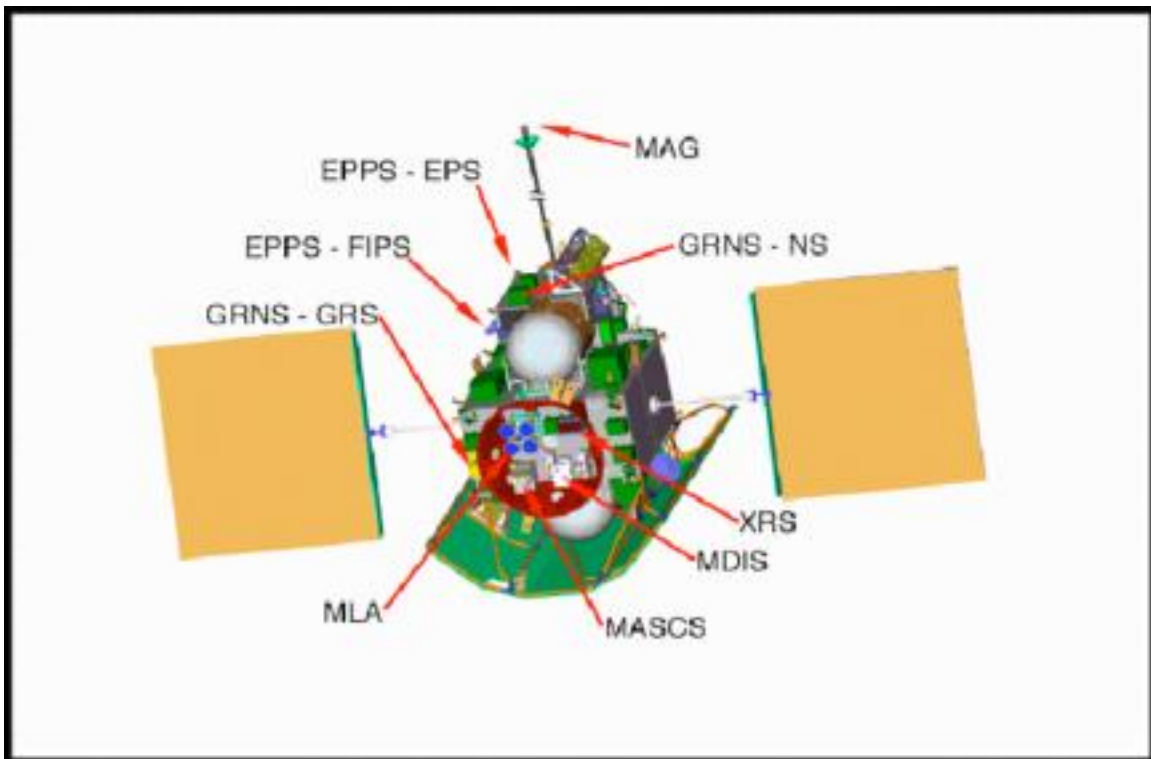


MESSENGER MASCS UVVS+VIRS Combined Derived Data Record Specification

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Document Review

This document and the archive it describes have been through PDS Peer Review and have been accepted into the PDS archive.

William McClintock, MESSENGER Cognizant Co-Investigator/MASCS, has reviewed and approved this document.

Noam Izenberg, MESSENGER MASCS Instrument Scientist, has reviewed and approved this document.

Lyle Huber, PDS Atmospheres Node Representative, has reviewed and approved this document.

Susan Ensor, MESSENGER Science Operations Center Lead, has reviewed and approved this document.

Document Change History

Revision Number	Revision Date	Author	Section	Remarks
1.0	8/22/16	N. Izenberg, J. Ward	All	Initial Document.
2.0	1/23/17	N. Izenberg, J. Ward	5.2.2, Appendix A, B	Response to PDS review. Changed one DQI field and added Appendix B.
3.0	3/30/17	J. Ward	Appendix A, 5.3.1	Fixed errors in format file. Added mission phase to file naming convention.

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1. Purpose and Scope of Document

1.1 Purpose

This document provides users of the MESSENGER MASCS Ultraviolet and Visible Spectrometer (UVVS) and Visible and Infrared Spectrograph (VIRS) data products with a detailed description of the UVVS+VIRS Combined Spectrum Derived Data Record (DDR) product generation and storage. The UVVS+VIRS combined data products are deliverables to the Planetary Data System (PDS) and the scientific community that it supports. All data formats are compliant with PDS standards. In addition, this Specification documents the format and location of the DDR in the MESSENGER MASCS CDR/DDR/DAP PDS archive volume (VOLUME_ID = MESSMAS_2101).

1.2 Scope

This Specification is useful to those who wish to understand the format and content of the UVVS+VIRS combined DDR data products. Typically, these individuals include data analysts and planetary scientists. The Specification applies to DDR data products produced during the course of MESSENGER mission operations. Calibrated Data Records (CDRs), other DDRs, and Derived Analysis Products (DAPs) from MASCS UVVS and VIRS are addressed in the UVVS CDR/DDR SIS and the VIRS CDR/DDR/DAP SIS [Applicable Documents 8 and 9]. EDR data products are archived in a separate PDS archive volume.

