

Lunar Reconnaissance Orbiter Project

LYMAN ALPHA MAPPING PROJECT

PIPELINE REDUCED DATA RECORD (RDR)

DATA PRODUCT

SOFTWARE INTERFACE SPECIFICATION

June 2009

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Contract NNG05EC87C

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REVISION NOTICE

Change	Date	Affected Portions
Initial draft	20 December 2007	
Updated draft, incorporating comments from Karen North and Stan Scott	24 February 2008	Miscellaneous small corrections and additions
Removed remaining TBD/TBS items	15 December 2008	Section 2
Added clarifying text; reformatted	02 February 2009	Miscellaneous
Added primary FITS header keyword, HVOPSLVL	06 February 2009	Appendix A
Removed "consecutive" from description of Calibrated Calculated Count Rate extension; clarified SCUT time stamp in RDR filename to refer to the start of the file rather than the start of the first data acquisition in the file	09 February 2009	Section 4.2; Section 4.3.5
Added text to Calibrated Calculated Count Rate extension description to say that if no pixel list data are present, the data portion of the extension would be empty.	03 March 2009	Section 4.2
Modified example PDS label; removed CAL_HISTOGRAM_DATA_ARRAY pointer since there is no histogram mode data in the example.	20 March 2009	Appendix E
Added second example PDS label for the case where histogram mode data are present.	03 April 2009	Appendix F
Initial release	16 April 2009	
Revision 1	04 June 2009	Appendix E – Example PDS Label #1, Appendix F – Example PDS Label #2, placed quotes around the values of SPACECRAFT_CLOCK_START_COUNT and SPACECRAFT_CLOCK_STOP_COUNT

1. PURPOSE AND SCOPE OF DOCUMENT

The purpose of this Data Product SIS is to provide users of the LAMP Pipeline RDR (CODMAC Level 3) data product with a detailed description of the product and a description of how it was generated, including data sources and destinations. The Pipeline RDR product contains time-tagged sequences of calibrated and spatially-located far-UV photon detections (when LAMP is operated in pixel list mode) and/or calibrated far-UV spectral images (when LAMP is operated in histogram mode). Housekeeping and ancillary data, which will be used to interpret the calibrated data, are also included. This SIS is intended to provide enough information to enable users to read and understand the data product. The users for whom this SIS is intended are the scientists who will analyze the data, including those associated with the Lunar Reconnaissance Orbiter Project, and those in the general planetary science community.

This Data Product SIS describes the inputs to the Pipeline RDR data product, and how it is processed, formatted, labeled, and uniquely identified. The document discusses standards used in generating the product and software that may be used to access the product. The data product structure and organization is described in sufficient detail to enable a user to read the product. Finally, an example of a product label is provided.

2. APPLICABLE DOCUMENTS

This Data Product SIS is intended to be consistent with the following documents:

1. Planetary Data System Standards Reference, version 3.7, March 20, 2006, JPL Document D-7669, Part 2.
2. Planetary Science Data Dictionary Document, revision E, August 28, 2002, JPL Document D-7116.
3. Lunar Reconnaissance Orbiter Data Management and Archive Plan, 431-PLAN-000182.
4. LRO LAMP Instrument Team Data Management and Archive Plan, 11239-DMAP-01.
5. Interface Control Document for the LRO Ground System, 431-ICD-000049.
6. LAMP Science Team and PDS Imaging Node Interface Control Document, JPL Document D-49057.
7. Lyman Alpha Mapping Project EDR Archive Volume Software Interface Specification, 11239-EDRAV_SIS-01.
8. Definition of the Flexible Image Transport System (FITS), version 2.1b, December 9, 2005, IAU FITS Working Group (<http://fits.gsfc.nasa.gov/iaufwg/>).
9. "LAMP: the Lyman Alpha Mapping Project aboard the NASA Lunar Reconnaissance Orbiter mission," by Gladstone, G. Randall, Stern, S. Alan, Retherford, Kurt D., Black, Ron, Scherrer, John R., Slater, David C., Stone, John M., Feldman, Paul D., and Crider, Dana, in *Astrobiology and Planetary Missions*, edited by Hoover, Richard B., Levin, Gilbert V., Rozanov, Alexei Y., and Gladstone, G. Randall, Proceedings of the SPIE, Sep. 2005, Vol. 5906, pp. 380-388.
10. Lyman Alpha Mapping Project Experiment Data Record (EDR) Data Product Software Interface Specification, 11239-EDRDP_SIS-01.
11. Lyman Alpha Mapping Project Pipeline Reduced Data Record (RDR) Archive Volume Software Interface Specification, 11239-RDRAV_SIS-01.

12. "A Standardized Lunar Coordinate System for the Lunar Reconnaissance Orbiter," LRO Project White Paper, 451-SCI-000958, Version 3, January 30, 2008.

3. RELATIONSHIPS WITH OTHER INTERFACES

The LAMP Pipeline RDR Archive Volume SIS [11] describes how the data products specified by this document will be made available through the PDS, and could be affected by a change in this SIS.

4. DATA PRODUCT CHARACTERISTICS AND ENVIRONMENT

This section describes the LAMP Pipeline RDR data product in greater detail, including how the data are acquired, the types of data in the Pipeline RDR, and how the data are processed and validated.

4.1 Instrument Overview

The LAMP UV spectrograph instrument is largely based on the Pluto ALICE instrument flying on board the New Horizons spacecraft. (The Pluto ALICE design, in turn, is based largely on the design of the Rosetta ALICE instrument.) LAMP consists of a telescope, a Rowland-circle spectrograph, and an electronics section; it also includes an extended forward light baffle, a pair of Lunar Terminator Sensors (LTS), and a thermal radiator. The telescope mirror collects incoming light that passes through the entrance aperture at the front end of the instrument and directs it towards the entrance slit of the Rowland-circle imaging spectrograph. The spectrograph contains a reflective holographic diffraction grating and a UV-sensitive, solar-blind, 2-D open-structure microchannel plate detector located on the Rowland circle. The command and data handling (C&DH) and detector electronics section is located directly behind the spectrograph section next to the detector. LAMP has a passband of 57.5-196.5 nm and a pixel format of 1024 spectral by 32 spatial pixels.

The detector system outputs to the C&DH electronics the pixel location for each detected photon event, a location consisting of a spectral and a spatial coordinate. The first (x) dimension provides the spectral location of the detected photon and the second (y) dimension provides one-dimensional spatial information. The events are processed by its own C&DH electronics. The C&DH is also the controller of the LAMP instrument; it receives commands from the spacecraft, acquires data from the MCP detector system, and returns telemetry to the spacecraft. Science data generation is performed by the detector hardware, but the C&DH also controls this function.

The LAMP instrument has two acquisition modes in which the spectral/spatial data from the detector are processed by the C&DH subsystem. The main LAMP data acquisition mode is the *pixel list* acquisition mode. In this mode the instrument stores photon event data as they arrive from the detector system. In order to provide timing information, "time hacks" are inserted into the data stream at a programmable interval between 4 and 512 msec. In addition, LAMP provides a *histogram* acquisition mode. This mode is mainly used for calibration acquisition operations and allows for long integrations to obtain observations of faint sources with high signal-to-noise ratios. In histogram acquisition mode, the detector accumulates the number of events that are occurring at each of the 1024 x 32 pixel "locations" provided by the detector electronics over a period of time.

The LTS has been added to protect the highly-sensitive LAMP instrument from observing the relatively bright daylit regions of the Moon with the aperture door open, either by lowering the detector high voltage or closing the aperture door. The design of the LTS uses redundant Si PN photodiode detectors and amplifier electronics which are fed by an externally mounted mechanical collimator that oversamples the LAMP field of view. The LTS field of view is 1° x 10° for both a "forward" photodiode (parallel to the LAMP slit but canted at 1.5° ahead of the track of the LAMP boresight) and an "aft" photodiode

(parallel to the LAMP slit but canted 1.5° behind the track of the LAMP boresight). When both sensors are operating simultaneously, the signal from these two diodes are each differenced at a 10-Hz rate with “dark” photodiodes (to correct for temperature effects) and combined (in a programmable way) to provide LAMP’s response to the crossing of the terminator (from day to night or vice versa). LAMP can also operate with only a single working LTS. In fact, this will be the standard mode of operation when only a single LVPS is being used. Depending on the orientation of the LRO spacecraft, the forward and aft LTS photodiodes will switch roles several times during the mission. The LAMP aperture door has a small (1.0 mm diameter) hole in it which allows dayside observations at about the same count rate with the door closed as are observed on the night side when the aperture door is open. The LRO mission plan calls for using the LTS to lower and raise the detector high voltage until minimum LAMP experiment objectives are met, then using the LTS to close and open the aperture door to allow continuous LAMP day and night side observations for the remainder of the mission.

