of spacecraft above reference Mars ellipsoid
SPACECRAFTGEOMETRY/V_SPACECRAFT	double64[3]	km	IAU_MARS	Position of spacecraft relative to Mars center of mass
SPACECRAFTGEOMETRY/V_SPACECRAFT_RATE	double64[3]	km/s	IAU_MARS	Velocity of spacecraft
SPACECRAFTGEOMETRY/V_SUN	double64[3]	km	IAU_MARS	Position of Sun relative to Mars center of mass
SPACECRAFTGEOMETRY/V_SUN_RATE	double64[3]	km/s	IAU_MARS	Velocity of Sun
SPACECRAFTGEOMETRY/VX_SPACECRAFT	double64[3]	unit vector	IAU_MARS	Direction of spacecraft X axis
SPACECRAFTGEOMETRY/VY_SPACECRAFT	double64[3]	unit vector	IAU_MARS	Direction of spacecraft Y axis
SPACECRAFTGEOMETRY/VZ_SPACECRAFT	double64[3]	unit vector	IAU_MARS	Direction of spacecraft Z axis
SPACECRAFTGEOMETRY/VX_INSTRUMENT	double64[3]	unit vector	IAU_MARS	Direction of instrument field of view X axis, including scan mirror rotation. This is the instrument spatial direction.
SPACECRAFTGEOMETRY/VY_INSTRUMENT	double64[3]	unit vector	IAU_MARS	Direction of instrument field of view Y axis, including scan mirror rotation. This is the instrument scan direction
SPACECRAFTGEOMETRY/VZ_INSTRUMENT	double64[3]	unit vector	IAU_MARS	Direction of instrument field of view Z axis, including scan mirror rotation. This is the

				instrument boresight.
SPACECRAFTGEOMETRY/V_SPACECRAFT_MSO	double64[3]	km	MAVEN_MSO	Position of spacecraft relative to Mars center of mass
SPACECRAFTGEOMETRY/V_SPACECRAFT_RATE_MSO	double64[3]	km/s	MAVEN_MSO	Velocity of spacecraft
SPACECRAFTGEOMETRY/V_SPACECRAFT_INERTIAL	double64[3]	km	Inertial	Position of spacecraft relative to Mars center of mass
SPACECRAFTGEOMETRY/V_SPACECRAFT_RATE_INERTIAL	double64[3]	km/s	Inertial	Velocity of spacecraft
SPACECRAFTGEOMETRY/V_SPACECRAFT_INERTIAL_FRAME	string			Spice name of inertial frame
SPACECRAFTGEOMETRY/V_SPACECRAFT_INERTIAL_CENTER	string			Spice name of inertial center of mass
SPACECRAFTGEOMETRY/V_SUN_MSO	double64[3]	km	MAVEN_MSO	Position of Sun relative to Mars center of mass
SPACECRAFTGEOMETRY/V_SUN_RATE_MSO	double64[3]	km/s	MAVEN_MSO	Velocity of Sun
SPACECRAFTGEOMETRY/VX_SPACECRAFT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of spacecraft X axis
SPACECRAFTGEOMETRY/VY_SPACECRAFT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of spacecraft Y axis
SPACECRAFTGEOMETRY/VZ_SPACECRAFT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of spacecraft Z axis
SPACECRAFTGEOMETRY/VX_INSTRUMENT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of instrument field of view X axis, including scan mirror rotation. This is the instrument spatial direction.
SPACECRAFTGEOMETRY/VY_INSTRUMENT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of instrument field of view Y axis, including scan mirror rotation. This is the instrument scan direction
SPACECRAFTGEOMETRY/VZ_INSTRUMENT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
SPACECRAFTGEOMETRY/VX_SPACECRAFT_INERTIAL	double64[3]	unit vector	Inertial	Direction of spacecraft X axis
SPACECRAFTGEOMETRY/VY_SPACECRAFT_INERTIAL	double64[3]	unit vector	Inertial	Direction of spacecraft Y axis
SPACECRAFTGEOMETRY/VZ_SPACECRAFT_INERTIAL	double64[3]	unit vector	Inertial	Direction of spacecraft Z axis
SPACECRAFTGEOMETRY/VX_INSTRUMENT_INERTIAL	double64[3]	unit vector	Inertial	Direction of instrument field of view X axis, including scan mirror rotation. This is the instrument spatial direction.
SPACECRAFTGEOMETRY/VY_INSTRUMENT_INERTIAL	double64[3]	unit vector	Inertial	Direction of instrument field of view Y axis, including scan mirror rotation. This is the instrument scan direction
SPACECRAFTGEOMETRY/VZ_INSTRUMENT_INERTIAL	double64[3]	unit vector	Inertial	Direction of instrument field of view Z axis, including scan mirror rotation. This is the

				instrument boresight.
SPACECRAFTGEOMETRY/INST_SUN_ANGLE	double64	deg		Angle between instrument boresight (taking into account mirror position) and Sun, deg
PIXELGEOMETRY	Table[Integrations]			
PIXELGEOMETRY/PIXEL_VEC	double64[5,Spatial,3]	unit vector	IAU_MARS	Unit vector from spacecraft along lines of sight for 4 corners and center of each spatial bin
PIXELGEOMETRY/PIXEL_CORNER_RA	double64[5,Spatial]	deg	J2000	Right ascension of line of sight of 4 corners and center of each spatial bin
PIXELGEOMETRY/PIXEL_CORNER_DEC	double64[5,Spatial]	deg	J2000	Declination of line of sight of 4 corners and center of each spatial bin
PIXELGEOMETRY/PIXEL_CORNER_LAT	double64[5,Spatial]	deg	IAU_MARS	Geodetic Latitude of tangent or impact point of line of sight with Mars ellipsoid, for 4 corners and center of each spatial bin
PIXELGEOMETRY/PIXEL_CORNER_LON	double64[5,Spatial]	deg	IAU_MARS	East Longitude of tangent or impact point of line of sight with Mars ellipsoid, for 4 corners and center of each spatial bin
PIXELGEOMETRY/PIXEL_CORNER_MRH_ALT	double64[5,Spatial]	km		Altitude of tangent point, or zero if line of sight hits ellipsoid, for 4 corners and center of each spatial bin
PIXELGEOMETRY/PIXEL_CORNER_MRH_ALT_RATE	double64[5,Spatial]	km/s		Time rate of change of altitude of tangent point
PIXELGEOMETRY/PIXEL_CORNER_LOS	double64[5,Spatial]	km		Distance from spacecraft to tangent or impact point
PIXELGEOMETRY/PIXEL_SOLAR_ZENITH_ANGLE	double64[Spatial]			
PIXELGEOMETRY/PIXEL_EMISSION_ANGLE	double64[Spatial]	deg		Angle between surface normal and vector to spacecraft, at tangent or impact point
PIXELGEOMETRY/PIXEL_ZENITH_ANGLE	double64[Spatial]	deg		Angle between pixel look direction and spacecraft zenith (90deg plus lookdown angle)
PIXELGEOMETRY/PIXEL_PHASE_ANGLE	double64[Spatial]	deg		Angle between spacecraft and sun as seen from tangent or impact point
PIXELGEOMETRY/PIXEL_LOCAL_TIME	double64[Spatial]			
OBSERVATION	Table[1]			
OBSERVATION/PRODUCT_ID	string			Original filename of this product
OBSERVATION/COLLECTION_ID	string			PDS collection ID (currently unused)
OBSERVATION/BUNDLE_ID	string			PDS bundle ID (currently unused)
OBSERVATION/CODE_SVN_REVISION	string			SVN revision number of code used to produce this product
OBSERVATION/ANC_SVN_R	string			SVN revision number of