2. Applicable Documents

This SIS references the following documents:

1. MESSENGER Mercury: Surface, Space Environment, Geochemistry, Ranging; A mission to Orbit and Explore the Planet Mercury, Concept Study, March 1999. Document ID number FG632/ 99-0479.
2. Planetary Data System Archive Preparation Guide, NASA/JPL, August 29, 2006, Version 1.1, JPL D-31224.
3. Planetary Data System Standards Reference, NASA/JPL, March 20, 2006, Version 3.7, JPL D-7669, Part-2.
4. MESSENGER Data Management and Archiving Plan. The Johns Hopkins University, APL. Document ID number 7384-9019.
5. [PLR] Appendix 7 to the discovery program Plan; Program Level Requirement for the MESSENGER Discovery project; June 20, 2001.
6. MASCS Users Guide. Laboratory for Atmospheric and Space Physics, University of Colorado. Document ID number 20580-T5-5103.
7. Instrument Calibration Report. Mercury Atmospheric and Surface Composition Spectrometer (MASCS) on the Mercury: Surface, Space Environment, Geochemistry, Ranging (MESSENGER) Mission. LASP/CU Document Number 20580-T6-7915.
8. MESSENGER MASCS UVVS Calibrated and Derived Data Record Software Interface Specification, Version 5.5, March 30, 2017, PDS VOLUME_ID: MESSMAS_2101.
9. MESSENGER MASCS VIRS Calibrated Data Record, Derived Data Record, and Derived Analysis Product Software Interface Specification, Version 5.2, March 30, 2017, PDS VOLUME_ID: MESSMAS_2101.

10. MASCS Instrument Paper: W. E. McClintock and M. R. Lankton (2007) *Space Sci. Rev.* 131, 481-522.

3. Relationships with other Interfaces

The UVVS and VIRS data products are stored on hard disk and in an SQL (Structured Query Language) relational database for rapid mission access during mission operations. The data products are electronically transferred to the PDS Geosciences and Atmospheres Nodes according to the delivery schedule in the MESSENGER Data Management and Archiving Plan [Applicable Document 4]. The UVVS and VIRS CDRs, DDRs, and DAPs contain some data that are useful in cross-comparison, therefore both the UVVS and VIRS CDRs/DDR/DAPs are grouped together in the MASCS CDR/DDR/DAP archive volume stored at both PDS nodes.

4. Roles and Responsibilities

The roles and responsibilities of the instrument teams, Applied Physics Laboratory (APL), Applied Coherent Technology Corporation (ACT), and the PDS are defined in the MESSENGER Data Management and Archiving Plan [Applicable Document 4].

5. Data Product Characteristics and Environment

5.1 Instrument Overview

Refer to UVVS_CDR_DDR_SIS.PDF and VIRS_CDR_DDR_DAP_SIS.PDF in the DOCUMENT directory of this volume.

5.2 Data Product Overview

Please see Appendix B for a summary table of all MASCS data products.

5.2.1 UVVS and VIRS DDRs

For UVVS and VIRS DDRs, see UVVS_CDR_DDR_SIS.PDF and VIRS_CDR_DDR_DAP_SIS.PDF in the DOCUMENT directory of this volume.

5.2.2 UVVS+VIRS Combined DDRs

The UVVS+VIRS DDRs consist of derived data from UVVS' middle ultraviolet (MUV) photomultiplier tube, and VIRS. Spatially proximate UVVS and VIRS spectra are combined to create a single extended wavelength surface reflectance spectrum from 210 nm to 1450 nm. The combination is conducted by software that locates automatically or with human assistance, the closest best matching VIRS spectrum to a given UVVS spectrum, and combines the two data sets into a single spectrum for that location.

The UVVS+VIRS Combined +DDR data product contains all the data from one observation pair (matched UVVS and VIRS observations). One observation pair is associated with one DDR data product showing derived science data (photometrically corrected surface reflectance), and location information for each wavelength bin of a UVVS surface observation and the

corresponding VIRS observation. The DDRs are in binary table format, and each is described by a detached PDS label. The label files define source DDR files, the time of acquisition of the UVVS observation, product creation time, etc. The label points to an associated format file that defines the fields of the binary table contained within the data file.

The combined spectrum contains footprint information similar to that shown in Figure 1, and spectrum information similar to that shown in Figure 2.