4.2 Data Product Overview

The source of the data contained in the LAMP Pipeline RDR data product is the LAMP EDR data product, produced in an earlier stage (nicknamed “Lima”) of the data processing pipeline from files received from the LRO MOC containing, respectively, the LAMP instrument low-speed housekeeping telemetry and the LAMP science data. These files are delivered from the MOC on a nominal basis of one file of each type per orbit. The LAMP EDR data product combines these file pairs, also on a one file per orbit basis. The next step (nicknamed “Mike”) in the LAMP data processing pipeline calibrates and spatially locates the data contained in the EDR data product. The resulting Pipeline RDR data product contains the following ten types of data:

1. **Calibrated Spectral Image (Aperture Door Open):** This is a reconstructed histogram generated from the pixel list data in the EDR data product but with instrumental calibrations applied. Only the pixel list data acquired when the aperture door was open are included in this dataset. If the aperture door state is unavailable (i.e., housekeeping data are unavailable), all calibrated pixel list data are included in this histogram. If the EDR data product contains only data acquired with LAMP operating in histogram mode, this dataset will contain a copy of the first histogram image but with instrumental calibrations applied. This summary image is used as a “quick-look” check on data quality. [Extension 0 = primary FITS header and data unit (HDU)]
2. **Calibrated Spectral Image (Aperture Door Closed):** This is similar to the first dataset, but the reconstructed histogram here is generated from pixel list data acquired when the aperture door was closed. If housekeeping data are unavailable, this dataset will be empty. If the EDR data product contains only data acquired in histogram mode, this dataset will contain a copy of the second histogram image with instrumental calibrations applied. This summary image is used as a “quick-look” check on data quality. [Extension 1]
3. **Acquisition List:** This dataset contains a list of the generated frame acquisitions as determined from the housekeeping data file. The list includes, for each frame, the instrument frame sequence number, start and stop times, mode type, aperture door and other instrument state information. These data are simply copied as is from the EDR data product. The frame acquisition times and instrument state data contained in this list are used to cross-reference with the pixel list mode data in Extension 3 for purposes of selecting data and checking timing consistency. [Extension 2]
4. **Calibrated Pixel List Mode Data:** This dataset contains a calibrated version of the complete pixel list science dataset from the EDR data product, plus propagated estimated errors introduced by the separate calibration steps, plus ancillary spatial location and pointing information that is needed on a per-photon basis. If the input EDR data product contains only histogram data, then

this extension will be empty. These are the primary science data for use in making maps and other pixel list derived science products. [Extension 3]

5. Ancillary Data: This dataset contains ancillary spatial location and pointing information that varies smoothly and slowly over the LRO orbit. Also included in this extension are other slowly varying instrument-related quantities such as the detector locations of the STIM pixels, a measure of the background dark signal, and data quality flags. Entries in this table are typically separated by one-minute intervals instead of on a per-photon basis in order to reduce data volume and computation time. [Extension 4]
6. Calibrated Histogram Mode Data: This dataset contains a calibrated version of the complete histogram science dataset from the EDR data product, plus propagated estimated errors introduced by the separate calibration steps. If there are N histogram mode spectral images in the input EDR data product, this extension will consist of a stacked image cube containing 2N total images (i.e., N data + error image pairs). If N is greater than 1, then the Acquisition List (Extension 2) will be used to time-order the data + error image pairs within the image cube, from earliest to latest. If the input EDR data product contains only pixel list data, which will normally be true, then this extension will be empty. [Extension 5]
7. Calibrated Calculated Count Rate: This dataset contains a high-resolution sequence of UV photon count rates computed from the calibrated pixel list data for each acquisition (nominally the whole orbit). The resolution of this count rate sequence depends on the commanded “hack time” interval. If no pixel list science data are available, e.g., if data are acquired only in histogram mode, then this dataset will be empty. (The lower-resolution [1 Hz] count rate data are available in all cases in the housekeeping [Extension 8] dataset.) This sequence will be used to assess the variation in bulk far-UV signal throughout the orbit, and may be especially useful when trending data obtained near the terminator or during exceptional events (e.g., solar flares). [Extension 6]
8. LTS Data: LAMP housekeeping data contain up to 10 values per second of gain and offset corrected measurement values from each of the two LAMP Lunar Terminator Sensors (LTS). This dataset provides the full 10-Hz LTS dataset. These data are simply copied as is from the EDR data product. These coincident LTS data will be used with the count rate sequence in Extension 6 to confirm that LAMP is viewing the appropriate day/night/shadow scenes. (Raw 14-bit LTS data sampled at the 1-Hz HK rate is included together with this 10-Hz gain and offset corrected LTS dataset in the housekeeping data Extension 8.) [Extension 7]
9. Housekeeping Data: This dataset contains the complete housekeeping dataset, both in raw format and, where applicable, in calibrated engineering units. These data are simply copied as is from the EDR data product. HK data are included here to assist with joint instrument and data quality trending analyses (foreseen and unforeseen). [Extension 8]
10. Wavelength Lookup Image: This dataset contains a 1024 x 32 image whose floating-point pixel values are the wavelengths corresponding to the pixel locations on the detector. This wavelength calibration image is provided to be used with Extensions 0 and 1 for quick-look checks, but **not** for scientific analysis. Its file-averaged wavelength solution makes it generally unsuitable to be used with pixel list data. [Extension 9]

Detailed specifications for the LAMP Pipeline RDR data product can be found in Section 5 and Appendix A of this document.

4.3 Data Processing

Data format is described in Section 5, Detailed Data Product Specifications. Data volume will vary somewhat because it is a function of the UV photon detection rate and the instrument mode. In the nominal case, the raw LAMP low-speed housekeeping telemetry data file will consist of one 128-byte packet per second for the duration of the approximately 113-minute LRO orbit (~6780 packets), plus a 64-byte file header. The raw LAMP science data file will consist of a number of instrument-generated 65536-byte frames, each preceded by a 6-byte acquisition (completion) time field, plus a 64-byte file header. As mentioned above, the exact number of science data frames will vary from file to file. When operated in nominal pixel list mode with a 4-msec hack rate, LAMP is expected to generate approximately 285 data frames per orbit when taking data over the entire orbit. Each EDR data product file generated is expected to average around 21.5 MB. The additional data added to the Pipeline RDR data product file is expected to increase the size of each file by about a factor of 20 compared to the input EDR file. Thus, each Pipeline RDR file will be of the order of 400 MB in size.

4.3.1 Data Processing Level

The LAMP Pipeline RDR data product contains calibrated UV photon detections/spectra and associated data corresponding to CODMAC Level 3 (see Appendix D).

4.3.2 Data Product Generation

In the nominal operational sequence, the LAMP instrument will generate one low-speed telemetry file and one science data file for each orbit. Once per day these LAMP-generated files will be retrieved from the spacecraft by the LRO MOC and then transferred by the MOC to the primary LAMP SOC pipeline computer. The LAMP SOC pipeline “executive” program will execute once per day and detect the newly delivered data files. After cataloging the received files, the “executive” program will initiate execution of the LAMP SOC data processing pipeline. The first element of the pipeline (“Lima”) will be responsible for converting the data files received from the MOC into the EDR data products. The second element of the pipeline (“Mike”) will be responsible for applying instrumental calibrations to the science data and spatially locating the data with the help of input SPICE kernels, ultimately creating the Pipeline RDR data products whose format is described in this document. Multiple versions of the output Pipeline RDR products may be made available if software bugs affecting the output data are uncovered and corrected. In the event of an error whose correction alters released data, the data will be reprocessed by the revised software and made available.

4.3.3 Data Flow

The immediate source of the data contained in each LAMP Pipeline RDR data product will be the LAMP EDR data product as well as auxiliary spacecraft housekeeping data, attitude and geometric information from SPICE kernels, and instrument calibration files. The original sources of the instrument data are, of course, the science and housekeeping files generated by the LAMP instrument itself. As mentioned above, these instrument-generated data files will be retrieved from the LRO spacecraft by the LRO MOC and then transferred to the LAMP SOC for further processing. The details of this latter transfer mechanism are described in [5]. After the LAMP Pipeline RDR data products are produced by the LAMP SOC, they will be archived (see [11]) and transferred to the PDS Imaging Node for permanent storage and public access. The details of this transfer mechanism are described in [6]. The LAMP Pipeline RDR data products will be delivered to the PDS Imaging Node in sequential data releases at three-month intervals as specified in Table 3 of [4].

As mentioned above, the input EDR data product files will have an average size of about 21.5 MB per orbit. Including the supplemental data added to each LAMP Pipeline RDR data product, and allowing for approximately 12.75 orbits per day, the total daily volume of LAMP Pipeline RDR data products produced will be approximately 5.5 GB. Over the 365 days of the nominal LRO mission, total Pipeline RDR data product volume will be approximately 2000 GB (2 TB).

4.3.4 Data Processing Steps

In order to create the Pipeline RDR data product, the “Mike” part of the LAMP pipeline will apply two primary types of conversions to the EDR data product: (1) instrumental corrections and calibrations, and (2) spatial location determination. In general, six different types of instrumental corrections and calibrations will be performed:

1. Deadtime correction – this accounts for the fact that the LAMP MCP detector is insensitive to the detection of new UV photons for a short period of time following a previous detection, and this deadtime effect typically increases with increasing flux;
2. Dark count correction/characterization – this is done because the LAMP MCP detector will generate some very low level of events in the complete absence of UV illumination. Thus, these spurious detections need to be subtracted out in order to get a better estimate of the true flux of UV photons;
3. Flatfield normalization – this is performed to account for variations in sensitivity across the LAMP MCP detector in the spatial dimension;
4. Effective area normalization – this is performed to account for the fact that the effective area (i.e., the sensitivity) of the LAMP instrument aperture is wavelength dependent; and
5. Wavelength lookup image – this is created in order to specify the UV wavelength associated with each pixel of the detector.
6. Stray light correction – this correction accounts for instrument scattered light outside of the viewing scene contaminating the observation. An estimated signal level is subtracted, e.g., based on proximity to the terminator and/or known sunlit peaks when viewing the night side. This estimation will be developed either from a detailed instrument simulator or analytical assessment of the collection of contaminated datasets (if any). The reliability of the scattered light estimation method requires in flight commissioning and/or science data and further demonstration; we might treat this effect by setting larger estimated (systematic) errors instead if this method proves unreliable. We may leave this effect untreated if the scattered light is shown to be negligible.