EVISION				ancillary data used to produce this product
OBSERVATION/PRODUCT_CREATION_DATE	string	UTC		Product creation date
OBSERVATION/OBSERVATION_TYPE	string			Observation type string
OBSERVATION/MISSION_PHASE	string			Mission phase string
OBSERVATION/TARGET_NAME	string			Target name string
OBSERVATION/ORBIT_SEGMENT	int16			Orbit segment (periapse, apoapse, corona etc, currently 0)
OBSERVATION/ORBIT_NUMBER	int16			Orbit number (MOI is start of orbit 1, orbit number changes 30min before each periapse)
OBSERVATION/SOLAR_LONGITUDE	float32	deg		Solar longitude, 0deg=Martian spring equinox, 90deg=solstice, etc
OBSERVATION/GRATING_SELECT	string			Grating select (one of 'ECHELLE'/'LOWRES')
OBSERVATION/KEYHOLE_SELECT	string			Keyhole select (one of 'LARGE'/'SMALL'/'NEITHER')
OBSERVATION/BIN_PATTERN_INDEX	string			Name of linear or nonlinear binning table used for this observation.
OBSERVATION/CADENCE	double64			
OBSERVATION/INT_TIME	double64			
OBSERVATION/DUTY_CYCLE	double64			
OBSERVATION/WAVELENGTH_SHIFT	double64	nm		Wavelength offset
OBSERVATION/WAVELENGTH_FUV	double64[Spectral]	nm		Wavelength of center of each bin for FUV channel
OBSERVATION/WAVELENGTH_WIDTH_FUV	double64[Spectral,Spatial]			
OBSERVATION/WAVELENGTH_MUV	int16	nm		Wavelength of center of each bin for MUV channel
OBSERVATION/WAVELENGTH_WIDTH_MUV	int16			
OBSERVATION/KERNELS	string[8]			
OBSERVATION/MCP_VOLT	float32			
OBSERVATION/MCP_GAIN_FUV	double64			
OBSERVATION/MCP_GAIN_MUV	int16			
OBSERVATION/CALIBRATION_VERSION	int16			
OBSERVATION/L1B_FUV	string			Name of L1B FUV files used in L1C
OBSERVATION/L1B_MUV	string			Name of L1B MUV files used in L1C
ENGINEERING	Table[1]			

ENGINEERING/SCI_PKT_CKSUM	int16			
ENGINEERING/SCI_ERR_FLAGS	int16			
ENGINEERING/XUV	string	FUV/MUV	SCI_IMG_DET	Which channel this is
ENGINEERING/LENGTH	int64	byte	SCI_IMG_LENGTH	Length of entire science image to which this segment belongs
ENGINEERING/IMAGE_NUMBER	int32		SCI_IMG_CT	Series number of this image
ENGINEERING/AVERAGE	int32	DN	SCI_AVERAGE	Average DN value of last packet of observation, not significant
ENGINEERING/CHECKSUM	int32		SCI_CHECKSUM	Checksum of last packet of observation, not significant, not being checked
ENGINEERING/START_TIME	int64	s	SCI_TM	Time when image set containing this segment was initiated
ENGINEERING/START_TIME__SUB	int32	1/65536 s	SCI_TM_SS	Time when image set containing this segment was initiated
ENGINEERING/CADENCE	int32	ms	SCI_IMG_CADENCE	Image cadence parameter for this image set
ENGINEERING/NUMBER	int32		SCI_IMG_NUM	Total number of commanded images for this set (equal to number of integrations)
ENGINEERING/INT_TIME	int32	ms	SCI_IMG_INT_TM	Image integration time parameter for this image set
ENGINEERING/MIRROR_POS	int32	DN	SCI_MIRROR_START	Position of mirror when image set began
ENGINEERING/STEP_NUM	int32	DN	SCI_MIRROR_NUM	Value of mirror step number when this image was initiated
ENGINEERING/STEP_SIZE	int16	DN	SCI_MIRROR_SIZE	Value of mirror step size when this image was initiated
ENGINEERING/STEP_INT	int16	DN	SCI_MIRROR_INT	Value of mirror step interval when this image was initiated
ENGINEERING/BIN_SHIFT	int16	pixel	SCI_IMG_OFFSET	Offset between expected lyman alpha line and calculated
ENGINEERING/OBS_ID	int32		SCI_OBS_ID	Value of Obs ID telemetry point when this image was initiated
ENGINEERING/FUV_BAD_PIXEL_MASK	int16		SCI_FUV_PIX_MASK	Each detector has a list of pixels that are bad and those pixels are never included in the binned data. This bad pixel masking can be disabled, in which case all pixels are used.
ENGINEERING/MUV_BAD_PIXEL_MASK	int16		SCI_MUV_PIX_MASK	Each detector has a list of pixels that are bad and those pixels are never included in the binned data. This bad pixel masking can be disabled, in which case all pixels are used.
ENGINEERING/DATA_COMPRESSION	int16		SCI_COMP_STATE	If data compression is on, all detector data will be sent in 16 bit pixels. If compression is off, the data can be up to 32 bits wide and it will be different for

				each bin. Compression should always be enabled unless taking a full frame image.
ENGINEERING/TEST_PATTERN	int16		SCI_TEST_PATTERN	There are two types of test patterns that can be produced. The 16 bit pattern rolls over at 65535 and the 12 bit pattern rolls over at 4095. This indicates which type will be used for the next test pattern image.
ENGINEERING/ON_CHIP_WINDOWING	int16		SCI_DET_WIN_MD	In linear bin mode, the Detector FPGA can read the entire array into SRAM and bin it from there, or it can only read out the pixels in the defined window. Running with the window enabled can save readout time.
ENGINEERING/BIN_TYPE	string		SCI_DET_BIN_TYPE	There are two types of binning, linear and non-linear. This indicates which the detector will use for the next set of images.
ENGINEERING/SCAN_MODE	string		SCI_DET_SCAN_MD	The detector can peform three different types of readouts, in addition to generating a test pattern. This indicates which readout will be used for the next set of images.
ENGINEERING/MODE	string			
ENGINEERING/TIME_FLAG	string		SCI_TIME_SYNC	Indicates if time was sync'd when this packet was logged (may be Synced/Freewheel)
ENGINEERING/BIN_SHIFT_DIR	int16			
ENGINEERING/SHUTTER_ON	int32	ms	SCI_SHUT_ON	Shutter cycle on time for this image set
ENGINEERING/SHUTTER_OFF	int32	ms	SCI_SHUT_OFF	Shutter cycle off time for this image set
ENGINEERING/SHUTTER_NUM	int16		SCI_SHUT_NUM	Shutter cycle number for this image set
ENGINEERING/SET_TOTAL	int32		SCI_IMG_NUM_ACT	It is possible that not all commanded images are received in the SDRAM. This is the actual number received, out of the commanded
ENGINEERING/BIN_X_ROW	int16		SCI_BIN_SPEC_ROW	Image bin table for this image set
ENGINEERING/BIN_Y_ROW	int16		SCI_BIN_SPAT_ROW	Image bin table row for this image set
ENGINEERING/MCP_GAIN	int32	DN	SCI_MCP_CMD	MCP value when this image set was initiated. (Commanded value, use that DN conversion)
ENGINEERING/SCI_SEG_TOTAL	int32		SCI_SEG_TOTAL	Series number of this segment (eg 1 out of 4)
ENGINEERING/SCI_SEG_LENGTH	int32	byte	SCI_SEG_LENGTH	Length of this segment of the science image

ENGINEERING/SCI_SEG_NUM	int32		SCI_SEG_NUM	Number of segments for this image
ENGINEERING/PROCESS_DATE	string			
ENGINEERING/SCI_IMG_DATA_LENGTH_	int32			
BINNING_FUV	Table[1]			
BINNING_FUV/SPEPIXLO	int16[Spectral]			
BINNING_FUV/SPEPIXHI	int16[Spectral]			
BINNING_FUV/SPEBINWIDTH	int16[Spectral+1]			

Table 24: Echelle processed data file structure.

Field Name	Data Type	Unit	Frame	Description
EMISSIONS	Table[Emissions]			
EMISSIONS/SPECIES_ID	string			
BRIGHTNESSES	Table[Integrations]			
BRIGHTNESSES/BRIGHT_H_KR	double64			
BRIGHTNESSES/BRIGHT_D_KR	double64			
BRIGHTNESSES/BRIGHT_DATA_KRPERANG	double64[Spectral]			
BRIGHTNESSES/BRIGHT_ONESIGMA_KR	double64			
BRIGHTNESSES/H_MRH_ALTITUDE_KM	double64			
BRIGHTNESSES/D_MRH_ALTITUDE_KM	double64			
BRIGHTNESSES/H_TANGENT_SZA_DEG	double64			
BRIGHTNESSES/D_TANGENT_SZA_DEG	double64			
BRIGHTNESSES/ET	double64			
BRIGHTNESSES/LYMAN_ALPHA_WAVELENGTH_ANGSTROM	double64[Spectral]			
BRIGHTNESSES/UTC	string			
OBSERVATION	Table			
OBSERVATION/PRODUCT_ID	string			Original filename of this product
OBSERVATION/COLLECTION_ID	string			PDS collection ID
OBSERVATION/BUNDLE_ID	string			PDS bundle ID
OBSERVATION/SOFTWARE_VERSION	string			
OBSERVATION/PRODUCT_CREATION_DATE	string	UTC		Product creation date

OBSERVATION/ORBIT_SEGMENT	string			Orbit segment (periapse, apoapse, corona etc, currently 0)
OBSERVATION/ORBIT_NUMBER	int16			Orbit number (MOI is start of orbit 1, orbit number changes 30min before each periapse)"
OBSERVATION/KERNELS	string[kernels]			

6.1.4 Derived data file structures

IUVS derived data files will also be archived with PDS as FITS. As with the processed data files, the contents of the IUVS derived data files vary between observation modes. These products contain derived densities and column abundances at the native geometry of the observation and/or on a regular grid in altitude or latitude and longitude, as appropriate. The file structure for each mode is described in a separate table below. **At the current time, due to continued development of the pipeline, only a limited number of derived quantities are available for periapse scans.**

Table 25: Limb derived data file structure.