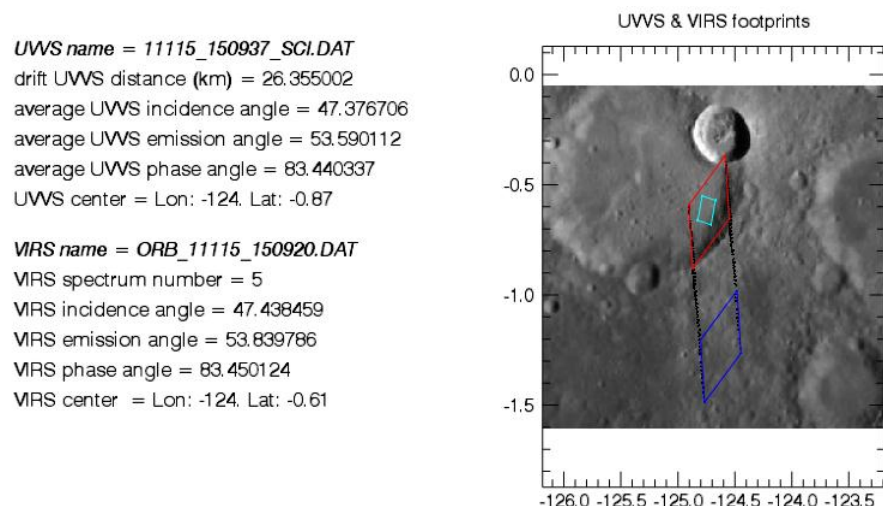


Figure 1. UVVS footprint of UVVS-VIRS Combined DDR is shown projected on an image mosaic background. The blue parallelogram represents the location of the first wavelength (210 nm) of the UVVS spectrum. The red shows the location of the last wavelength (300 nm). The cyan footprint represents the coordinate points of the VIRS footprint associated with the combined spectrum. Information on the source observations for UVVS and VIRS is also listed, and included in the DDR.

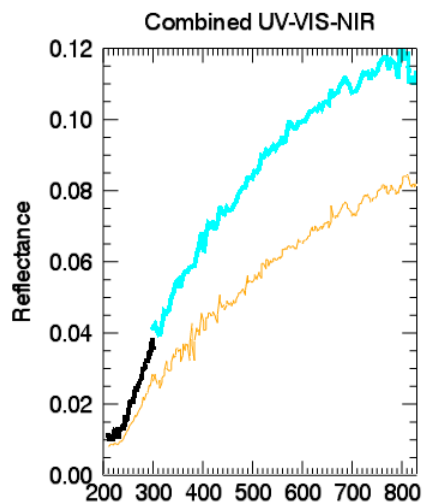


Figure 2. Combined spectrum data from UVVS and VIRS. UVVS reflectance is shown in black, VIRS (up to 840 nm) is shown in cyan. A mean Mercury spectrum for the southern hemisphere is shown in orange.

Components of the UVVS+VIRS Combined DDR include:

Component File IDs

1. UVVS Header File ID
2. UVVS Science File ID
3. VIRS VIS File ID
4. VIRS NIR File ID

These are the individual DDR files from which spectral and other information is extracted to make the combined DDR.

VIRS spectrum number

5. VIRS Spectrum Number (derived/selected by automated/human matching) (*int*)

VIRS observations may have dozens to thousands of individual spectra. This field denotes the spectrum number from the matching observation that is the closest/best match to the UVVS spectrum of the DDR.

UVVS derived footprint parameters

6. UVVS drift distance
7. UVVS smear as a % of footprint size

Drift is the ground distance in km between the center of the UVVS footprint of the first wavelength of the observation (blue in Fig. 1) to the last wavelength (red in Fig. 1).

Smear is the drift distance scaled to the size of the UVVS footprint, determined by the average size (in km) of two adjacent sides of the footprint parallelogram.

UVVS footprint parameters for all UVVS wavelengths

8. Lat, Lon coordinates of UVVS spectral footprints (center and 4 corners - C0, C1, C2, C3, C4)
 - a. *Lat Center (C0)*
 - b. *Lat Corner 1 (C1)*
 - c. *Lat Corner 2 (C2)*
 - d. *Lat Corner 3 (C3)*
 - e. *Lat Corner 4 (C4)*
 - f. *Lon Center (C0)*
 - g. *Lon Corner 1 (C1)*
 - h. *Lon Corner 2 (C2)*
 - i. *Lon Corner 3 (C3)*
 - j. *Lon Corner 4 (C4)*

Copied from the UVVS DDR. The UVVS spectrum is in 46 wavelength bins, each with its own footprint coordinates.

VIRS footprint parameters for VIRS spectrum

9. Lat, Lon coordinates of VIRS spectral footprint (center, and points describing the VIRS ovoid - C0, C1, C2, C3, C4)
 - a. *Lat ovoid coordinates (C0, C1, C2, C3, C4)*
 - b. *Lon ovoid coordinates (C0, C1, C2, C3, C4)*

Copied from the VIRS DDR.

Spatial relation between UVVS and VIRS footprints

10. Distance in km from center coordinates of UVVS to center coordinates of VIRS
11. Distance % of footprint size from center coordinates of UVVS to center coordinates of VIRS

Center to center distance between UVVS and VIRS in km and as a percentage of the UVVS footprint size – similar to component 7.

Photometric angles of the observation

12. Average i, e, phase UVVS (copied from UVVS SCI DDR of central wavelength) (*3xfloat*)

13. Average i, e, phase VIRS (copied from VIRS DDR) (*3xfloat*)

For UVVS, the incidence (i), emission (e) and phase angles (a) are taken from the central wavelength (256 nm) footprint. Both UVVS and VIRS are normalized to i=45°, e=45°, a=90°.