The deadtime, flatfield and effective area corrections and calibrations will result in a weighting factor to be applied to each detected UV photon. The end result will be that each detected photon will represent a number of “actual” photons that is slightly different than unity. For pixel list mode data, the dark count subtraction will be performed later when the photons are integrated into the CODMAC Level 5 UV map products. To facilitate this process, a measure of the dark signal as a function of time will be calculated and stored in the Ancillary Data table (Extension 4) of the Pipeline RDR data product. The calculation of instrument pointing and the spatial location of the origin of the detected UV photons will be performed using SPICE kernels and SPICE toolkit software.

4.3.5 Labeling and Identification

The dataset ID provided by the PDS for the LAMP Pipeline RDR data product is:

LRO-L-LAMP-3-RDR-V1.0

The version number is incremented should the entire Pipeline RDR dataset be revised.

The file naming convention for LAMP Pipeline RDR data files is LAMP_SCI_nnnnnnnnnn_vv.FIT. The ten-digit nnnnnnnnnn value will be a time stamp value, namely the Spacecraft UT (SCUT) of the start of the file. The two-digit vv value will be a version number to facilitate unique identification of (possibly reprocessed) Pipeline RDR data files. The .FIT extension indicates that the Pipeline RDR data files will be in FITS format. Each Pipeline RDR file will have a detached PDS label in a separate file of the same name, but with extension .LBL. The label file is stored in the same directory as the FITS data file that it describes.

4.4 Standards Used in Generating Data Products

4.4.1 PDS Standards

The LAMP Pipeline RDR data product complies with Planetary Data System standards for file formats and labels, as specified in the PDS Standards Reference [1].

4.4.2 Time Standards

Each LAMP housekeeping and science data file that is received from the LRO MOC contains a 64-byte header specifying, among other things, the SCUT (Spacecraft Universal Time) when the file was opened for writing and when the file was closed. SCUT is measured in seconds and fractional seconds elapsed since the epoch of the LRO mission timeline, 00:00 UTC January 1, 2001. Within the LAMP housekeeping dataset, each packet is stamped with the instrument time when the packet was generated. Instrument time will nominally be synchronized to SCUT as sent to LAMP by means of the time synchronization message. Within the science dataset, the SCUT for the start and stop times of a given data acquisition are determined by correlation with the housekeeping data. For data taken in histogram mode, there is no finer time resolution available. For data taken in pixel list mode, “time hacks” are inserted into the UV photon event data stream at a command-modifiable interval of between 4 msec and 512 msec. The nominal time hack interval is planned to be the minimum of 4 msec in order to provide for highest possible time resolution for the data taken in pixel list mode, the nominal operational mode for LAMP. Finally, while it is possible to convert SCUT to UTC using the NAIF SPICE toolkit and the appropriate LRO SPICE SCLK clock correlation file, it is not currently planned to include SCUT conversions to UTC in the LAMP Pipeline RDR data product.

4.4.3 Coordinate Systems

Lunar Reconnaissance Orbiter (LRO) reduced data record (RDR) data use lunar planetocentric/body-fixed coordinates with east-positive longitude from 0 to 360 degrees. A mean Earth/polar axis (ME) reference system (also called the mean Earth/rotation system) is used, with the z axis being the mean rotational pole and with the prime meridian (zero degrees longitude) defined by the mean Earth direction.

The ME reference system is used for all LRO archival data. This LRO standard is documented in [12]. Using coordinates in the ME system is consistent with recommendations from the International Astronomical Union (IAU)/International Association of Geodesy (IAG) Working Group on Cartographic Coordinates and Rotational Elements.

A Jet Propulsion Laboratory (JPL) planetary and lunar ephemeris and corresponding Euler angle set are used to define an ME frame to which the LRO data are registered. The LRO Data Working Group (LDWG) determines which ephemeris and Euler angle set should be used. Alternatively, LRO data can be registered to an existing or new reference frame in the ME system, via ties to surface points known in

the frame (examples include Lunar Laser Ranging (LLR) retroreflectors, points in images and Digital Elevation Models).

When a JPL planetary and lunar ephemeris is used, the JPL Navigation and Ancillary Information Facility (NAIF) provides the necessary lunar ephemeris file (SPK) and binary lunar orientation file (PCK) in a Principal Axes (PA) reference frame for use with the SPICE Toolkit. NAIF also provides the frames kernel (FK) used for accessing the PA orientation in the PCK and for transforming from the PA frame to the ME frame.

Alternatively, the JPL lunar ephemeris information is available in an ASCII format not requiring the use of the SPICE Toolkit. This information is available from a JPL website: <http://ssd.jpl.nasa.gov>.

4.4.4 Data Storage Conventions

The LAMP Pipeline RDR data product complies with the FITS standard for file formats and data storage conventions, as specified in the Definition of the Flexible Image Transport System (FITS) [8].

4.5 Data Validation

LAMP Pipeline RDR data products will be validated by the LAMP Team for science content and for compliance with PDS archive standards [1]. Further details on this validation can be found in [3] and [4].

5. DETAILED DATA PRODUCT SPECIFICATIONS

The LAMP Pipeline RDR data products shall be grouped into directories with one directory per flight day. Flight day is defined to be midnight-to-midnight UTC. Within each directory shall be labels containing pointers to the corresponding individual data products.

5.1 Data Product Structure and Organization

In the DATA directory of the Pipeline RDR archive, data for each flight day will be in a subdirectory named in the format YYYYDDD, indicating the year and day of year for the date of the start of data acquisition.

5.2 Data Format Descriptions

The ten types of data included in the LAMP Pipeline RDR data product are listed in Section 4.2. All of these data are stored in a single FITS file with a detached PDS label. Each data type within the FITS file is stored in a separate HDU (Header and Data Unit). The first two data types (quick-look spectral images), the sixth data type (calibrated histogram mode data) and the tenth data type (wavelength lookup image) will be stored as FITS images within their HDUs. The acquisition list will be stored as a FITS ASCII table. The remaining data types will be stored as FITS binary tables. A detailed listing of the proposed FITS format of the LAMP Pipeline RDR data product is given in Appendix A.

Finally, we present a few more words of explanation about the LTS data (Extension 5). All downlinked LTS data are included in the LAMP housekeeping packet. These consist of two separate data types that are generated and collected by the instrument:

1. Raw LTS data consisting of 14-bit values (0-16383 counts) at a rate of one value per LTS per housekeeping packet. The instrument collects these 14-bit raw values at a rate of 10 Hz, but only the one most recent value (i.e., the last in the previous series of ~10 samples) is reported in the HK packet for each LTS.

2. Corrected LTS data, i.e., gain and offset corrected onboard, consisting of 8-bit values (0-255), generated at a rate of 10 Hz. All such values for each LTS from the previous second (up to 10 values each) are collected and reported in the HK packet.

The 14-bit raw LTS values are gain and offset corrected into 8-bit values onboard, separately for each LTS. These values are used for the LTS light/dark function control of the aperture door. The corrected LTS data are reordered and provided in Extension 5 of the EDR FITS file for convenience as the final “LTS Data” product, which is then used to verify that the proper threshold values are selected. The raw and corrected LTS data in Extension 6 (“Housekeeping Data”) are used to verify correct operation of the LTS, but remain within the inconvenient housekeeping packets (e.g., the time hack clock and spacecraft clock must first be synchronized during extraction from the packets).

5.3 Label and Header Descriptions

Each LAMP Pipeline RDR data file is described by a PDS label in a separate file with the same root name, but with the extension “.LBL”. The label file is stored in the same directory as the FITS data file that it describes. The contents of the PDS label file are derived in part from the FITS header information contained in the HDU headers of the data file itself.

The data files themselves do not contain any embedded PDS headers, but do contain FITS headers according to the FITS standard [8].

Examples of LAMP Pipeline RDR PDS labels can be found in Appendices E and F to this document. An example of the FITS header is given in Appendix A.

6. APPLICABLE SOFTWARE

The format of the LAMP Pipeline RDR data product is standard FITS. There are a number of different software libraries available that enable the reading and writing of standard FITS files. These libraries are written in a number of different languages and are available for a variety of different computing platforms. A list of these libraries can be found at the FITS Support Office web site (<http://fits.gsfc.nasa.gov/>). Commonly used FITS libraries include the IDL Astronomy Library (<http://idlastro.gsfc.nasa.gov/fitsio.html>) and the CFITSIO/FITSIO library (<http://heasarc.gsfc.nasa.gov/docs/software/fitsio/fitsio.html>). For this reason, no additional special software will be included in the Pipeline RDR archive to parse and interpret the data files.

6.1 Utility Programs

No utility programs are planned at this time. However, they may be included in future revisions.

6.2 Applicable PDS Software Tools

PDS archive products should be able to be displayed with the program NASAVIEW, developed by the PDS and available free of charge for a variety of computer platforms from the PDS web site (http://pds.jpl.nasa.gov/tools/software_download.cfm).

6.3 Software Distribution and Update Procedures

Any developed software specific to LAMP Pipeline RDR data products will be distributed with the Pipeline RDR archive. Version numbers and a CHANGELOG document will describe updates. At this time, however, no need for any such software is anticipated.

APPENDIX A – DETAILED LAMP PIPELINE RDR FITS FILE SPECIFICATIONS

For each of the FITS HDUs described in Section 4.2 of this document, this Appendix lists and describes the specific header keywords and provides details on the format and layout of the data. Values followed by an asterisk (*) are variable on a per-file basis and are examples only.