SPECIES	Table[Species]			
SPECIES/ID	String			Name of atomic/molecular species
DENSITY	Table[Integrations]			
DENSITY/ALT	float32[Species, Altitudes]	km		
DENSITY/PROFILE	float32[Species, Altitudes]	cm-3		Retrieved Density
DENSITY/RANDOM_UNC	float32[Species, Altitudes]	cm-3		Random uncertainty in retrieved Density
DENSITY/SYSTEMATIC_UNC	float32[Species, Altitudes]	cm-3		Systematic uncertainty in retrieved Density
TEMPERATURE	Table[Integrations]			
TEMPERATURE/T0	float32			Upper boundary condition for the hydrostatic integration
TEMPERATURE/T0_ALT	float32			Alttiude of the assumed value of the T0
TEMPERATURE/T0_RANDOM_UNC	float32			Uncertainty in the T0 (upper boundary condition)

TEMPERATURE/ALT	float32[Altitudes]			Altitudes of retrieved temperature
TEMPERATURE/PROFILE	float32[Altitudes]	K		Retrieved temperature
TEMPERATURE/RANDOM_UNC	float32[Altitudes]	K		Random uncertainty in retrieved temperature
TEMPERATURE/SYSTEMATIC_UNC	float32[Altitudes]	K		Systematic uncertainty in retrieved temperature
GEOMETRY_RETRIEVAL	Table[Integrations]			
GEOMETRY_RETRIEVAL/LAT	double64	deg	IAU_MARS	Mean geodetic Latitude of binned tangent or impact point of line of sight with Mars ellipsoid
GEOMETRY_RETRIEVAL/LON	double64	deg	IAU_MARS	East Longitude of tangent point of line of sight
GEOMETRY_RETRIEVAL/LOOKDOWN	double64	deg	IAU_MARS	Angle between spacecraft normal and tangent point
GEOMETRY_RETRIEVAL/TANGENT_AZ	double64	deg	IAU_MARS	Angle (azimuth) between true north at spacecraft and tangent point
GEOMETRY_RETRIEVAL/TANGENT_DIST	double64	km	IAU_MARS	Distance between tangent point and spacecraft
GEOMETRY_RETRIEVAL/SPACECRAFT_ALT	double64	km	IAU_MARS	Mean altitude of the spacecraft during observation above reference Mars ellipsoid
GEOMETRY_RETRIEVAL/SUB_SPACECRAFT_LAT	double64	deg	IAU_MARS	Mean Geodetic Latitude of subspacecraft point
GEOMETRY_RETRIEVAL/SUB_SPACECRAFT_LON	double64	deg	IAU_MARS	Mean Geodetic Longitude of subspacecraft point
GEOMETRY_RETRIEVAL/SZA	double64	deg		Mean angle between surface normal and vector to Sun, at binned tangent or impact point
GEOMETRY_RETRIEVAL/PHASE_ANGLE	double64	deg		Angle between spacecraft and sun as seen from tangent or impact point
GEOMETRY_RETRIEVAL/LOCAL_TIME	double64	decimal hour		Local time at the location of tangent point
EMISSION_FEATURES	Table[Emissions]			
EMISSION_FEATURES/EMISSION	string			Name of emission feature
EMISSION_FEATURES/FIT_TEMPLATE	double64[256]			Spectra template for the given emission
EMISSION_FEATURES/START	float32	nm		Start value of wavelength for the multilinear fit for the given emission
EMISSION_FEATURES/STOP	float32	nm		Stop value of wavelength for the

				multilinear fit for the given emission
MODEL_RADIANCE	Table[Integrations]			
MODEL_RADIANCE/EUVM_FN	string			EUVM L3 filename used in the retrieval
MODEL_RADIANCE/EUV_FLUX	float32			Integrated value of EUV flux at the top of the atmosphere
MODEL_RADIANCE/SCALE_FACTOR	float32[Emissions]			Model scale factors for CO2, N2, and O retrieval
MODEL_RADIANCE/PROFILE	float32[Emissions,Altitudes]	kR		Model radiance of a given emissions calculated from forward model
MODEL_RADIANCE/RANDOM_UNC	float32[Emissions,Altitudes]	kR		Random uncertainty in the model radiance of a given emissions calculated from forward model
MODEL_RADIANCE/SYSTEMATIC_UNC	float32[Emissions,Altitudes]	kR		Systematic uncertainty in the model radiance of a given emissions calculated from forward model
GEOMETRY_RADIANCE	Table[Integrations]			
GEOMETRY_RADIANCE/TANGENT_ALT	double64[Altitudes]	km	IAU_MARS	Mean altitude of binned tangent point
GEOMETRY_RADIANCE/TANGENT_LAT	double64[Altitudes]	deg	IAU_MARS	Mean geodetic Latitude of binned tangent or impact point of line of sight with Mars ellipsoid
GEOMETRY_RADIANCE/TANGENT_LON	double64[Altitudes]	deg	IAU_MARS	East Longitude of tangent point of line of sight
GEOMETRY_RADIANCE/LOOKDOWN	double64[Altitudes]	deg	IAU_MARS	Angle between spacecraft normal and tangent point
GEOMETRY_RADIANCE/TANGENT_AZ	double64[Altitudes]	deg	IAU_MARS	Angle (azimuth) between true north at spacecraft and tangent point
GEOMETRY_RADIANCE/TANGENT_DIST	double64[Altitudes]	km	IAU_MARS	Distance between tangent point and spacecraft
GEOMETRY_RADIANCE/SPACECRAFT_ALT	double64[Altitudes]	km	IAU_MARS	Mean altitude of the spacecraft during observation above reference Mars ellipsoid
GEOMETRY_RADIANCE/SUB_SPACECRAFT_LAT	double64[Altitudes]	deg	IAU_MARS	Mean Geodetic Latitude of subspacecraft point
GEOMETRY_RADIANCE/SUB_SPACECRAFT_LON	double64[Altitudes]	deg	IAU_MARS	Mean Geodetic Longitude of subspacecraft point
GEOMETRY_RADIANCE/SZA	double64[Altitudes]	deg		Mean angle between surface normal and vector to Sun, at binned tangent or impact point
GEOMETRY_RADIANCE/PHASE_ANGLE	double64[Altitudes]	deg		Angle between spacecraft and sun as seen from tangent or impact point

GEOMETRY_RADIANCE/LOCAL_TIME	double64[Altitudes]	decimal hour		Local time at the location of tangent point
OBSERVATION	Table[1]			
OBSERVATION/PRODUCT_ID	string			Original filename of this product
OBSERVATION/COLLECTION_ID	string			PDS collection ID (currently unused)
OBSERVATION/BUNDLE_ID	string			PDS bundle ID (currently unused)
OBSERVATION/CODE_SVN_REVISION	string			SVN revision number of code used to produce this product
OBSERVATION/ANC_SVN_REVISION	string			SVN revision number of ancillary data used to produce this product
OBSERVATION/PRODUCT_CREATION_DATE	string	UTC		Product creation date
OBSERVATION/CALIBRATION_VERSION	int16			
SPECIES	Table[Species]			
SPECIES/ID	string			Name of atomic/molecular species
DENSITY	Table[Integrations]			
DENSITY/ALT	float32[Species,19]	km		
DENSITY/PROFILE	float32[Species,19]	cm-3		Retrieved Density
DENSITY/RANDOM_UNC	float32[Species,19]	cm-3		Random uncertainty in retrieved Density

Table 26: Disk MUV derived data file structure.