Quality factors for spectrum

14. “Goodness” of Match
15. DQI (*7xstring*)
 - a. Hot UVVS (0 = No, 1 = Yes, threshold of 35°C)
 - b. Hot VIRS (0 = No, 1 = Yes, threshold of 50°C)
 - c. AltVIRS (0 = No, 1 = Yes, derived/selected by automated/human matching)
 - d. Secondary AltVIRS ((0 = No, 1 = Yes, selected by human matching)
 - e. VIRS Binning (0 = unbinned, 1 = binned by 2)
 - f. UVVS Footprint Heterogeneity
 - g. Spare

Goodness of match UVVS reflectance at 300 nm ratioed to VIRS reflectance at 300 nm, with 1.00 being perfect match). Data Quality Indices (DQIs) a and b represent whether UVVS or VIRS detectors exceed levels that potentially affect data quality. DQIs c and d denote whether the VIRS observation chosen to match UVVS is not contemporaneous with the UVVS observation: Many – but not all – of the UVVS observations have contemporaneous VIRS observations at almost identical viewing geometries. However, not all do, and the ones that don’t need the “closest, best” VIRS spectrum match found by hand. The “AltVIRS” DQI numbers indicate if such an alternative VIRS spectrum was needed, and whether it is the absolute closest possible VIRS spectrum (in terms of distance in km from center coordinates of UVVS to center coordinates of VIRS) or the best spectral match, which will be proximate, but not necessarily the closest. DQI f is qualitative heterogeneity of UVVS footprint, graded, “0”, “1”, “2”, or “3”. A 1 indicates that the UVVS footprint, even if it smeared over a large area, is located on a uniform landscape. A 2 indicates that there are some small craters/ridges/etc. in the area covered by the observation, or the terrain changes between the start and end footprint of the individual UVVS footprint steps. A 3 indicates large craters/ridges/variation in the area covered by the observation or that one entire starting or ending step footprint is located on a different type of terrain. A “0” indicates no evaluation was made.

Spectrum Information

16. Wavelength file of combined spectrum
17. Photometrically corrected reflectance values of combined spectrum

18. Photometrically corrected reflectance noise values of combined spectrum

The combined UVVS+VIRS spectrum, with noise and wavelengths, in 504 wavelength bins.

Spares

19. 4 x Spare (*4 fields, 1xfloat each*)

Items 6-14, and DQI are all useful for filtering the dataset for desired qualities before reading in any spectra.

5.3 Data Processing

The UVVS+VIRS Combined DDR is a level 4 product as defined by the Committee on Data Management and Computation. The DDR files were produced by the MESSENGER Science Operations Center (SOC), operated jointly by APL and ACT. The DDR data products were made available to the MESSENGER Science Team for initial evaluation and validation. At the end of the evaluation and validation period, the data were organized, stored, and transmitted with other DDRs as described in the respective SIS documents.

5.3.1 Labeling and Identification

Labeling of the UVVS+VIRS Combined DDR conforms to the PDS version 3 standards. For more information on this standard consult the PDS Standards Reference JPL D-7669 Document [Applicable Document 3]. The purpose of the PDS label is to describe the data product and provide ancillary information about the data product.

UVVS+VIRS Combined DDR data products have the form “UVVSVIRSD_mmm_YYDOY_HHMMSS”, where mmm is the mission phase [Mercury Orbit (ORB) through Mercury Orbit Year 5 (OB5)], YYDOY are the year and day of year, and HHMMSS are the hour, minute, second designations taken from the source UVVS observation of each data set.

5.3.1.1 Example PDS Label for the UVVS+VIRS Combined Spectrum

```
PDS_VERSION_ID          = "PDS3"

/**** FILE FORMAT ****/
RECORD_TYPE              = FIXED_LENGTH
RECORD_BYTES             = 10485
FILE_RECORDS             = 1

/**** GENERAL DATA DESCRIPTION PARAMETERS ****/
PRODUCT_ID               = "UVVSVIRSD_OB4_14176_041429_DAT"
PRODUCT_VERSION_ID       = "V1 "
PRODUCT_CREATION_TIME    = 2016-07-26T13:22:44
PRODUCT_TYPE             = "DDR"
SOFTWARE_NAME            = "PIPE-MASCS2DDR"
SOFTWARE_VERSION_ID      = "1.0"
```

```

INSTRUMENT_HOST_NAME      = "MESSENGER"
INSTRUMENT_NAME           = "
  MERCURY ATMOSPHERIC AND SURFACE COMPOSITION SPECTROMETER"
INSTRUMENT_ID             = "MASCS"
DETECTOR_ID               = {"UVVS", "VIRS"}
DATA_SET_ID               = "MESS-E/V/H-MASCS-4-UVVS/VIRS-DDR-V1.0"
STANDARD_DATA_PRODUCT_ID  = "UVVSVIRSD"
MISSION_PHASE_NAME        = "MERCURY ORBIT YEAR 4"
TARGET_NAME               = "MERCURY"
OBSERVATION_TYPE          = "Joint UVVS - VIRS"
START_TIME                = "N/A"
STOP_TIME                 = "N/A"
SPACECRAFT_CLOCK_START_COUNT = "N/A"
SPACECRAFT_CLOCK_STOP_COUNT = "N/A"
^TABLE                    = "UVVSVIRSD_OB4_14176_041429.DAT"

OBJECT                     = TABLE
  COLUMNS                 = 32
  INTERCHANGE_FORMAT       = BINARY
  ROW_BYTES                = 10485
  ROWS                     = 1
  DESCRIPTION              = "

  Detailed descriptions for the parameters defined below are contained
  in UVVS_VIRS_COMBINED_DDR_SPEC.PDF located in the DOCUMENT
  directory of the MASCS CDR/DDR/DAP archive volume.

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

"

^STRUCTURE = "UVVSVIRSD.FMT"
END_OBJECT      = TABLE
END

```

5.4 Data Format Description

Data are stored in binary table format. Detached PDS labels provide detailed descriptions of the structure of the tables.