FITS Header Keyword	Value	Description
FITS File Header	Primary HDU	
SIMPLE	T	conforms to FITS standard
BITPIX	-32	array data type
NAXIS	2	number of array dimensions
NAXIS1	1024	number of spectral channels
NAXIS2	32	number of spatial channels
EXTEND	T	FITS extensions present
BZERO	0	no offset
BSCALE	1	default scaling factor
COMMENT	Mission Data	
MISSION	'LRO'	Mission: Lunar Reconnaissance Orbiter
HOSTNAME	'LRO'	Host name (PDS terminology)
INSTRUME	'LAMP'	Instrument: Lyman Alpha Mapping Project
FILETIME	'2008-02-14T19:12:46' (*)	Time file was created by SOC
SL1PROC	'LAMP-LIMA'	SOC pipeline level 1 software
SL1VER	'0.08'	SOC pipeline level 1 software version
SL1DATE	'2008-02-14'	SOC pipeline level 1 software date
TARGET	'MOON'	Target object
ORIGIN	'SwRI'	Southwest Research Institute (R)
COMMENT	Input (Source) Data	
HKFILNAM	'LAMP000028.hk' (*)	HK data file name/ident, from HK data file header, empty if none
HKSTRSEC	223940575.900 (*)	HK data file start time (SCUT, sec)
HKENDSEC	223940846.375 (*)	HK data file stop time (SCUT, sec)
HKSTRTIM	'2008-02-05T21:42:55.900' (*)	HK data file start time (UTC)
HKENDTIM	'2008-02-05T21:47:26.375' (*)	HK data file stop time (UTC)
SCFILNAM	'LAMP000028.sci' (*)	Sci data file name/ident, from Science data file header, empty if none
SCSTRSEC	223940575.900 (*)	Sci data file start time (SCUT, sec)
SCENDSEC	223940846.375 (*)	Sci data file stop time (SCUT, sec)
SCSTRTIM	'2008-02-05T21:42:55.900' (*)	Sci data file start time (UTC)
SCENDTIM	'2008-02-05T21:47:26.375' (*)	Sci data file stop time (UTC)
PIXONLY	True/False	Flag indicating science file with only pixellist data
HISONLY	True/False	Flag indicating science file with only histogram data
COMMENT	General Hk Overview	
PACKETS	270 (*)	Total number of housekeeping packets
HKGAPS	True/False	Gaps in HK packet stream

FITS Header Keyword	Value	Description
HWVERS	FM, LIIS-1, LIIS-2	Instrument H/W version/platform
SWVERS	1.00	Instrument flight software version
SWCHECK	'0xefd6'	Instrument flight software checksum
LVPSTAT	A / B / Both	LVP status
TEMPSFTY	Active, None	Temperature Safety
ANODSFTY	Active, None	Anode Safety
STRPSFTY	Active, None	Strip Safety
HVSFTY	Active, None	HV Safety
BRTSFTY	Active, None	Bright Safety
CYCLSFTY	Active, None	Cycle Safety
LASTSFTY	Last Safety Temp, Anode, Strip, HV, Bright, Cycle, none	Last active safety
HACKCLCK	0.004000118522 (*)	Instrument actual hack clock
HACKOFFS	223940340.338 (*)	Instrument hack clock offset
HACKCORR	0.953617 (*)	Instrument hack clock correlation
COMMENT	HVPS Hk Overview	
HVPSTAT	A / B / Both / None	HVPS status
HVLTCTL	Day / Night / Var	HVPS LTS control
HVSETMIN	-4.946 (*)	Maximum HV set voltage (kVolt)
HVSETMAX	-4.946 (*)	Minimum HV set voltage (kVolt)
MCPV1MIN	-4.949 (*)	Maximum MCP Voltage 1 (kVolt)
MCPV1MAX	-4.949 (*)	Minimum MCP Voltage 1 (kVolt)
STPI1MIN	14.30 (*)	Minimum Strip Current 1 (uA)
STPI1MAX	14.30 (*)	Maximum Strip Current 1 (uA)
ANOV1MIN	-608 (*)	Maximum Anode Voltage 1 (kVolt)
ANOV1MAX	-605 (*)	Minimum Anode Voltage 1 (kVolt)
MCPV2MIN	-4.978 (*)	Maximum MCP Voltage 2 (kVolt)
MCPV2MAX	-4.978 (*)	Minimum MCP Voltage 2 (kVolt)
STPI2MIN	3.78 (*)	Minimum Strip Voltage 2 (uA)
STPI2MAX	3.90 (*)	Maximum Strip Voltage 2 (uA)
ANOV2MIN	-605 (*)	Maximum Anode Voltage 2 (kVolt)
ANOV2MAX	-605 (*)	Minimum Anode Voltage 2 (kVolt)
HVOPSLVL	-4.946 (*)	Operational HV Level (kVolt)
COMMENT	Detector Hk Overview	
MINDISC	1.05 (*)	minimum discriminator voltage (Volt)
MAXDISC	1.05 (*)	maximum discriminator voltage (Volt)
EVCNTLO	9588447 (*)	Lowest value of 24-bit HW event counter
EVCNTHI	11374542 (*)	Highest value of 24-bit HW event counter
EVCOUNTS	1792896 (*)	Total event counts during the orbit (mod 2 ²⁴)
MINCNTR	6419 (*)	minimum countrate (Hz)
AVRCNTR	6640.4 (*)	average countrate (Hz)
MAXCNTR	6862 (*)	maximum countrate (Hz)
APDOOR	open / close / variable	Aperture door status during whole orbit
COMMENT	Temperature Hk Status	
MINCDHT	25.6 (*)	minimum C&DH temperature (degC)

FITS Header Keyword	Value	Description
AVRCDHT	25.6 (*)	average C&DH temperature (degC)
MAXCDHT	25.6 (*)	maximum C&DH temperature (degC)
MINDETHT	22.3 (*)	minimum detector temperature (degC)
AVRDETHT	22.3 (*)	average detector temperature (degC)
MAXDETHT	22.3 (*)	maximum detector temperature (degC)
MINMIRAT	22.7 (*)	minimum Mirror A temperature (degC)
AVRMIRAT	22.7 (*)	average Mirror A temperature (degC)
MAXMIRAT	22.7 (*)	maximum Mirror A temperature (degC)
MINMIRBT	22.7 (*)	minimum Mirror B temperature (degC)
AVRMIRBT	22.7 (*)	average Mirror B temperature (degC)
MAXMIRBT	22.7 (*)	maximum Mirror B temperature (degC)
MINGRTAT	21.6 (*)	minimum Grating A temperature (degC)
AVRGRTAT	21.6 (*)	average Grating A temperature (degC)
MAXGRTAT	21.6 (*)	maximum Grating A temp (degC)
MINGRTBT	21.6 (*)	minimum Grating B temperature (degC)
AVRGRTBT	21.6 (*)	average Grating B temperature (degC)
MAXGRTBT	21.6 (*)	maximum Grating B temp (degC)
MIRHTRST	On, Off, Variable	Mirror heaters status
GRTHTRST	On, Off, Variable	Grating heaters status
DETDOOR	Open, Close, Variable	Detector door status
COMMENT	Spectral Image Door open status	
DOEVTN	1215913 (*)	Door Open events in the histogram
DOTIME	199.974 (*)	Total Door Open time (sec)
DOSOURCE	'histo' / 'ground'	Source of the histogram information Histogram (on-board) or Ground (Pixellist)
DOMAXCNT	10235 (*)	Maximum count in the door open histogram
DOMINCNT	0 (*)	Minimum count in the door open histogram
DOMAXCR	6862 (*)	Door open histogram maximum countrate (Hz)
DOMINCR	6419 (*)	Door open histogram minimum countrate (Hz)
DOPATTRN	data, inc hi, inc lo, dec hi, dec lo, const	Data or test pattern in the door open histogram dataset
DOLTS	Day, Night, Var	Door open histogram LTS status
DOSTIMS	Off, Stim, Var	STIM status for the door open dataset
DOHVPS	A, B, Both, None, Variable	HVPS commanded status for the

FITS Header Keyword	Value	Description
		door open dataset
COMMENT	LAMP Level 2 (CODMAC Level 3) processing information	
SL2PROC	'LAMP-MIKE'	SOC pipeline level 2 software
SL2VER	'0.001'	SOC pipeline level 2 software version
SL2DATE	'2008-02-24'	SOC pipeline level 2 software date
FILE_IN	'LAMP_ENG_0223940575_00.FIT'	Input file for processing
FILE_OUT	'LAMP_SCI_0223940575_00.FIT'	Output file after processing
DIR_CAL	'cal/'	Directory for calibration data
BADFILE	"	File containing bad pixel mask
BADFLAG	F	Bad pixel mask applied to data
BADVALUE	'IEEE NaN'	Bad pixel value
DEADFLAG	T	Dead-time correction applied
DARKFILE	'LAMP_DARK_001.FIT'	Detector dark count rate file
DARKFLAG	T	Dark count correction applied
FLATFILE	'LAMP_FLAT_001.FIT'	Detector flatfield file
FLATFLAG	F	Flatfield correction applied
WAVEPRO	'lamp_mike_wavecald.pro'	IDL wavelength calibration procedure
WAVEFLAG	T	Wavelength calibration performed
AEFFFILE	'LAMP_AEFF_001.TAB'	Detector effective area file
AEFFFLAG	T	Effective area correction applied
RECTFLAG	F	Wavelength rectification applied
LOG_FILE	'LAMP_SCI_0223940575_00.LOG'	LAMP-MIKE processing logfile
MIKE_ERR	0	Exit status of LAMP-MIKE
COMMENT	SPICE files used in geometry calculations	
NUMBSPCK	13	Number of loaded SPICE kernels
SPCK0001	'FDF29_2009008_2009015_N01.BSP'	SPICE kernel 0001
SPCK0002	'FDF36_2009015_2009022_N01.BSP'	SPICE kernel 0002
SPCK0003	'LRO_CLKCOR_2009015_V00.TCS'	SPICE kernel 0003
SPCK0004	'LRO_EVENTS_2009015_2009022_V01.TEN'	SPICE kernel 0004
SPCK0005	'LRO_FRAMES_2009015_V01.TF'	SPICE kernel 0005
SPCK0006	'MOC42_2009015_2009042_N01.BC'	SPICE kernel 0006
SPCK0007	'MOC43_2009015_2009042_N01.BC'	SPICE kernel 0007
SPCK0008	'MOC44_2009015_2009042_N01.BC'	SPICE kernel 0008
SPCK0009	'DE418.BSP'	SPICE kernel 0009
SPCK0010	'NAIF0008.TLS'	SPICE kernel 0010
SPCK0011	'MOON_PA_DE403_1950-2198.BPC'	SPICE kernel 0011
SPCK0012	'PCK00008.TPC'	SPICE kernel 0012
SPCK0013	'MOON_060721.TF'	SPICE kernel 0013
END		
Primary HDU Data	Calibrated Spectral Image Door Open	2-D array 1024x32 of 32 bit event counts (calibrated)
XTENSION	'IMAGE'	Extension 1, Spectral Image Door Closed
BITPIX	-32	array data type, 32 bit words
NAXIS	2	number of array dimensions
NAXIS1	1024	number of spectral channels