Field Name	Data Type	Unit	Frame	Description
APOAPSE_GEOMETRY	Table[1]			
APOAPSE_GEOMETRY/LATITUDE	float32[Latitudes]	deg		Latitude
APOAPSE_GEOMETRY/LONGITUDE	float32[Longitudes]	deg		Longitude, counted east positive
APOAPSE_GEOMETRY/LOCAL_TIME	float32[Latitudes,Longitudes]	decimal hour		Local time
APOAPSE_GEOMETRY/SOLAR_ZENITH_ANGLE	float32[Latitudes,Longitudes]	deg		Solar zenith angle
APOAPSE_GEOMETRY/EMISSION_ANGLE	float32[Latitudes,Longitudes]	deg		Angle between normal and spacecraft
APOAPSE_GEOMETRY/PHAS	float32[Latitu	deg		Phase angle

E_ANGLE	des,Longitudes]			
APOAPSE_GEOMETRY/MODEL_SURFACE_PRESSURE	float32[Latitudes,Longitudes]	hPa		Model derived surface pressure
APOAPSE_GEOMETRY/MOLA_ALTITUDE	float32[Latitudes,Longitudes]	m		MOLA surface elevation above the areoid
APOAPSE_OZONE	Table[1]			
APOAPSE_OZONE/COLUMN	float32[Latitudes,Longitudes]	micrometer-atmosphere		Ozone vertical column
APOAPSE_OZONE/UNCERTAINTY	float32[Latitudes,Longitudes]	micrometer-atmosphere		Uncertainty (1-sigma) on ozone vertical column
APOAPSE_OZONE/CHI_SQUARE	float32[Latitudes,Longitudes]			Chi square value for the fit
APOAPSE_ALBEDO	Table[1]			
APOAPSE_ALBEDO/ALBEDO	float32[Latitudes,Longitudes]			MUV mean albedo of the surface + clouds
APOAPSE_ALBEDO/UNCERTAINTY	float32[Latitudes,Longitudes]			Uncertainty (1-sigma) on MUV mean albedo
APOAPSE_ALBEDO/CHI_SQUARE	float32[Latitudes,Longitudes]			Chi square value for the fit
APOAPSE_DUST	Table[1]			
APOAPSE_DUST/OPACITY	float32[Latitudes,Longitudes]			MUV dust vertical opacity
APOAPSE_DUST/UNCERTAINTY	float32[Latitudes,Longitudes]			Uncertainty (1-sigma) on MUV dust vertical opacity
APOAPSE_DUST/CHI_SQUARE	float32[Latitudes,Longitudes]			Chi square value for the fit
OBSERVATION	Table[1]			
OBSERVATION/PRODUCT_ID	string			Original filename of this product
OBSERVATION/COLLECTION_ID	string			PDS collection ID (currently unused)
OBSERVATION/BUNDLE_ID	string			PDS bundle ID (currently unused)
OBSERVATION/CODE_SVN_REVISION	string			SVN revision number of code used to produce this product
OBSERVATION/ANC_SVN_REVISION	string			SVN revision number of ancillary data used to produce this product
OBSERVATION/PRODUCT_CREATION_DATE	string	UTC		Product creation date

OBSERVATION/CALIBRATION_VERSION	int16			
OBSERVATION/MISSION_PHASE	string			Mission phase string
OBSERVATION/TARGET_NAME	string			Target name string
OBSERVATION/ORBIT_SEGMENT	int16			Orbit segment (periapse, apoapse, corona etc, currently 0)
OBSERVATION/ORBIT_NUMBER	int16			Orbit number (MOI is start of orbit 1, orbit number changes 30min before each periapse)
OBSERVATION/SOLAR_LONGITUDE	float32	deg		Solar longitude, 0deg=Martian spring equinox, 90deg=solstice, etc
OBSERVATION/L1C_FN	string			Name of L1C file used in L2

Table 27: Disk FUV derived data file structure.

Field Name	Data Type	Unit	Frame	Description
EMISSION_FEATURES	Table[11]			
EMISSION_FEATURES/EMISSION	string			Name of emission feature
EMISSION_FEATURES/FIT_TEMPLATE	double64[Spectral]			Spectra template for the given emission
EMISSION_FEATURES/START	float32	nm		Start value of wavelength for the multilinear fit for the given emission
EMISSION_FEATURES/STOP	float32	nm		Stop value of wavelength for the multilinear fit for the given emission
EMISSION_FEATURES/DOF	float32			Degree of freedom for regression fitted emision features.
BRIGHTNESS_RATIO	Table[1]			
BRIGHTNESS_RATIO/ID	string[2]			
BRIGHTNESS_RATIO/VALUE	double64[Latitudes,Longitudes,2]			
BRIGHTNESS_RATIO/RANDOM_UNC	double64[Latitudes,Longitudes,2]			
BRIGHTNESS_RATIO/SYSTEMATIC_UNC	double64[Latitudes,Longitudes,2]			
COLUMN_DENSITY_RATIO	Table[1]			
COLUMN_DENSITY_RATIO/ID	string[2]			
COLUMN_DENSITY_RATIO/VALUE	double64[Latitudes,Longitudes,2]			
COLUMN_DENSITY_RATIO/RANDOM_UNC	double64[Latitudes,Longitudes,2]			

COLUMN_DENSITY_RATIO/ SYSTEMATIC_UNC	double64[Latitudes,Longitudes,2]			
APOAPSE_GEOMETRY	Table[1]			
APOAPSE_GEOMETRY/LATITUDE	float32[Latitudes]	deg		Latitude
APOAPSE_GEOMETRY/LONGITUDE	float32[Longitudes]	deg		Longitude, counted east positive
APOAPSE_GEOMETRY/LOCAL_TIME	float32[Latitudes,Longitudes]	decimal hour		Local time
APOAPSE_GEOMETRY/SOLAR_ZENITH_ANGLE	float32[Latitudes,Longitudes]	deg		Solar zenith angle
APOAPSE_GEOMETRY/PHASE_ANGLE	float32[Latitudes,Longitudes]	deg		Phase angle
APOAPSE_GEOMETRY/EMISSION_ANGLE	float32[Latitudes,Longitudes]	deg		Angle between normal and spacecraft
OBSERVATION	Table[1]			
OBSERVATION/PRODUCT_ID	string			Original filename of this product
OBSERVATION/COLLECTION_ID	string			PDS collection ID (currently unused)
OBSERVATION/BUNDLE_ID	string			PDS bundle ID (currently unused)
OBSERVATION/CODE_SVN_REVISION	string			SVN revision number of code used to produce this product
OBSERVATION/ANC_SVN_REVISION	string			SVN revision number of ancillary data used to produce this product
OBSERVATION/PRODUCT_CREATION_DATE	string	UTC		Product creation date
OBSERVATION/OBSERVATION_TYPE	string			Observation type string
OBSERVATION/CALIBRATION_VERSION	int16			
OBSERVATION/MISSION_PHASE	string			Mission phase string
OBSERVATION/TARGET_NAME	string			Target name string
OBSERVATION/ORBIT_SEGMENT	int16			Orbit segment (periapse, apoapse, corona etc, currently 0)
OBSERVATION/ORBIT_NUMBER	int16			Orbit number (MOI is start of orbit 1, orbit number changes 30min before each periapse)
OBSERVATION/SOLAR_LONGITUDE	float32	deg		Solar longitude, 0deg=Martian spring equinox, 90deg=solstice, etc
OBSERVATION/GRATING_SELECT	string			Grating select (one of 'ECHELLE'/'LOWRES')
OBSERVATION/KEYHOLE_SELECT	string			Keyhole select (one of 'LARGE'/'SMALL'/'NEITHER')

OBSERVATION/BIN_PATTERN_INDEX	string			Name of linear or nonlinear binning table used for this observation.
OBSERVATION/CADENCE	float32			
OBSERVATION/INT_TIME	float32			
OBSERVATION/DUTY_CYCLE	float32			
OBSERVATION/CHANNEL	string			
OBSERVATION/KERNELS	string[8]			
OBSERVATION/L1C_FN	string			Name of L1C file used in L2
OBSERVATION/EUVM_L3_FN	string			

Table 28: Corona derived data file structure.