5.5 Data Location

The UVVS+VIRS data products are located in the UVVS_VIRS_COMBINED folder on the MASCS CDR/DDR/DAP archive volume. See section 6.1.3 of UVVS_CDR_DDR_SIS.PDF and VIRS_CDR_DDR_DAP_SIS.PDF for the full directory structure.

6. Appendices

APPENDIX A- UVVSVIRSD.FMT FILE

```

OBJECT          = COLUMN
  NAME           = UVVS_HDR_DDR_NAME
  COLUMN_NUMBER  = 1
  BYTES          = 31
  DATA_TYPE     = CHARACTER
  START_BYTE     = 1
  DESCRIPTION    = "Name of the UVVS Surface DDR Header File from which
  UVVS header data were extracted."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  NAME           = UVVS_SCI_DDR_NAME
  COLUMN_NUMBER  = 2
  BYTES          = 31
  DATA_TYPE     = CHARACTER
  START_BYTE     = 32
  DESCRIPTION    = "Name of the UVVS Surface DDR Science File from which
  UVVS science data were extracted."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  NAME           = VIRS_VIS_DDR_NAME
  COLUMN_NUMBER  = 3
  BYTES          = 27
  DATA_TYPE     = CHARACTER
  START_BYTE     = 63
  DESCRIPTION    = "Name of the VIRS VIS DDR File from which VIRS VIS data
  were extracted."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  NAME           = VIRS_NIR_DDR_NAME
  COLUMN_NUMBER  = 4
  BYTES          = 27
  DATA_TYPE     = CHARACTER
  START_BYTE     = 90
  DESCRIPTION    = "Name of the VIRS NIR DDR File from which VIRS NIR data
  were extracted."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  NAME           = VIRS_SPECTRUM_NUMBER
  COLUMN_NUMBER  = 5
  BYTES          = 2
  DATA_TYPE     = MSB_UNSIGNED_INTEGER
  START_BYTE     = 117
  DESCRIPTION    = "VIRS Spectrum Number."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
  NAME           = UVVS_DRIFT

```

```

    COLUMN_NUMBER      = 6
    BYTES               = 8
    DATA_TYPE          = IEEE_REAL
    START_BYTE          = 119
    MISSING_CONSTANT    = -1.E32
    DESCRIPTION         = "UVVS drift Distance from first to last step. Unit = km."
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
    NAME               = UVVS_SMEAR
    COLUMN_NUMBER      = 7
    BYTES              = 8
    DATA_TYPE         = IEEE_REAL
    START_BYTE         = 127
    MISSING_CONSTANT    = -1.E32
    DESCRIPTION        = "UVVS smear as a percentage of footprint size."
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
    NAME               = UVVS_TARGET_LATITUDE_C0
    COLUMN_NUMBER      = 8
    BYTES              = 368
    DATA_TYPE         = IEEE_REAL
    START_BYTE         = 135
    ITEMS              = 46
    ITEM_BYTES         = 8
    MISSING_CONSTANT    = -1.E32
    DESCRIPTION        = "This indicates the UVVS BIN-average latitudes at the
    locations where the field-of-view center and corners intersect the planet
    surface. Format: (center, corner 1, corner 2, corner 3, corner 4).
    Unit = degrees."
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
    NAME               = UVVS_TARGET_LATITUDE_C1
    COLUMN_NUMBER      = 9
    BYTES              = 368
    DATA_TYPE         = IEEE_REAL
    START_BYTE         = 503
    ITEMS              = 46
    ITEM_BYTES         = 8
    MISSING_CONSTANT    = -1.E32
    DESCRIPTION        = "This indicates the UVVS BIN-average latitudes at the
    locations where the field-of-view center and corners intersect the planet
    surface. Format: (center, corner 1, corner 2, corner 3, corner 4).
    Unit = degrees."
END_OBJECT             = COLUMN

OBJECT                 = COLUMN
    NAME               = UVVS_TARGET_LATITUDE_C2
    COLUMN_NUMBER      = 10
    BYTES              = 368
    DATA_TYPE         = IEEE_REAL
    START_BYTE         = 871
    ITEMS              = 46
    ITEM_BYTES         = 8
    MISSING_CONSTANT    = -1.E32