FITS Header Keyword	Value	Description
NAXIS2	32	number of spatial channels
BZERO	0	no offset
BSCALE	1	default scaling factor
PCOUNT	0	extension size parameter
GCOUNT	1	extension size parameter
EXTNAME	'Calibrated Door Closed Spectral Image'	Extension name
EXTVER	1	Extension version number
COMMENT	Spectral Image Door closed status	
DCEVTN	0 (*)	Door closed events in the histogram
DCTIME	0.000 (*)	Total Door closed acquisition time (sec)
DCSOURCE	HISTO / GROUND	Source of the histogram information Histogram (on-board) or Ground (Pixellist)
DCMAXCNT	0 (*)	Maximum count in door closed histogram
DCMINCNT	0 (*)	Minimum count in door closed histogram
DCMAXCR	0 (*)	Door closed histogram maximum countrate (Hz)
DCMINCR	-1 (*)	Door closed histogram minimum countrate (Hz)
DCPATTRN	data, inc hi, inc lo, dec hi, dec lo, const	Data or test pattern in the door open histogram dataset
DCLTS	Day, Night, Var	Door closed histogram LTS status
DCSTIMS	ON, OFF, Variable	STIM status for the door open dataset
DCHVPS	A, B, Both, None, Variable	HVPS commanded status for the door open dataset
END		
Extension 1 HDU Data	Calibrated Spectral Image Door Closed	1024 x 32 array of 32 bit event counts (calibrated)
XTENSION	'TABLE'	Extension 2, Acquisition List
BITPIX	8	array data type, 8-bit ASCII characters
NAXIS	2	number of array dimensions
NAXIS1	64	number of characters per line
NAXIS2	38 (*)	number of acquisitions
PCOUNT	0	extension size parameter
GCOUNT	1	extension size parameter
TFIELDS	12	Number of element fields per line
EXTNAME	'Acquisition List (HK)'	Acquisition/frames list
EXTVER	1	Extension version number
TFORM1	'D14.3'	Format of field 1
TFORM2	'D14.3'	Format of field 2
TFORM3	'I5'	Format of field 3
TFORM4	'I1'	Format of field 4
TFORM5	'I4'	Format of field 5

FITS Header Keyword	Value	Description
TFORM6	'I1'	Format of field 6
TFORM7	'I1'	Format of field 7
TFORM8	'I1'	Format of field 8
TFORM9	'I1'	Format of field 9
TFORM10	'I1'	Format of field 10
TFORM11	'I2'	Format of field 11
TFORM12	'I8'	Format of field 12
TBCOL1	1	Start column for field 1
TBCOL2	16	Start column for field 2
TBCOL3	31	Start column for field 3
TBCOL4	37	Start column for field 4
TBCOL5	39	Start column for field 5
TBCOL6	44	Start column for field 6
TBCOL7	46	Start column for field 7
TBCOL8	48	Start column for field 8
TBCOL9	50	Start column for field 9
TBCOL10	52	Start column for field 10
TBCOL11	54	Start column for field 11
TBCOL12	57	Start column for field 12
TTYPE1	'START_TIME'	Start time of acquisition (sec since 1/1/2001)
TTYPE2	'STOP_TIME'	Stop time of acquisition (sec since 1/1/2001)
TTYPE3	'SCI_HDR'	Science frame header from HK stream
TTYPE4	'ACQ_MODE'	Acquisition type (0=pixel, 1=histo)
TTYPE5	'FRAME_NO'	Frame number (0-4095)
TTYPE6	'APD_STATE'	Aperture door state (1=error, 2=closed, 3=open, 4=between, 5=variable)
TTYPE7	'LTS_STATE'	LTS state (1=day, 2=dark, 5=variable)
TTYPE8	'STIM_STATE'	STIM state (1=off, 2=on, 5=variable)
TTYPE9	'HVPS_STATE'	HVPS state (1=off, 2=A, 3=B, 4=both, 5=variable)
TTYPE10	'HACK_RATE'	Hack rate (0=N/A, 1=4 msec, 2=8 msec, ..., 8=512 msec)
TTYPE11	'FR_PATTERN'	Data pattern (0=data, 1=no frame, 2=test pattern)
TTYPE12	'CHECKSUM'	Frame data checksum (3 bytes)
TUNIT1	'sec'	Unit for SCUT
TUNIT2	'sec'	Unit for SCUT
COMMENT		
NHKACQS	38 (*)	number of acquisitions reported in housekeeping data
CONACQS	True / False	true if all the acquisitions in this extension are continuous
FACQSTA	223940640.795 (*)	first acquisition start time
LACQEND	223940840.795 (*)	last acquisition end time

FITS Header Keyword	Value	Description
PIXONLY	true / false	pixellist acquisitions only in this file
HISONLY	true / false	histogram acquisitions only in this file
END		
Extension 2 HDU Data	Acquisition List	ASCII Data Table with number of entries matching number of acquisitions, empty if no acquisitions reported in housekeeping data
XTENSION	'BINTABLE'	Extension 3, Calibrated Pixellist Mode Data
BITPIX	8	array data type, 8-bit bytes
NAXIS	2	number of array dimensions
NAXIS1	87	number of bytes per frame
NAXIS2	1000 (*)	number of detected photons
PCOUNT	0	extension size parameter
GCOUNT	1	extension size parameter
TFIELDS	23	Number of element fields per line
EXTNAME	'Calibrated Pixel List Mode Data'	Extension name
EXTVER	1	Extension version number
TFORM1	'1J'	Column 1 format
TTYPE1	'HACK_TIME'	Label for column 1
TFORM2	'1I'	Column 2 format
TTYPE2	'DETECTOR_X'	Label for column 2
TFORM3	'1I'	Column 3 format
TTYPE3	'DETECTOR_Y'	Label for column 3
TFORM4	'1I'	Column 4 format
TTYPE4	'SPATIAL_ROW'	Label for column 4
TFORM5	'1E'	Column 5 format
TTYPE5	'WAVELENGTH'	Label for column 5
TFORM6	'1D'	Column 6 format
TTYPE6	'SCUT_TIME'	Label for column 6
TFORM7	'1E'	Column 7 format
TTYPE7	'WEIGHTED_COUNT'	Label for column 7
TFORM8	'1E'	Column 8 format
TTYPE8	'WEIGHTED_VARIANCE'	Label for column 8
TFORM9	'1E'	Column 9 format
TTYPE9	'LATITUDE'	Label for column 9
TFORM10	'1E'	Column 10 format
TTYPE10	'LONGITUDE'	Label for column 10
TFORM11	'1E'	Column 11 format
TTYPE11	'LATITUDE_LL'	Label for column 11
TFORM12	'1E'	Column 12 format
TTYPE12	'LONGITUDE_LL'	Label for column 12
TFORM13	'1E'	Column 13 format
TTYPE13	'LATITUDE_UL'	Label for column 13
TFORM14	'1E'	Column 14 format
TTYPE14	'LONGITUDE_UL'	Label for column 14
TFORM15	'1E'	Column 15 format
TTYPE15	'LATITUDE_UR'	Label for column 15