Field Name	Data Type	Unit	Frame	Description
EMISSION_FEATURES	Table[Emissions]			
EMISSION_FEATURES/ID	string			Name of emission feature
SPECIES	Table[Species]			
SPECIES/ID	string			Name of atomic/molecular species
OUTBOUND_ABOVE_LIMB	Table[Altitudes]			
OUTBOUND_ABOVE_LIMB/COLUMN	float32[Species]	cm-2		Column density along line of sight
OUTBOUND_ABOVE_LIMB/COLUMN_UNC	float32[Species]	cm-2		Column density along line of sight uncertainty
OUTBOUND_ABOVE_LIMB/DENSITY	float32[Species]	cm-3		Density at the tangent point
OUTBOUND_ABOVE_LIMB/DENSITY_UNC	float32[Species]	cm-3		Density at the tangent point uncertainty
OUTBOUND_ABOVE_LIMB/MODEL_RADIANCE	float32[Species]	kR		Model fit outbound scan emission feature radiance
OUTBOUND_ABOVE_LIMB/MODEL_RADIANCE_UNC	float32[Species]	kR		Model fit outbound scan radiance uncertainty
OUTBOUND_ABOVE_LIMB/RADIANCE	float32[Species]	kR		Outbound scan emission feature radiance
OUTBOUND_ABOVE_LIMB/RADIANCE_UNC	float32[Species]	kR		Outbound scan radiance uncertainty
OUTBOUND_ABOVE_LIMB/RADIANCE_REL_RESIDUAL	float32[Species]			
OUTBOUND_ABOVE_LIMB/TANGENT_ALT	float32	km		Altitude of tangent point, or zero if line of sight hits ellipsoid
OUTBOUND_ABOVE_LIMB/TANGENT_LOS	float32	km		Distance from spacecraft to tangent or impact point
OUTBOUND_ABOVE_LIMB/TANGENT_LAT	float32	deg		Geodetic Latitude of tangent or impact point of line of sight with Mars ellipsoid
OUTBOUND_ABOVE_LIMB/TANGENT_LON	float32	deg		East Longitude of tangent or impact point of line of sight with Mars ellipsoid

OUTBOUND_ABOVE_LIMB/ RA	float32	deg	J2000	Right ascension of line of sight
OUTBOUND_ABOVE_LIMB/ DEC	float32	deg	J2000	Declination of line of sight
OUTBOUND_ABOVE_LIMB/ V_TANGENT	double64[3]	km	IAU_MARS	Position of tangent point, or NaNs if line of sight hits ellipsoid
OUTBOUND_ABOVE_LIMB/ V_TANGENT_MSO	double64[3]	km	MAVEN_MSO	Position of tangent point, or NaNs if line of sight hits ellipsoid
OUTBOUND_ABOVE_LIMB/ VZ_INSTRUMENT	double64[3]	unit vector	IAU_MARS	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
OUTBOUND_ABOVE_LIMB/ VZ_INSTRUMENT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
OUTBOUND_ABOVE_LIMB/ VZ_INSTRUMENT_DOPPLER	float32	km/s		Doppler shift along the line of sight
OUTBOUND_ABOVE_LIMB/S PACECRAFT_ALT	float32	km		Altitude of spacecraft above reference Mars ellipsoid
OUTBOUND_ABOVE_LIMB/S UB_SPACECRAFT_LAT	float32	deg		Geodetic Latitude of subspacecraft point
OUTBOUND_ABOVE_LIMB/S UB_SPACECRAFT_LON	float32	deg		East Longitude of subspacecraft point
OUTBOUND_ABOVE_LIMB/ V_SPACECRAFT	double64[3]	km	IAU_MARS	Position of spacecraft relative to Mars center of mass
OUTBOUND_ABOVE_LIMB/ V_SPACECRAFT_MSO	double64[3]	km	MAVEN_MSO	Position of spacecraft relative to Mars center of mass
OUTBOUND_ABOVE_LIMB/S UB_SOLAR_LAT	float32	deg		Geodetic Latitude of subsolar point
OUTBOUND_ABOVE_LIMB/S UB_SOLAR_LON	float32	deg		East Longitude of subsolar point
OUTBOUND_ABOVE_LIMB/ V_SUN	double64[3]	km	IAU_MARS	Position of Sun relative to Mars center of mass
OUTBOUND_ABOVE_LIMB/ V_SUN_MSO	double64[3]	km	MAVEN_MSO	Position of Sun relative to Mars center of mass
OUTBOUND_ABOVE_LIMB/ ET	float32	ET s		Time that the integration began (corrected for SCLK errors by SCLK kernel)
OUTBOUND_ABOVE_LIMB/ UTC	float32	UTC date string		Time that the integration began (corrected for SCLK errors by SCLK kernel)
INBOUND_ABOVE_LIMB	Table[Altitudes]			
INBOUND_ABOVE_LIMB/CO LUMN	float32[Species]	cm-2		Column density along line of sight
INBOUND_ABOVE_LIMB/CO LUMN_UNC	float32[Species]	cm-2		Column density along line of sight uncertainty
INBOUND_ABOVE_LIMB/M ODEL_RADIANCE	float32[Species]	kR		Model fit inbound scan emission feature radiance
INBOUND_ABOVE_LIMB/M ODEL_RADIANCE_UNC	float32[Species]	kR		Model fit inbound scan radiance uncertainty
INBOUND_ABOVE_LIMB/RA	float32[Speci	kR		Inbound scan emission feature

DIANCE	es]			radiance
INBOUND_ABOVE_LIMB/RADIANCE_UNC	float32[Species]	kR		Inbound scan radiance uncertainty
INBOUND_ABOVE_LIMB/RADIANCE_REL_RESIDUAL	float32[Species]			
INBOUND_ABOVE_LIMB/RA	double64	deg	J2000	Right ascension of line of sight
INBOUND_ABOVE_LIMB/DEC	double64	deg	J2000	Declination of line of sight
INBOUND_ABOVE_LIMB/VZ_INSTRUMENT	double64[3]	unit vector	IAU_MARS	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
INBOUND_ABOVE_LIMB/VZ_INSTRUMENT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
INBOUND_ABOVE_LIMB/VZ_INSTRUMENT_DOPPLER	float32	km/s		Doppler shift along the line of sight
INBOUND_ABOVE_LIMB/SPACECRAFT_ALT	double64	km		Altitude of spacecraft above reference Mars ellipsoid
INBOUND_ABOVE_LIMB/SUB_SPACECRAFT_LAT	double64	deg		Geodetic Latitude of subspacecraft point
INBOUND_ABOVE_LIMB/SUB_SPACECRAFT_LON	double64	deg		East Longitude of subspacecraft point
INBOUND_ABOVE_LIMB/V_SPACECRAFT	double64[3]	km	IAU_MARS	Position of spacecraft relative to Mars center of mass
INBOUND_ABOVE_LIMB/V_SPACECRAFT_MSO	double64[3]	km	MAVEN_MSO	Position of spacecraft relative to Mars center of mass
INBOUND_ABOVE_LIMB/SUB_SOLAR_LAT	double64	deg		Geodetic Latitude of subsolar point
INBOUND_ABOVE_LIMB/SUB_SOLAR_LON	double64	deg		East Longitude of subsolar point
INBOUND_ABOVE_LIMB/V_SUN	double64[3]	km	IAU_MARS	Position of Sun relative to Mars center of mass
INBOUND_ABOVE_LIMB/V_SUN_MSO	double64[3]	km	MAVEN_MSO	Position of Sun relative to Mars center of mass
INBOUND_ABOVE_LIMB/ET	double64	ET s		Time that the integration began (corrected for SCLK errors by SCLK kernel)
INBOUND_ABOVE_LIMB/UTC	double64	UTC date string		Time that the integration began (corrected for SCLK errors by SCLK kernel)
INBOUND_BELOW_LIMB	Table[Altitudes_below_limb]			
INBOUND_BELOW_LIMB/COLUMN	float32[Species]	cm-2		Column density along line of sight
INBOUND_BELOW_LIMB/COLUMN_UNC	float32[Species]	cm-2		Column density along line of sight uncertainty
INBOUND_BELOW_LIMB/MODEL_RADIANCE	float32[Species]	kR		Model fit inbound scan emission feature radiance
INBOUND_BELOW_LIMB/MODEL_RADIANCE_UNC	float32[Species]	kR		Model fit inbound scan radiance uncertainty
INBOUND_BELOW_LIMB/RADIANCE	float32[Species]	kR		Inbound scan emission feature radiance