```

```

DESCRIPTION      = "This indicates the UVVS BIN-average latitudes at the
locations where the field-of-view center and corners intersect the planet
surface. Format: (center, corner 1, corner 2, corner 3, corner 4).
Unit = degrees."
END_OBJECT       = COLUMN

OBJECT           = COLUMN
NAME             = UVVS_TARGET_LATITUDE_C3
COLUMN_NUMBER    = 11
BYTES            = 368
DATA_TYPE        = IEEE_REAL
START_BYTE       = 1239
ITEMS            = 46
ITEM_BYTES       = 8
MISSING_CONSTANT = -1.E32
DESCRIPTION      = "This indicates the UVVS BIN-average latitudes at the
locations where the field-of-view center and corners intersect the planet
surface. Format: (center, corner 1, corner 2, corner 3, corner 4).
Unit = degrees."
END_OBJECT       = COLUMN

OBJECT           = COLUMN
NAME             = UVVS_TARGET_LATITUDE_C4
COLUMN_NUMBER    = 12
BYTES            = 368
DATA_TYPE        = IEEE_REAL
START_BYTE       = 1607
ITEMS            = 46
ITEM_BYTES       = 8
MISSING_CONSTANT = -1.E32
DESCRIPTION      = "This indicates the UVVS BIN-average latitudes at the
locations where the field-of-view center and corners intersect the planet
surface. Format: (center, corner 1, corner 2, corner 3, corner 4).
Unit = degrees."
END_OBJECT       = COLUMN

OBJECT           = COLUMN
NAME             = UVVS_TARGET_LONGITUDE_C0
COLUMN_NUMBER    = 13
BYTES            = 368
DATA_TYPE        = IEEE_REAL
START_BYTE       = 1975
ITEMS            = 46
ITEM_BYTES       = 8
MISSING_CONSTANT = -1.E32
DESCRIPTION      = "This indicates the UVVS BIN-average longitudes at the
locations where the field-of-view center and corners intersect the planet
surface. Format: (center, corner 1, corner 2, corner 3, corner 4).
Unit = degrees."
END_OBJECT       = COLUMN

OBJECT           = COLUMN
NAME             = UVVS_TARGET_LONGITUDE_C1
COLUMN_NUMBER    = 14
BYTES            = 368
DATA_TYPE        = IEEE_REAL
START_BYTE       = 2343

```

```

ITEMS                = 46
ITEM_BYTES           = 8
MISSING_CONSTANT    = -1.E32
DESCRIPTION          = "This indicates the UVVS BIN-average longitudes at the
                        locations where the field-of-view center and corners intersect the planet
                        surface. Format: (center, corner 1, corner 2, corner 3, corner 4).
                        Unit = degrees."
END_OBJECT           = COLUMN

OBJECT               = COLUMN
NAME                 = UVVS_TARGET_LONGITUDE_C2
COLUMN_NUMBER        = 15
BYTES                = 368
DATA_TYPE            = IEEE_REAL
START_BYTE           = 2711
ITEMS                = 46
ITEM_BYTES           = 8
MISSING_CONSTANT    = -1.E32
DESCRIPTION          = "This indicates the UVVS BIN-average longitudes at the
                        locations where the field-of-view center and corners intersect the planet
                        surface. Format: (center, corner 1, corner 2, corner 3, corner 4).
                        Unit = degrees."
END_OBJECT           = COLUMN

OBJECT               = COLUMN
NAME                 = UVVS_TARGET_LONGITUDE_C3
COLUMN_NUMBER        = 16
BYTES                = 368
DATA_TYPE            = IEEE_REAL
START_BYTE           = 3079
ITEMS                = 46
ITEM_BYTES           = 8
MISSING_CONSTANT    = -1.E32
DESCRIPTION          = "This indicates the UVVS BIN-average longitudes at the
                        locations where the field-of-view center and corners intersect the planet
                        surface. Format: (center, corner 1, corner 2, corner 3, corner 4).
                        Unit = degrees."
END_OBJECT           = COLUMN

OBJECT               = COLUMN
NAME                 = UVVS_TARGET_LONGITUDE_C4
COLUMN_NUMBER        = 17
BYTES                = 368
DATA_TYPE            = IEEE_REAL
START_BYTE           = 3447
ITEMS                = 46
ITEM_BYTES           = 8
MISSING_CONSTANT    = -1.E32
DESCRIPTION          = "This indicates the UVVS BIN-average longitudes at the
                        locations where the field-of-view center and corners intersect the planet
                        surface. Format: (center, corner 1, corner 2, corner 3, corner 4).
                        Unit = degrees."
END_OBJECT           = COLUMN

OBJECT               = COLUMN
NAME                 = VIRS_TARGET_LATITUDE_SET
COLUMN_NUMBER        = 18

```

```

    BYTES                = 40
    DATA_TYPE           = IEEE_REAL
    START_BYTE           = 3815
    ITEMS                = 5
    ITEM_BYTES           = 8
    MISSING_CONSTANT     = -1.E32
    INVALID_CONSTANT     = 1.E32
    DESCRIPTION = "Derived latitude of VIRS footprint center, uprange edge
    (c1), downrange edge (c2), port, (c3) and starboard (c4) edges (5 total
    values, coordinates as in Figure 4 of VIRS_CDR_DDR_DAP_SIS.PDF; center
    point, c1, c2, c3, c4) on planet target corresponding to spectral
    observation. Unit = degrees."
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
    NAME                = VIRS_TARGET_LONGITUDE_SET
    COLUMN_NUMBER       = 19
    BYTES               = 40
    DATA_TYPE          = IEEE_REAL
    START_BYTE          = 3855
    ITEMS               = 5
    ITEM_BYTES          = 8
    MISSING_CONSTANT    = -1.E32
    INVALID_CONSTANT    = 1.E32
    DESCRIPTION = "Derived longitude of VIRS footprint center, uprange edge
    (c1), downrange edge (c2), port, (c3) and starboard (c4) edges (5 total
    values, coordinates as in Figure 4 of VIRS_CDR_DDR_DAP_SIS.PDF; center
    point, c1, c2, c3, c4) on planet target corresponding to spectral
    observation. Unit = degrees. PER SPECTRUM column."
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
    NAME                = VIRS_UVVS_CENTER_DISTANCE
    COLUMN_NUMBER       = 20
    BYTES               = 8
    DATA_TYPE          = IEEE_REAL
    START_BYTE          = 3895
    MISSING_CONSTANT    = -1.E32
    DESCRIPTION = "Distance from center coordinates of UVVS to center
    coordinates of VIRS. Unit = km."
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
    NAME                = VIRS_UVVS_OFFSET_PERCENTAGE
    COLUMN_NUMBER       = 21
    BYTES               = 8
    DATA_TYPE          = IEEE_REAL
    START_BYTE          = 3903
    MISSING_CONSTANT    = -1.E32
    DESCRIPTION = "Distance percentage of footprint size from center
    coordinates of UVVS to center coordinates of VIRS."
END_OBJECT              = COLUMN

OBJECT                  = COLUMN
    NAME                = UVVS_CENTER_PHOT_ANGLES
    COLUMN_NUMBER       = 22
    BYTES               = 24