FITS Header Keyword	Value	Description
TFORM16	'1E'	Column 16 format
TTYPE16	'LONGITUDE_UR'	Label for column 16
TFORM17	'1E'	Column 17 format
TTYPE17	'LATITUDE_LR'	Label for column 17
TFORM18	'1E'	Column 18 format
TTYPE18	'LONGITUDE_LR'	Label for column 18
TFORM19	'1E'	Column 19 format
TTYPE19	'ALTITUDE'	Label for column 19
TFORM20	'1E'	Column 20 format
TTYPE20	'INCIDENCE_ANGLE'	Label for column 20
TFORM21	'1E'	Column 21 format
TTYPE21	'EMISSION_ANGLE'	Label for column 21
TFORM22	'1E'	Column 22 format
TTYPE22	'DEADTIME_FACTOR'	Label for column 22
TFORM23	'1B'	Column 23 format
TTYPE23	'PIX_DATA_QUAL'	Label for column 23
END		
Extension 3 HDU Data	Calibrated Pixel List Mode Data	Binary Table
XTENSION	'BINTABLE'	Extension 4, Ancillary Data
BITPIX	8	array data type, 8-bit bytes
NAXIS	2	number of array dimensions
NAXIS1	89	number of bytes per frame
NAXIS2	1000 (*)	number of table rows
PCOUNT	0	extension size parameter
GCOUNT	1	extension size parameter
TFIELDS	25	Number of element fields per line
EXTNAME	'Ancillary Data'	Extension name
EXTVER	1	Extension version number
TFORM1	'1D'	Column 1 format
TTYPE1	'SCUT_TIME_SLOW'	Label for column 1
TFORM2	'1I'	Column 2 format
TTYPE2	'ORBIT_NUMBER'	Label for column 2
TFORM3	'1E'	Column 3 format
TTYPE3	'SOLAR_ZENITH_ANGLE'	Label for column 3
TFORM4	'1B'	Column 4 format
TTYPE4	'SC_SHADOW_FLAG'	Label for column 4
TFORM5	'1E'	Column 5 format
TTYPE5	'SUBSOLAR_LATITUDE'	Label for column 5
TFORM6	'1E'	Column 6 format
TTYPE6	'SUBSOLAR_LONGITUDE'	Label for column 6
TFORM7	'1E'	Column 7 format
TTYPE7	'SUBSC_LATITUDE'	Label for column 7
TFORM8	'1E'	Column 8 format
TTYPE8	'SUBSC_LONGITUDE'	Label for column 8
TFORM9	'1E'	Column 9 format
TTYPE9	'SC_ZENITH_ANGLE'	Label for column 9

FITS Header Keyword	Value	Description
TFORM10	'1E'	Column 10 format
TTYPE10	'EARTH_PHASE_ANGLE'	Label for column 10
TFORM11	'1E'	Column 11 format
TTYPE11	'PHASE_ANGLE'	Label for column 11
TFORM12	'1E'	Column 12 format
TTYPE12	'AZIMUTH_ANGLE'	Label for column 12
TFORM13	'1E'	Column 13 format
TTYPE13	'RA'	Label for column 13
TFORM14	'1E'	Column 14 format
TTYPE14	'DEC'	Label for column 14
TFORM15	'1E'	Column 15 format
TTYPE15	'ECLIPTIC_X'	Label for column 15
TFORM16	'1E'	Column 16 format
TTYPE16	'ECLIPTIC_Y'	Label for column 16
TFORM17	'1E'	Column 17 format
TTYPE17	'ECLIPTIC_Z'	Label for column 17
TFORM18	'1E'	Column 18 format
TTYPE18	'STIM_DRIFT1'	Label for column 18
TFORM19	'1E'	Column 19 format
TTYPE19	'STIM_DRIFT2'	Label for column 19
TFORM20	'1B'	Column 20 format
TTYPE20	'OTHER_INST_INTERF'	Label for column 20
TFORM21	'1I'	Column 21 format
TTYPE21	'GLOBAL_DATA_QUAL'	Label for column 21
TFORM22	'1I'	Column 22 format
TTYPE22	'HEURISTIC_QUALITY'	Label for column 22
TFORM23	'1E'	Column 23 format
TTYPE23	'DARK_FACTOR'	Label for column 23
TFORM24	'1E'	Column 24 format
TTYPE24	'STRAY_FACTOR'	Label for column 24
TFORM25	'1B'	Column 25 format
TTYPE25	'OFF_NADIR_POINTING'	Label for column 25
Extension 4 HDU Data	Ancillary Data	Binary Table
XTENSION	'IMAGE'	Extension 5, Calibrated histogram mode data
BITPIX	-32	array data type, 32-bit floating point
NAXIS	0	number of array dimensions
PCOUNT	0	extension size parameter
GCOUNT	1	extension size parameter
BZERO	0	no offset
BSCALE	1	default scaling factor
EXTNAME	'Calibrated Histogram Mode Data'	Extension name
EXTVER	1	Extension version number
END		
Extension 5 HDU Data	Calibrated Histogram Mode Data	3-D Image Cube

FITS Header Keyword	Value	Description
XTENSION	'BINTABLE'	Extension 6, Calibrated Calculated countrate
BITPIX	8	array data type, 8-bit bytes
NAXIS	2	number of array dimensions
NAXIS1	16	Number of bytes per countrate entry
NAXIS2	12498 (*)	Number of countrate entries
PCOUNT	0	extension size parameter
GCOUNT	1	extension size parameter
TFIELDS	3	Number of element fields per line
EXTNAME	'Calibrated Calculated Countrate'	Extension name
EXTVER	1	Extension version number
TTYPE1	'HACK_TIME'	Hack time at interval start (wrap extended)
TTYPE2	'SCUT_TIME'	Hack time converted to SCUT (sec)
TTYPE3	'COUNT_RATE'	Countrate for the interval (Hz)
TFORM1	'J'	4 byte long
TFORM2	'D'	8 byte double
TFORM3	'J'	4 byte long
TDISP2	'D14.3'	Preferred display format for SCUT
TUNIT2	'sec'	Unit for SCUT
TUNIT3	'Hz'	Unit for countrate
COMMENT		
CRTIME	199.974 (*)	Time span for countrate data
MINCR	4124 (*)	Overall minimum countrate (Hz)
AVRCR	6164.0 (*)	Overall average countrate (Hz)
MAXCR	8312 (*)	Overall maximum countrate (Hz)
MINCRDO	4124 (*)	Door open minimum countrate (Hz)
AVRCRDO	6080.4 (*)	Door open average countrate (Hz)
MAXCRDO	8312 (*)	Door open maximum countrate (Hz)
MINCRDC	65535 (*)	Door closed minimum countrate (Hz)
AVRCRDC	-1.0 (*)	Door closed average countrate (Hz)
MAXCRDC	0 (*)	Door closed maximum countrate (Hz)
END		
Extension 6 HDU Data	Calibrated Calculated countrate	Binary data table
XTENSION	'BINTABLE'	Extension 7, LTS data
BITPIX	8	array data type, 8-bit bytes
NAXIS	2	number of array dimensions
NAXIS1	14	Number of bytes per table row
NAXIS2	2700 (*)	Number of LTS entries
PCOUNT	0	extension size parameter
GCOUNT	1	extension size parameter
TFIELDS	4	Number of element fields per line
EXTNAME	'LTS Data (HK)'	Extension name
EXTVER	1	Extension version number
TTYPE1	'HACK_TIME'	Hack time at interval start (wrap extended)

FITS Header Keyword	Value	Description
TTYPE2	'SCUT_TIME'	Hack time converted to SCUT (sec)
TTYPE3	'LTS_A'	LTS A high rate scaled value
TTYPE4	'LTS_B'	LTS B high rate scaled value
TFORM1	'J'	4 byte long
TFORM2	'D'	8 byte double
TFORM3	'B'	One byte
TFORM4	'B'	One byte
TDISP2	'D14.3'	Preferred display format for time
TUNIT2	'sec'	Unit for SCUT
COMMENT		
LTSVALD	True / False	LTS A data valid flag
LTSBVALD	True / False	LTS B data valid flag
LTSTVALD	True / False	LTS timing data valid flag
LTSAMIN	121 (*)	LTS A minimum value
LTSAAVR	166.0 (*)	LTS A average value
LTSAMAX	214 (*)	LTS A maximum value
LTSBMIN	69 (*)	LTS B minimum value
LTSBAVR	84.2 (*)	LTS B average value
LTSBMAX	108 (*)	LTS B maximum value
END		
Extension 7 HDU Data	LTS data	Data table with 3 values per entry, some columns may be empty, length is equal to number of housekeeping packets times ten
XTENSION	'BINTABLE'	Extension 8, Housekeeping Table
BITPIX	8	array data type, 8-bit bytes
NAXIS	2	number of array dimensions
NAXIS1	229	Bytes needed to encode one LAMP HK packet, plus calibrated raw values
NAXIS2	270 (*)	Number of housekeeping packets
PCOUNT	0	extension size parameter
GCOUNT	1	extension size parameter
TFIELDS	37	Number of element fields per line
EXTNAME	'Housekeeping Table (HK)'	Extension name
EXTVER	1	Extension version number
TTYPE1	'SCUT_TIME'	Spacecraft UTC (sec since epoch from HK)
TTYPE2	'HACK_TIME'	Extended instrument hack time (since HK on)
TTYPE3	'PACK_CNT'	14-bit packet count (since HK on)
TTYPE4	'PACKET_DATA'	Raw HK CCSDS packet (122 bytes)
TTYPE5	'INST_STATE'	Instrument state (2,6=SAFE, 1,5=CHK, 3=PIX, 7=HIS)
TTYPE6	'LAST_SAFETY'	Last safety (0=none)
TTYPE7	'LVPS_STAT'	Active LVPS (1=A, 2=B, 3=both)
TTYPE8	'HVPS_STAT'	Active HVPS (0=off, 1=A, 2=B, 3=both)
TTYPE9	'MIRR_TMP_SET'	Mirror temperature set point (degC)
TTYPE10	'GRAT_TMP_SET'	Grating temperature set point (degC)
TTYPE11	'MIRR_HTR_STAT'	Mirror heater status (0=off, 1=A, 2=B,