INBOUND_BELOW_LIMB/RADIANCE_UNC	float32[Species]	kR		Inbound scan radiance uncertainty
INBOUND_BELOW_LIMB/RADIANCE_REL_RESIDUAL	float32[Species]			
INBOUND_BELOW_LIMB/RA	double64	deg	J2000	Right ascension of line of sight
INBOUND_BELOW_LIMB/DEC	double64	deg	J2000	Declination of line of sight
INBOUND_BELOW_LIMB/VZ_INSTRUMENT	double64[3]	unit vector	IAU_MARS	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
INBOUND_BELOW_LIMB/VZ_INSTRUMENT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
INBOUND_BELOW_LIMB/VZ_INSTRUMENT_DOPPLER	float32	km/s		Doppler shift along the line of sight relative to solar system barycenter
INBOUND_BELOW_LIMB/SPACECRAFT_ALT	double64	km		Altitude of spacecraft above reference Mars ellipsoid
INBOUND_BELOW_LIMB/SUB_SPACECRAFT_LAT	double64	deg		Geodetic Latitude of subspacecraft point
INBOUND_BELOW_LIMB/SUB_SPACECRAFT_LON	double64	deg		East Longitude of subspacecraft point
INBOUND_BELOW_LIMB/V_SPACECRAFT	double64[3]	km	IAU_MARS	Position of spacecraft relative to Mars center of mass
INBOUND_BELOW_LIMB/V_SPACECRAFT_MSO	double64[3]	km	MAVEN_MSO	Position of spacecraft relative to Mars center of mass
INBOUND_BELOW_LIMB/SUB_SOLAR_LAT	double64	deg		Geodetic Latitude of subsolar point
INBOUND_BELOW_LIMB/SUB_SOLAR_LON	double64	deg		East Longitude of subsolar point
INBOUND_BELOW_LIMB/V_SUN	double64[3]	km	IAU_MARS	Position of Sun relative to Mars center of mass
INBOUND_BELOW_LIMB/V_SUN_MSO	double64[3]	km	MAVEN_MSO	Position of Sun relative to Mars center of mass
INBOUND_BELOW_LIMB/ET	double64	ET s		Time that the integration began (corrected for SCLK errors by SCLK kernel)
INBOUND_BELOW_LIMB/UTC	double64	UTC date string		Time that the integration began (corrected for SCLK errors by SCLK kernel)
HYDROGEN_MODEL	Table[1]			
HYDROGEN_MODEL/EXOBASE_TEMP	float32	K		Model derived temperature at the exobase
HYDROGEN_MODEL/EXOBASE_DENSITY	float32	cm-3		Model derived density at the exobase
HYDROGEN_MODEL/FIT_PARAM_UNC	float32[Species]			
HYDROGEN_MODEL/FIT_QUAL	float32[3]			
HYDROGEN_MODEL/ESC_FLUX	float32	cm-2/s		Model derived escape flux at the subsolar point
HYDROGEN_MODEL/GLOBAL_ESC_RATE	float32	s-1		Model derived global escape rate

OXYGEN_MODEL	Table[1]			
OXYGEN_MODEL/E_MEAN_500KM	float32	eV		Model derived mean non-thermal O kinetic energy at 500 km
OXYGEN_MODEL/DR_RATE_200KM	float32	cm-3/s		Model derived O2+ dissociative recombination rate at 200km
OXYGEN_MODEL/DR_RATE_UNC	float32			
OXYGEN_MODEL/FIT_QUAL	float32			
OXYGEN_MODEL/ESC_FLUX	float32	cm-2/s		Model derived escape flux at the subsolar point
OXYGEN_MODEL/GLOBAL_ESC_RATE	float32	s-1		Model derived global escape rate
OBSERVATION	Table[1]			
OBSERVATION/PRODUCT_ID	string			Original filename of this product
OBSERVATION/COLLECTION_ID	string			PDS collection ID (currently unused)
OBSERVATION/BUNDLE_ID	string			PDS bundle ID (currently unused)
OBSERVATION/L1B_OUTBOUND	string			
OBSERVATION/L1B_INBOUND	string			
OBSERVATION/CODE_SVN_REVISION	string			SVN revision number of code used to produce this product
OBSERVATION/ANC_SVN_REVISION	string			SVN revision number of ancillary data used to produce this product
OBSERVATION/PRODUCT_CREATION_DATE	string	UTC		Product creation date
OBSERVATION/OBSERVATION_TYPE	string			Observation type string
OBSERVATION/CALIBRATION_VERSION	int16			
OBSERVATION/MISSION_PHASE	string			Mission phase string
OBSERVATION/TARGET_NAME	string			Target name string
OBSERVATION/ORBIT_SEGMENT	int16			Orbit segment (periapse, apoapse, corona etc, currently 0)
OBSERVATION/ORBIT_NUMBER	int16			Orbit number (MOI is start of orbit 1, orbit number changes 30min before each periapse)
OBSERVATION/SOLAR_LONGITUDE	float32	deg		Solar longitude, 0deg=Martian spring equinox, 90deg=solstice, etc
OBSERVATION/GRATING_SELECT	string			Grating select (one of 'ECHELLE'/'LOWRES')
OBSERVATION/KEYHOLE_SELECT	string			Keyhole select (one of 'LARGE'/'SMALL'/'NEITHER')
OBSERVATION/BIN_PATTERN_INDEX	string			Name of linear or nonlinear binning table used for this observation.

OBSERVATION/CADENCE	float32			
OBSERVATION/INT_TIME	float32			
OBSERVATION/DUTY_CYCLE	float32			
OBSERVATION/CHANNEL	string			
OBSERVATION/KERNELS	string[8]			
OBSERVATION/MCP_VOLT	float32			
OBSERVATION/MCP_GAIN	float32			

Table 29: Occultation derived data file structure.

Field Name	Data Type	Unit	Frame	Description
COLUMN_DENSITY	Table[1]			
COLUMN_DENSITY/PROFILE	double64[3,Retrievals]	cm-2		column density
COLUMN_DENSITY/UNCERTAINTY	double64[3,Retrievals]	cm-2		uncertainty of the column density
AEROSOL_COEFFICIENTS	Table[1]			
AEROSOL_COEFFICIENTS/TAU_1000NM	double64[Retrievals]			optical depth of the aerosols at 1000 nm
AEROSOL_COEFFICIENTS/TAU_1000NM_UNCERTAINTY	double64[Retrievals]			uncertainty of the optical depth of the aerosols at 1000 nm
AEROSOL_COEFFICIENTS/A_COEFF	double64[Retrievals]			Angstrom coefficient of the aerosols
AEROSOL_COEFFICIENTS/A_COEFF_UNCERTAINTY	double64[Retrievals]			uncertainty of the Angstrom coefficient of the aerosols
NUMBER_DENSITY	Table[1]			
NUMBER_DENSITY/PROFILE	double64[3,Retrievals]	cm-3		local number density
NUMBER_DENSITY/UNCERTAINTY	double64[3,Retrievals]	cm-3		uncertainty of the local number density
TEMPERATURE	Table[1]			
TEMPERATURE/PROFILE	double64[Retrievals]	K		
TEMPERATURE/UNCERTAINTY	double64[Retrievals]	K		uncertainty of the temperature obtained from the CO2 number density
PRESSURE	Table[1]			
PRESSURE/PROFILE	double64[Retrievals]	Pa		pressure
PRESSURE/UNCERTAINTY	double64[Retrievals]	Pa		uncertainty of the pressure
SPECIES	Table[1]			
SPECIES/ID	string[3]			Name of atomic/molecular species
RETRIEVED_GEOMETRY	Table[Retrievals]			
RETRIEVED_GEOMETRY/ALTITUDE	double64	km		tangent altitude of the nearpoint for each integration
RETRIEVED_GEOMETRY/RADIAL_DISTANCE	double64			
RETRIEVED_GEOMETRY/UT	string	UTC		UTC time when the integraiton