```

```

DATA_TYPE      = IEEE_REAL
START_BYTE     = 3911
ITEMS          = 3
ITEM_BYTES     = 8
MISSING_CONSTANT = -1.E32
DESCRIPTION    = "Average incidence, emission and phase UVVS angles.
Unit = degrees."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
NAME           = VIRS_CENTER_PHOT_ANGLES
COLUMN_NUMBER  = 23
BYTES          = 24
DATA_TYPE      = IEEE_REAL
START_BYTE     = 3935
ITEMS          = 3
ITEM_BYTES     = 8
MISSING_CONSTANT = -1.E32
DESCRIPTION    = "Average incidence, emission and phase VIRS angles.
Unit = degrees."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
NAME           = VIRS_UVVS_MATCH
COLUMN_NUMBER  = 24
BYTES          = 8
DATA_TYPE      = IEEE_REAL
START_BYTE     = 3959
MISSING_CONSTANT = -1.E32
DESCRIPTION    = "'Goodness of Match': (VIRS photometrically corrected
reflectance at 300 nm )/ (UVVS photometrically corrected reflectance at
300 nm) Where 1.00 is a perfect match."
END_OBJECT     = COLUMN

OBJECT         = COLUMN
NAME           = DATA_QUALITY_INDEX
COLUMN_NUMBER  = 25
BYTES          = 7
DATA_TYPE      = CHARACTER
START_BYTE     = 3967
DESCRIPTION    = "7 character index of data quality. Each digit signifies
quality factor of measurements.
Format: ABCDEFG
A: Hot UVVS (threshold)
  0 = Temperature does not exceed 50 deg C
  1 = Temperature exceeds 50 deg C
B: Hot VIRS (threshold)
  0 = Temperature does not exceed 35 deg C threshold.
  1 = Temperature exceeds 35 deg C threshold.
C: AltVIRS
  0 = UVVS and VIRS are near contemporaneous.
  1 = UVVS and VIRS are not contemporaneous. Best, closest
    overlapping VIRS observation matched with UVVS
D: Secondary AltVIRS (not closest, but best)
  0 = Default
  1 = UVVS and VIRS are not contemporaneous. Best overlapping
    VIRS observation matched with UVVS - but NOT geographically

```

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        closest.
E: VIRS Binning
  0 = No VIRS binning (i.e. binned by 1)
  1 = VIRS spectrum binned by 2, rebinned to full-size in DDR.
F: UVVS Footprint Heterogeneity
  0 = No evaluation
  1 = Footprint on uniform landscape
  2 = Small craters or topography variation within UVVS footprint
  3 = Large craters or topographic variation within UVVS footprint
G: Spare."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
NAME            = FULLSPEC_WAVELENGTHS
COLUMN_NUMBER   = 26
BYTES           = 2160
DATA_TYPE       = IEEE_REAL
START_BYTE      = 3974
ITEMS           = 540
ITEM_BYTES      = 4
DESCRIPTION     = "Wavelength file of combined spectrum: 46 UVVS wavelengths,
494 VIRS wavelengths."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
NAME            = FULLSPEC_PHOTOM_IOF_DATA
COLUMN_NUMBER   = 27
BYTES           = 2160
DATA_TYPE       = IEEE_REAL
START_BYTE      = 6134
ITEMS           = 540
ITEM_BYTES      = 4
INVALID_CONSTANT = 1.E32
DESCRIPTION     = "Photometrically corrected reflectance values of combined
spectrum: 46 UVVS wavelengths, 494 VIRS wavelengths."
END_OBJECT      = COLUMN

OBJECT          = COLUMN
NAME            = FULLSPEC_PHOTOM_IOF_NOISE_DATA
COLUMN_NUMBER   = 28
BYTES           = 2160
DATA_TYPE       = IEEE_REAL
START_BYTE      = 8294
ITEMS           = 540
ITEM_BYTES      = 4
INVALID_CONSTANT = 1.E32
DESCRIPTION     = "Photometrically corrected reflectance noise of combined
spectrum: 46 UVVS wavelengths, 494 VIRS wavelengths."
END_OBJECT      = COLUMN