FITS Header Keyword	Value	Description
		3=both)
TTYPE12	'GRAT_HTR_STAT'	Grating heater status (0=off, 1=A, 2=B, 3=both)
TTYPE13	'MIRR_A_TMP'	Mirror temperature A (primary) (degC)
TTYPE14	'MIRR_B_TMP'	Mirror temperature B (redundant) (degC)
TTYPE15	'GRAT_A_TMP'	Grating temperature A (primary) (degC)
TTYPE16	'GRAT_B_TMP'	Grating temperature B (redundant) (degC)
TTYPE17	'CDH_ELEC_TMP'	C&DH electronics temperature (degC)
TTYPE18	'DET_HOUS_TMP'	Detector housing temperature (degC)
TTYPE19	'APDOOR'	Aperture door (1=closed, 2=open, 3=between)
TTYPE20	'LTS_DARK'	LTS dark status (0=light, 1=dark)
TTYPE21	'STIM_STAT'	STIM status (0=off, 1=on)
TTYPE22	'HV_SETPNT'	Detector HVPS setpoint (kVolt)
TTYPE23	'MCPV1'	Detector MCP voltage 1 (kVolt)
TTYPE24	'ANODEV1'	Detector anode voltage 1 (kVolt)
TTYPE25	'STRIPI1'	Detector strip current 1 (uA)
TTYPE26	'MCPV2'	Detector MCP voltage 2 (kVolt)
TTYPE27	'ANODEV2'	Detector anode voltage 2 (kVolt)
TTYPE28	'STRIPI2'	Detector strip current 2 (uA)
TTYPE29	'MAX_MCPV'	Maximum MCP voltage last second (kVolt)
TTYPE30	'MAX_STRIPI'	Maximum summed strip current last second (uA)
TTYPE31	'DISCRIM'	Detector discriminator voltage (Volt)
TTYPE32	'COUNT_RATE'	Analog (raw) countrate (Hz)
TTYPE33	'RAW_LTS_A'	Raw LTS A (14 bits, raw counts)
TTYPE34	'RAW_LTS_B'	Raw LTS B (14 bits, raw counts)
TTYPE35	'LTS_CYCLES'	LTS safing cycles in acquisition
TTYPE36	'SAFETY'	Current safety status (0=none pending)
TTYPE37	'SAFE_TIMER'	Safety timeout timer (sec remaining)
TFORM1	'D'	8 byte double
TFORM2	'J'	4 byte long
TFORM3	'I'	2 byte integer
TFORM4	'122B'	122 bytes
TFORM5	'B'	1 byte state
TFORM6	'B'	1 byte state
TFORM7	'B'	1 byte state
TFORM8	'B'	1 byte state
TFORM9	'E'	4 byte float
TFORM10	'E'	4 byte float
TFORM11	'B'	1 byte state
TFORM12	'B'	1 byte state
TFORM13	'E'	4 byte float

FITS Header Keyword	Value	Description
TFORM14	'E'	4 byte float
TFORM15	'E'	4 byte float
TFORM16	'E'	4 byte float
TFORM17	'E'	4 byte float
TFORM18	'E'	4 byte float
TFORM19	'B'	1 byte state
TFORM20	'B'	1 byte state
TFORM21	'B'	1 byte state
TFORM22	'E'	4 byte float
TFORM23	'E'	4 byte float
TFORM24	'E'	4 byte float
TFORM25	'E'	4 byte float
TFORM26	'E'	4 byte float
TFORM27	'E'	4 byte float
TFORM28	'E'	4 byte float
TFORM29	'E'	4 byte float
TFORM30	'E'	4 byte float
TFORM31	'E'	4 byte float
TFORM32	'J'	4 byte long
TFORM33	'I'	2 byte integer
TFORM34	'I'	2 byte integer
TFORM35	'B'	1 byte integer
TFORM36	'B'	1 byte status
TFORM37	'I'	2 byte integer
COMMENT		
TDISP1	'D14.3'	Preferred display format for time
TUNIT1	'sec'	Unit for time
TUNIT2	'hacks'	Unit for time
TDISP9	'F5.1'	Preferred display format for temperature
TUNIT9	'degC'	Unit for temperature
TDISP10	'F5.1'	Preferred display format for temperature
TUNIT10	'degC'	Unit for temperature
TDISP13	'F5.1'	Preferred display format for temperature
TUNIT13	'degC'	Unit for temperature
TDISP14	'F5.1'	Preferred display format for temperature
TUNIT14	'degC'	Unit for temperature
TDISP15	'F5.1'	Preferred display format for temperature
TUNIT15	'degC'	Unit for temperature
TDISP16	'F5.1'	Preferred display format for temperature
TUNIT16	'degC'	Unit for temperature
TDISP17	'F5.1'	Preferred display format for temperature
TUNIT17	'degC'	Unit for temperature
TDISP18	'F5.1'	Preferred display format for

FITS Header Keyword	Value	Description
		temperature
TUNIT18	'degC'	Unit for temperature
TDISP22	'F6.3'	Preferred display unit for HvSet
TUNIT22	'kVolt'	Unit for HvSet
TDISP23	'F6.3'	Preferred display unit for McpV
TUNIT23	'kVolt'	Unit for McpV
TDISP24	'F4.1'	Preferred display format for AnodeV
TUNIT24	'Volt'	Unit for AnodeV
TDISP25	'F5.2'	Preferred display format for Strip Current
TUNIT25	'uA'	Unit for Strip Current
TDISP26	'F6.3'	Preferred display unit for McpV
TUNIT26	'kVolt'	Unit for McpV
TDISP27	'F4.1'	Preferred display format for AnodeV
TUNIT27	'Volt'	Unit for AnodeV
TDISP28	'F5.2'	Preferred display format for Strip Current
TUNIT28	'uA'	Unit for Strip Current
TDISP29	'F6.3'	Preferred display unit for McpV
TUNIT29	'kVolt'	Unit for McpV
TDISP30	'F5.2'	Preferred display format for Strip Current
TUNIT30	'uA'	Unit for Strip Current
TDISP31	'F4.2'	Preferred display format for Discriminator
TUNIT31	'Volt'	Unit for Discriminator
TUNIT32	'Hz'	Unit for Countrate
TUNIT33	'counts'	Unit for raw LTS
TUNIT34	'counts'	Unit for raw LTS
TUNIT37	'sec'	Unit for safety timeout
COMMENT		
HKEARLY	223940576.795 (*)	Earliest HK packet time (after sync)
HKLATEST	223940845.795 (*)	Latest HK packet time
HKENTRS	270 (*)	total number of HK packets
COMPHK	True / False	complete list flag (after sync)
ORDRHK	True / False	incrementing time order flag
END		
Extension 8:	Housekeeping Table	HK data table, including both the raw values and the values converted into engineering units where applicable.
XTENSION	'IMAGE'	Extension 9, Wavelength lookup image
BITPIX	-32	array data type, 32 bit words
NAXIS	2	number of array dimensions
NAXIS1	1024	number of spectral channels
NAXIS2	32	number of spatial channels
PCOUNT	0	extension size parameter
GCOUNT	1	extension size parameter
EXTNAME	'Wavelength Lookup Image'	Extension name

FITS Header Keyword	Value	Description
EXTVER	1	Extension version number
END		
Extension 9:	Wavelength Lookup Image	1024x32 image where every pixel value is the wavelength (in Angstroms) associated with the pixel.

APPENDIX B – GLOSSARY

Archive – An archive consists of one or more data sets along with all the documentation and ancillary information needed to understand and use the data. An archive is a logical construct independent of the medium on which it is stored.

Archive Volume, Archive Volume Set – A volume is a unit of media on which data products are stored; for example, one CD-ROM or DVD-ROM. An *archive volume* is a volume containing all or part of an archive; that is, data products plus documentation and ancillary files. When an archive spans multiple volumes, they are called an *archive volume set*. Usually the documentation and some ancillary files are repeated on each volume of the set, so that a single volume can be used alone.

Catalog Information – Descriptive information about a data set (e.g. mission description, spacecraft description, instrument description), expressed in Object Description Language (ODL) which is suitable for loading into a PDS catalog.

Data Product – A labeled grouping of data resulting from a scientific observation, usually stored in one file. A product label identifies, describes, and defines the structure of the data. An example of a data product is a planetary image, a spectrum table, or a time series table.

Data Set – An accumulation of data products. A data set together with supporting documentation and ancillary files is an archive.

Standard Data Product – A data product generated in a predefined way using well-understood procedures, processed in "pipeline" fashion. Data products that are generated in a nonstandard way are sometimes called *special data products*.

APPENDIX C – ACRONYMS AND ABBREVIATIONS

ASCII	American Standard Code for Information Interchange
C&DH	Command and Data Handling
CD-ROM	Compact Disk - Read-Only Memory
CODMAC	Committee on Data Management, Archiving and Computing
DVD-ROM	Digital Video Disk – Read-Only Memory
EDR	Experiment Data Record
FITS	Flexible Image Transport System
HDU	Header and Data Unit (FITS)
HK	Housekeeping
HVPS	High-Voltage Power Supply
HW	Hardware
IAU	International Astronomical Union
ICD	Interface Control Document
IDL	Interactive Data Language
ISO	International Standards Organization
JPL	Jet Propulsion Laboratory
LAMP	Lyman Alpha Mapping Project
LRO	Lunar Reconnaissance Orbiter
LTS	Lunar Terminator Sensor
MCP	Microchannel Plate
MOC	Mission Operations Center
NAIF	Navigation and Ancillary Information Facility
NASA	National Aeronautics and Space Administration
PDS	Planetary Data System
RDR	Reduced Data Record
SCLK	Spacecraft Clock (SPICE kernel)
SCUT	Spacecraft Universal Time
SIS	Software Interface Specification
SOC	Science Operations Center
SPICE	Spacecraft, Planet, Instrument, C-matrix (pointing), and Events
TBD	To Be Determined
TBS	To Be Supplied
UTC	Coordinated Universal Time
UV	Ultraviolet