C_TIME				began
RETRIEVED_GEOMETRY/ET_TIME	string	ET s		
RETRIEVED_GEOMETRY/LONGITUDE_PG	double64			
RETRIEVED_GEOMETRY/LATITUDE_PG	double64			
RETRIEVED_GEOMETRY/LONGITUDE_PC	double64			
RETRIEVED_GEOMETRY/LATITUDE_PC	double64			
RETRIEVED_GEOMETRY/SZA	double64	deg		solar zenith angle
RETRIEVED_GEOMETRY/LOCAL_TIME	double64	hrs		
HLP_GEOMETRY	Table[1]			
HLP_GEOMETRY/HLP_LON_PG	float32			
HLP_GEOMETRY/HLP_LAT_PG	float32			
HLP_GEOMETRY/HLP_LON_PC	float32			
HLP_GEOMETRY/HLP_LAT_PC	float32			
HLP_GEOMETRY/HLP_SZA	float32			
HLP_GEOMETRY/HLP_LT	float32			
OCCULTATION_GEOMETRY	Table[Integrations]			
OCCULTATION_GEOMETRY/ALTITUDE	double64	km		tangent altitude of the nearpoint for each integration
OCCULTATION_GEOMETRY/RADIAL_DISTANCE	double64	km		
OCCULTATION_GEOMETRY/UTC_TIME	string	UTC		UTC time when the integraiton began
OCCULTATION_GEOMETRY/ET_TIME	string	ET s		time when the integration began (corrected for SCLK errors by SCLK kernel)
OCCULTATION_GEOMETRY/LONGITUDE_PG	double64	deg		
OCCULTATION_GEOMETRY/LATITUDE_PG	double64	deg		
OCCULTATION_GEOMETRY/LONGITUDE_PC	double64	deg		
OCCULTATION_GEOMETRY/LATITUDE_PC	double64	deg		
OCCULTATION_GEOMETRY/SZA	double64	deg		Solar zenith angle
OCCULTATION_GEOMETRY/LOCAL_TIME	double64	decimal hour		Local time
SPACECRAFTGEOMETRY	Table[Integrations]			
SPACECRAFTGEOMETRY/SUB_SPACECRAFT_LAT	double64	deg		Geodetic Latitude of subspacecraft point
SPACECRAFTGEOMETRY/S	double64	deg		East Longitude of subspacecraft

UB_SPACECRAFT_LON				point
SPACECRAFTGEOMETRY/SUB_SOLAR_LAT	double64	deg		Geodetic Latitude of subsolar point
SPACECRAFTGEOMETRY/SUB_SOLAR_LON	double64	deg		East Longitude of subsolar point
SPACECRAFTGEOMETRY/SPACECRAFT_ALT	double64	km		Altitude of spacecraft above reference Mars ellipsoid
SPACECRAFTGEOMETRY/V_SPACECRAFT	double64[3]	km	IAU_MARS	Position of spacecraft relative to Mars center of mass
SPACECRAFTGEOMETRY/V_SPACECRAFT_RATE	double64[3]	km/s	IAU_MARS	Velocity of spacecraft
SPACECRAFTGEOMETRY/V_SUN	double64[3]	km	IAU_MARS	Position of Sun relative to Mars center of mass
SPACECRAFTGEOMETRY/V_SUN_RATE	double64[3]	km/s	IAU_MARS	Velocity of Sun
SPACECRAFTGEOMETRY/VX_SPACECRAFT	double64[3]	unit vector	IAU_MARS	Direction of spacecraft X axis
SPACECRAFTGEOMETRY/VY_SPACECRAFT	double64[3]	unit vector	IAU_MARS	Direction of spacecraft Y axis
SPACECRAFTGEOMETRY/VZ_SPACECRAFT	double64[3]	unit vector	IAU_MARS	Direction of spacecraft Z axis
SPACECRAFTGEOMETRY/VX_INSTRUMENT	double64[3]	unit vector	IAU_MARS	Direction of instrument field of view X axis, including scan mirror rotation. This is the instrument spatial direction.
SPACECRAFTGEOMETRY/VY_INSTRUMENT	double64[3]	unit vector	IAU_MARS	Direction of instrument field of view Y axis, including scan mirror rotation. This is the instrument scan direction
SPACECRAFTGEOMETRY/VZ_INSTRUMENT	double64[3]	unit vector	IAU_MARS	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
SPACECRAFTGEOMETRY/V_SPACECRAFT_MSO	double64[3]	km	MAVEN_MSO	Position of spacecraft relative to Mars center of mass
SPACECRAFTGEOMETRY/V_SPACECRAFT_RATE_MSO	double64[3]	km/s	MAVEN_MSO	Velocity of spacecraft
SPACECRAFTGEOMETRY/V_SPACECRAFT_INERTIAL	double64[3]	km	Inertial	Position of spacecraft relative to Mars center of mass
SPACECRAFTGEOMETRY/V_SPACECRAFT_RATE_INERTIAL	double64[3]	km/s	Inertial	Velocity of spacecraft
SPACECRAFTGEOMETRY/V_SPACECRAFT_INERTIAL_FRAME	string			Spice name of inertial frame
SPACECRAFTGEOMETRY/V_SPACECRAFT_INERTIAL_CENTER	string			Spice name of inertial center of mass
SPACECRAFTGEOMETRY/V_SUN_MSO	double64[3]	km	MAVEN_MSO	Position of Sun relative to Mars center of mass
SPACECRAFTGEOMETRY/V_SUN_RATE_MSO	double64[3]	km/s	MAVEN_MSO	Velocity of Sun
SPACECRAFTGEOMETRY/VX_SPACECRAFT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of spacecraft X axis
SPACECRAFTGEOMETRY/V	double64[3]	unit	MAVEN_MSO	Direction of spacecraft Y axis

Y_SPACECRAFT_MSO		vector		
SPACECRAFTGEOMETRY/V Z_SPACECRAFT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of spacecraft Z axis
SPACECRAFTGEOMETRY/V X_INSTRUMENT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of instrument field of view X axis, including scan mirror rotation. This is the instrument spatial direction.
SPACECRAFTGEOMETRY/V Y_INSTRUMENT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of instrument field of view Y axis, including scan mirror rotation. This is the instrument scan direction
SPACECRAFTGEOMETRY/V Z_INSTRUMENT_MSO	double64[3]	unit vector	MAVEN_MSO	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
SPACECRAFTGEOMETRY/V X_SPACECRAFT_INERTIAL	double64[3]	unit vector	Inertial	Direction of spacecraft X axis
SPACECRAFTGEOMETRY/V Y_SPACECRAFT_INERTIAL	double64[3]	unit vector	Inertial	Direction of spacecraft Y axis
SPACECRAFTGEOMETRY/V Z_SPACECRAFT_INERTIAL	double64[3]	unit vector	Inertial	Direction of spacecraft Z axis
SPACECRAFTGEOMETRY/V X_INSTRUMENT_INERTIAL	double64[3]	unit vector	Inertial	Direction of instrument field of view X axis, including scan mirror rotation. This is the instrument spatial direction.
SPACECRAFTGEOMETRY/V Y_INSTRUMENT_INERTIAL	double64[3]	unit vector	Inertial	Direction of instrument field of view Y axis, including scan mirror rotation. This is the instrument scan direction
SPACECRAFTGEOMETRY/V Z_INSTRUMENT_INERTIAL	double64[3]	unit vector	Inertial	Direction of instrument field of view Z axis, including scan mirror rotation. This is the instrument boresight.
SPACECRAFTGEOMETRY/IN ST_SUN_ANGLE	double64	deg		Angle between instrument boresight (taking into account mirror position) and Sun, deg
OBSERVATION	Table[1]			
OBSERVATION/PRODUCT_I D	string			Original filename of this product
OBSERVATION/COLLECTIO N_ID	string			PDS collection ID (currently unused)
OBSERVATION/BUNDLE_ID	string			PDS bundle ID (currently unused)
OBSERVATION/CODE_SVN_ REVISION	string			SVN revision number of code used to produce this product
OBSERVATION/ANC_SVN_R EVISION	string			SVN revision number of ancillary data used to produce this product
OBSERVATION/PRODUCT_C REATION_DATE	string	UTC		Product creation date
OBSERVATION/OBSERVATI ON_TYPE	string			Observation type string
OBSERVATION/MISSION_PH ASE	string			Mission phase string

OBSERVATION/TARGET_NAME	string			Target name string
OBSERVATION/ORBIT_SEGMENT	int16			Orbit segment (periapse, apoapse, corona etc, currently 0)
OBSERVATION/ORBIT_NUMBER	int16			Orbit number (MOI is start of orbit 1, orbit number changes 30min before each periapse)
OBSERVATION/SOLAR_LONGITUDE	float32	deg		Solar longitude, 0deg=Martian spring equinox, 90deg=solstice, etc
OBSERVATION/GRATING_SELECT	string			Grating select (one of 'ECHELLE'/'LOWRES')
OBSERVATION/KEYHOLE_SELECT	string			Keyhole select (one of 'LARGE'/'SMALL'/'NEITHER')
OBSERVATION/BIN_PATTERN_INDEX	string			Name of linear or nonlinear binning table used for this observation.
OBSERVATION/CADENCE	double64			
OBSERVATION/INT_TIME	double64			
OBSERVATION/DUTY_CYCLE	double64			
OBSERVATION/WAVELENGTH_SHIFT	double64	nm		Wavelength offset
OBSERVATION/WAVELENGTH_FUV	double64[Spectral]	nm		Wavelength of center of each bin for FUV channel
OBSERVATION/WAVELENGTH_WIDTH_FUV	double64[Spectral,Spatial]			
OBSERVATION/WAVELENGTH_MUV	int16	nm		Wavelength of center of each bin for MUV channel
OBSERVATION/WAVELENGTH_WIDTH_MUV	int16			
OBSERVATION/KERNELS	string[8]			
OBSERVATION/MCP_VOLT	float32			
OBSERVATION/MCP_GAIN_FUV	double64			
OBSERVATION/MCP_GAIN_MUV	int16			
OBSERVATION/CALIBRATION_VERSION	int16			
OBSERVATION/L1B_FUV	string			Name of L1B FUV files used in L1C
OBSERVATION/L1B_MUV	string			Name of L1B MUV files used in L1C

6.2 Document Product File Formats

6.3 PDS Labels

PDS labels are ASCII text files written, in the eXtensible Markup Language (XML). All product labels are detached from the digital files (if any) containing the data objects they describe (except Product_Bundle). There is one label for every product. Each product, however, may contain one or more data objects. The data objects of a given product may all reside in a single file, or they may be stored in multiple separate files. PDS4 label files must end with the file extension ".xml".