/* SPARE COLUMNS */
OBJECT          = COLUMN
NAME            = SPARE_1
COLUMN_NUMBER   = 29
BYTES           = 8
DATA_TYPE       = IEEE_REAL
START_BYTE      = 10454

```

```

        DESCRIPTION = "SPARE column."
END_OBJECT      = COLUMN

```

```

OBJECT          = COLUMN
    NAME          = SPARE_2
    COLUMN_NUMBER = 30
    BYTES          = 8
    DATA_TYPE     = IEEE_REAL
    START_BYTE     = 10462
    DESCRIPTION    = "SPARE column."
END_OBJECT      = COLUMN

```

```

OBJECT          = COLUMN
    NAME          = SPARE_3
    COLUMN_NUMBER = 31
    BYTES          = 8
    DATA_TYPE     = IEEE_REAL
    START_BYTE     = 10470
    DESCRIPTION    = "SPARE column."
END_OBJECT      = COLUMN

```

```

OBJECT          = COLUMN
    NAME          = SPARE_4
    COLUMN_NUMBER = 32
    BYTES          = 8
    DATA_TYPE     = IEEE_REAL
    START_BYTE     = 10478
    DESCRIPTION    = "SPARE column."
END_OBJECT      = COLUMN

```

APPENDIX B- MASCS Data Product Summary

VOLUME_ID = MESSMAS_1001	Description	DATA_SET_ID	STANDARD_ DATA_ PRODUCT_ID	SIS Section
UVVS EDRs	UVVS Experiment Data Records	MESS-E/V/H-MASCS-2-UVVS-EDR-V1.0	UVVSFUV UVVSMUV UVVSVIS UVVSHK	UVVSEDRSIS 5.2
VIRS EDRs	VIRS Experiment Data Records	MESS-E/V/H-MASCS-2-VIRS-EDR-V1.0	VIRSNIR VIRSVIS VIRSHK	VIRSEDRSIS 5.2
VOLUME_ID = MESSMAS_2101	Description	DATA_SET_ID	STANDARD_ DATA_ PRODUCT_ID	SIS Section
UVVS CDRs	Calibrated data derived from UVVS EDRs	MESS-E/V/H-MASCS-3-UVVS-CDR-CALDATA-V1.0	UVVSCFUVHDR UVVSCFUVSCI UVVSCMUVHDR UVVSCMUVSCI UVVSCVISHDR UVVSCVISSCI	UVVS_CDR_DDR_SIS 5.2.1
UVVS MUV Surface DDR	Reflectance data derived from UVVS MUV surface CDRs	MESS-E/V/H-MASCS-4-UVVS- DDR-V1.0	UVVSDMUVHDR UVVSDMUVSCI	UVVS_CDR_DDR_SIS 5.2.2.1
UVVS FUV Surface DDR	Reflectance data derived from UVVS FUV surface CDRs	MESS-E/V/H-MASCS-4-UVVS- DDR-V1.0	UVVSDFUVHDR UVVSDFUVSCI	UVVS_CDR_DDR_SIS 5.2.2.2
UVVS Atmosphere DDR	Time-ordered sequences of radiance values measured along lines of sight perpendicular to Mercury radius vectors	MESS-E/V/H-MASCS-4-UVVS- DDR-V1.0	UVVSDNALS UVVSDNALD UVVSDNANS UVVSDMGLS UVVSDMGLD UVVSDMGNS UVVSDCALS UVVSDCALD UVVSDCANS	UVVS_CDR_DDR_SIS 5.2.2.3
UVVS Atmosphere Summary DDR	Orbit-level summary products that gather together all of the observations for a given species for a given orbit into a single file	MESS-E/V/H-MASCS-4-UVVS- DDR-V1.0	UVVSDNASUM UVVSDMGSUM UVVSDCASUM	UVVS_CDR_DDR_SIS 5.2.2.3
UVVS Atmospheric Model DDR	A series of model fits to data averaged over specific Mercury true anomalies and local times	MESS-E/V/H-MASCS-4-UVVS- DDR-V1.0	UVVSDNAMOD UVVSDCAMOD	UVVS_CDR_DDR_SIS 5.2.2.4

VIRS CDRs	Calibrated data derived from VIRS EDRs	MESS-E/V/H-MASCS-3-VIRS-CDR-CALDATA-V1.0	VIRSCNIR VIRSCVIS	VIRS_CDR_DDR_DAP_SIS 5.2.1
VIRS DDRs	Reflectance data derived from VIRS CDRs	MESS-E/V/H-MASCS-4-VIRS-DDR-V2.0	VIRSDNIR VIRSDVIS	VIRS_CDR_DDR_DAP_SIS 5.2.2
VIRS DAPs	A 500 meter per pixel mosaic map of 1 wavelength (750 nm) of VIRS spectral data for footprints covering the planet Mercury	MESS-E/V/H-MASCS-5-VIRS-DAP-V2.0	VIRSDAP	VIRS_CDR_DDR_DAP_SIS 5.2.3
UVVS + VIRS Combined DDRs	Derived data from UVVS' middle ultraviolet (MUV) photomultiplier tube, and VIRS	MESS-E/V/H-MASCS-4-UVVS/VIRS-DDR-V1.0	UVVSVIRSD	UVVS_VIRS_COMBINED_DDR_SPEC 5.2.2