The structure of PDS label files is governed by the XML documents described in Section 6.3.1.

6.3.1 XML Documents

For the MAVEN mission PDS labels will conform to the PDS master schema based upon the 1.1.0.1 version of the PDS Information Model for structure, and the 1.1.0.1 version of the PDS schematron for content. By use of an XML editor these documents may be used to validate the structure and content of the product labels.

The PDS master schema and schematron documents are produced, managed, and supplied to MAVEN by the PDS. In addition to these documents, the MAVEN mission has produced additional XML documents which govern the products in this archive. These documents contain attribute and parameter definitions specific to the MAVEN mission. A full list of XML documents associated with this archive is provided in **Error! Reference source not found.**. A list of the XML documents associated with this archive is included in this document in the XML_Schema collection section for each bundle.

Examples of PDS labels required for the IUVS archive are shown in Appendix C (bundle products), Appendix D (collection products), and Appendix E (basic products).

6.4 Delivery Package

Data transfers, whether from data providers to PDS or from PDS to data users or to the deep archive, are accomplished using delivery packages. Delivery packages include the following required elements:

1. The package which consists of a compressed bundle of the products being transferred.
2. A transfer manifest which maps each product's LIDVID to the physical location of the product label in the package after uncompression.
3. A checksum manifest which lists the MD5 checksum of each file included in the package after uncompression.

IUVS archive delivery packages (including the transfer and checksum manifests) for delivery to PDS are produced at the MAVEN SDC.

6.4.1 The Package

The directory structure used for the delivery package is described in the Appendix in Section F.1. Delivery packages are compressed using tar/gzip and are transferred electronically using the ssh protocol.

6.4.2 Transfer Manifest

The "transfer manifest" is a file provided with each transfer to, from, or within PDS. The transfer manifest is external to the delivery package. It contains an entry for each label file in the package, and maps the product LIDVID to the file specification name for the associated product's label file. Details of the structure of the transfer manifest are provided in Section F.2.

The transfer manifest is external to the delivery package, and is not an archive product. As a result, it does not require a PDS label.

6.4.3 Checksum Manifest

The checksum manifest contains an MD5 checksum for every file included as part of the delivery package. This includes both the PDS product labels and the files containing the digital objects which they describe. The format used for a checksum manifest is the standard output generated by the md5deep utility. Details of the structure of the checksum manifest are provided in section F.3.

The checksum manifest is external to the delivery package, and is not an archive product. As a result, it does not require a PDS label.

Appendix A Support staff and cognizant persons

Table 30: Archive support staff

IUVS team			
Name	**Address**	**Phone**	**Email**
Dr. Justin Deighan IUVS Archivist	Laboratory for Atmospheric and Space Physics Space Science Building (SPSC) University of Colorado 3665 Discovery Drive Boulder, Colorado 80303 USA	+001 303 735 0542	justin.deighan@lasp.colorado.edu
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NMSU			
Name	**Address**	**Phone**	**Email**
Dr. Nancy Chanover Atmospheres Node Manager	Dept. of Astronomy, MSC 4500 New Mexico State University P.O. Box 30001 Las Cruces, NM USA	+1 575 646 2567	nchanove@nmsu.edu
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Appendix B Naming conventions for MAVEN science data files

This section describes the naming convention used for science data files for the MAVEN mission.

Raw (MAVEN Level 0):

mvn_<inst>_<grouping>_l0_< yyyy><mm><dd>_v<xx>.dat

Level 1, 2, 3+:

mvn_<inst>_<level>_<descriptor>_<yyyy><mm><dd>T<hh><mm><ss>_v<xx>_r<yy>.<ext>

Code	**Description**
<inst>	3-letter instrument ID
<grouping>	Three-letter code: options are all, svy, and arc for all data, survey data, and archive data respectively. Primarily for PF to divide their survey and archive data at Level 0.
<yyyy>	4-digit year
<mm>	2-digit month, *e.g.* 01, 12
<dd>	2-digit day of month, *e.g.* 02, 31
<hh>	2-digit hour, separated from the date by T. OPTIONAL. (always present in IUVS products)
<mm>	2-digit minute. OPTIONAL. (always present in IUVS products)
<ss>	2-digit second. OPTIONAL. (always present in IUVS products)
v<xx>	2-digit software version: which version of the software was used to create this data product?
r<yy>	2-digit data version: is this a new version of a previous file, though the same software version was used for both? (Likely to be used in the case of retransmits to fill in data gaps)
<descriptor>	A description of the data. Defined by the creator of the dataset. There are no underscores in the value.
.<ext>	File type extension: .fits, .txt, .cdf, .png
<level>	A code indicating the MAVEN processing level of the data (valid values: l1a, l1b, l1c, l2, l3)

Instrument name	**<instrument>**
IUVS	iuv
NGIMS	ngi
LPW	lpw
MAG	mag
SEP	sep
SWIA	swi
SWEA	swe
STATIC	sta
PF package	pfp

For the IUVS mission the descriptor field is further subdivided into fields, with dashes (-) delimiting fields instead of underscores. The descriptor fields are as follows:

<missionphase><ooooo>-<mode>-<channel>

Code	Description
<missionphase>	Either "orbit" for data collected in Mars orbit, or "cycle" for data collected in cruise
<ooooo>	5-digit orbit or cycle number
<mode>	String describing observation mode. Set of values is open-ended, but includes "periapse", "apoapse", "outlimb", "outdisk", "outbound", "inbound", "corona", "occultation", etc. Cruise observations typically use an arbitrary numerical mode number.
<channel>	Channel and light/dark code: may be "fuv", "muv", "ech" for FUV/MUV/Echelle at all data product levels, and additionally "fuvdark", "muvdark", and "echdark" for raw dark images

Appendix C Sample Bundle Product Label

This section provides a sample bundle product label.

Appendix D Sample Collection Product Label

This section provides a sample collection product label.

Appendix E Sample Data Product Labels

This section provides sample product labels for the various data types described in this document. The large sizes of IUVS XML label files make them inappropriate to reproduce here. Instead, the following external sample file is available for examination:

mvn_iuv_l1a_corona-inbound-dark-fuvdark_20150803T144710.xml

Appendix F PDS Delivery Package Manifest File Record Structures

The delivery package includes two manifest files: a transfer manifest, and MD5 checksum manifest. When delivered as part of a data delivery, these two files are not PDS archive products, and do not require PDS labels files. The format of each of these files is described below.

F.1 Transfer Package Directory Structure

The delivery structure follows a temporal scheme, with the top level being designated by year of data collection, and the second level within that by numerical month (e.g. January = 01).

F.2 Transfer Manifest Record Structure

The transfer manifest is defined as a two field fixed-width table where each row of the table describes one of the products in the package. The first field defines the LIDVID of each product in the package. The second field defines the file specification name of the corresponding product label in the package. The file specification name defines the name and location of the product relative to the location of the bundle product.

F.3 Checksum Manifest Record Structure

The checksum manifest consists of two fields: a 32 character hexadecimal (using lowercase letters) MD5, and a file specification from the root directory of the unzipped delivery package to every file included in the package. The file specification uses forward slashes ("/") as path delimiters. The two fields are separated by two spaces. Manifest records may be of variable length. This is the standard output format for a variety of MD5 checksum tools (*e.g.* md5deep, etc.).