APPENDIX D – NASA AND CODMAC DATA LEVEL DEFINITIONS

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

APPENDIX E – EXAMPLE PDS LABEL #1

An example PDS label for the LAMP Pipeline RDR data product with no histogram mode data.

```

PDS_VERSION_ID          = PDS3
DD_VERSION_ID           = PDSCAT1R65
LABEL_REVISION_NOTE     = "2008-02-15, David E. Kaufmann (SwRI), V0.1;"

/* FILE CHARACTERISTIC DATA ELEMENTS */

DATA_FORMAT              = FITS
FILE_NAME                 = "LAMP_SCI_0223940575_00.FIT"
FILE_RECORDS              = 303
RECORD_BYTES             = 2880 /* FITS standard record length */
RECORD_TYPE               = FIXED_LENGTH

/* DATA OBJECT POINTERS */

^CAL_SPECTRAL_IMAGE_DOOR_OPEN_HEADER = ("LAMP_SCI_0223940575_00.FIT", 1)
^CAL_SPECTRAL_IMAGE_DOOR_OPEN_IMAGE  = ("LAMP_SCI_0223940575_00.FIT", 6)
^CAL_SPECTRAL_IMAGE_DOOR_CLOSED_HEADER = ("LAMP_SCI_0223940575_00.FIT", 52)
^CAL_SPECTRAL_IMAGE_DOOR_CLOSED_IMAGE = ("LAMP_SCI_0223940575_00.FIT", 53)
^ACQUISITION_LIST_HEADER              = ("LAMP_SCI_0223940575_00.FIT", 99)
^ACQUISITION_LIST_TABLE               = ("LAMP_SCI_0223940575_00.FIT", 101)
^CAL_PIXELLIST_DATA_HEADER            = ("LAMP_SCI_0223940575_00.FIT", 104)
^CAL_PIXELLIST_DATA_TABLE             = ("LAMP_SCI_0223940575_00.FIT", 106)
^ANCILLARY_DATA_HEADER                = ("LAMP_SCI_0223940575_00.FIT", 138)
^ANCILLARY_DATA_TABLE                 = ("LAMP_SCI_0223940575_00.FIT", 140)
^CAL_HISTOGRAM_DATA_HEADER            = ("LAMP_SCI_0223940575_00.FIT", 141)
^CAL_CALCULATED_COUNTRATE_HEADER      = ("LAMP_SCI_0223940575_00.FIT", 142)
^CAL_CALCULATED_COUNTRATE_TABLE      = ("LAMP_SCI_0223940575_00.FIT", 144)
^LTS_DATA_HEADER                     = ("LAMP_SCI_0223940575_00.FIT", 214)
^LTS_DATA_TABLE                      = ("LAMP_SCI_0223940575_00.FIT", 216)
^HOUSEKEEPING_HEADER                 = ("LAMP_SCI_0223940575_00.FIT", 230)
^HOUSEKEEPING_TABLE                  = ("LAMP_SCI_0223940575_00.FIT", 235)
^WAVELENGTH_LOOKUP_HEADER            = ("LAMP_SCI_0223940575_00.FIT", 257)
^WAVELENGTH_LOOKUP_IMAGE             = ("LAMP_SCI_0223940575_00.FIT", 258)

/* IDENTIFICATION DATA ELEMENTS */

DATA_SET_ID               = "LRO-L-LAMP-3-RDR-V1.0"
INSTRUMENT_HOST_NAME      = "LUNAR RECONNAISSANCE ORBITER"
INSTRUMENT_NAME           = "LYMAN ALPHA MAPPING PROJECT"
PRODUCT_CREATION_TIME     = 2008-02-14T19:12:46
PRODUCT_ID                = "LAMP_SCI_0223940575_00.FIT"
SPACECRAFT_CLOCK_START_COUNT = "223940575.900"
SPACECRAFT_CLOCK_STOP_COUNT = "223940846.375"
START_TIME                = 2008-02-05T21:42:55.900
STOP_TIME                 = 2008-02-05T21:47:26.375
TARGET_NAME               = "MOON"

/* DESCRIPTIVE DATA ELEMENTS */

DATA_QUALITY_ID           = 0
DATA_QUALITY_DESC         = "Data quality is nominal"
DATA_SET_NAME             = "LRO MOON LAMP 3 REDUCED DATA RECORD V1.0"
EXPOSURE_DURATION         = 199.990 <s>
INSTRUMENT_HOST_ID        = "LRO"
INSTRUMENT_ID             = "LAMP"
INSTRUMENT_MODE_ID        = "PIXEL" /* PIXEL, HISTO, MIXED */

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```

INSTRUMENT_MODE_DESC      = "PIXELLIST"
INSTRUMENT_TYPE           = "SPECTROGRAPH"
MISSION_ID                = "LRO"
MISSION_NAME              = "LUNAR RECONNAISSANCE ORBITER"
MISSION_PHASE_NAME        = "PRIMARY MISSION"
PRODUCER_FULL_NAME        = "DAVID E. KAUFMANN"
PRODUCER_ID               = "LRO_LAMP"
PRODUCER_INSTITUTION_NAME = "SOUTHWEST RESEARCH INSTITUTE"
PRODUCT_TYPE              = "RDR" /* CODMAC Data Level 3 */
SOFTWARE_NAME             = "LAMP-MIKE"
SPACECRAFT_NAME           = "LUNAR RECONNAISSANCE ORBITER"
TARGET_DESC               = "MOON"
TARGET_TYPE               = "SATELLITE"

/* DATA OBJECT DEFINITIONS */

OBJECT                    = CAL_SPECTRAL_IMAGE_DOOR_OPEN_HEADER
  BYTES                   = 14400 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE             = FITS
  INTERCHANGE_FORMAT      = ASCII
  RECORDS                 = 5
  DESCRIPTION             = "
    FITS header for LRO LAMP calibrated (CODMAC Data Level 3)
    observation."
END_OBJECT                = CAL_SPECTRAL_IMAGE_DOOR_OPEN_HEADER

OBJECT                    = CAL_SPECTRAL_IMAGE_DOOR_OPEN_IMAGE
  SAMPLE_BITS             = 32
  SAMPLE_TYPE             = IEEE_REAL
  AXIS_ORDER_TYPE         = FIRST_INDEX_FASTEST
  LINE_DISPLAY_DIRECTION  = UP
  SAMPLE_DISPLAY_DIRECTION = RIGHT
  LINE_SAMPLES            = 1024
  LINES                   = 32
  INTERCHANGE_FORMAT      = BINARY
  OFFSET                  = 0
  SCALING_FACTOR          = 1.00000
  DESCRIPTION             = "
    Reconstructed histogram image for LRO LAMP calibrated (CODMAC Data
    Level 3) pixel list data taken with the instrument aperture door
    open, or first histogram image if all data taken in histogram
    mode. Units are calibrated counts."
END_OBJECT                = CAL_SPECTRAL_IMAGE_DOOR_OPEN_IMAGE

OBJECT                    = CAL_SPECTRAL_IMAGE_DOOR_CLOSED_HEADER
  BYTES                   = 2880 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE             = FITS
  INTERCHANGE_FORMAT      = ASCII
  RECORDS                 = 1
  DESCRIPTION             = "
    This is the FITS header for FITS extension number = 1, FITS
    extension name = CAL_SPECTRAL_IMAGE_DOOR_CLOSED"
END_OBJECT                = CAL_SPECTRAL_IMAGE_DOOR_CLOSED_HEADER

OBJECT                    = CAL_SPECTRAL_IMAGE_DOOR_CLOSED_IMAGE
  SAMPLE_BITS             = 32
  SAMPLE_TYPE             = IEEE_REAL
  AXIS_ORDER_TYPE         = FIRST_INDEX_FASTEST
  LINE_DISPLAY_DIRECTION  = UP
  SAMPLE_DISPLAY_DIRECTION = RIGHT
  LINE_SAMPLES            = 1024

```

```

    LINES = 32
    INTERCHANGE_FORMAT = BINARY
    OFFSET = 0
    SCALING_FACTOR = 1.00000
    DESCRIPTION = "
        Reconstructed histogram image for LRO LAMP calibrated (CODMAC Data
        Level 3) pixel list data taken with the instrument aperture door
        closed, or second histogram image if all data taken in histogram
        mode. Units are calibrated counts."
END_OBJECT = CAL_SPECTRAL_IMAGE_DOOR_CLOSED_IMAGE

OBJECT = ACQUISITION_LIST_HEADER
    BYTES = 5760 /* RECORD_BYTES x RECORDS */
    HEADER_TYPE = FITS
    INTERCHANGE_FORMAT = ASCII
    RECORDS = 2
    DESCRIPTION = "
        This is the FITS header for FITS extension number = 2, FITS
        extension name = ACQUISITION_LIST"
END_OBJECT = ACQUISITION_LIST_HEADER

OBJECT = ACQUISITION_LIST_TABLE
    INTERCHANGE_FORMAT = ASCII
    ROWS = 38
    COLUMNS = 12
    ROW_BYTES = 64
    OBJECT = COLUMN
        NAME = "START_TIME "
        DATA_TYPE = ASCII_REAL
        START_BYTE = 1
        BYTES = 15
        DESCRIPTION = "
            Start time of acquisition (seconds since 00:00 UTC, 01 Jan 2001)"
END_OBJECT = COLUMN
    OBJECT = COLUMN
        NAME = "STOP_TIME "
        DATA_TYPE = ASCII_REAL
        START_BYTE = 16
        BYTES = 15
        DESCRIPTION = "
            Stop time of acquisition (seconds since 00:00 UTC, 01 Jan 2001)"
END_OBJECT = COLUMN
    OBJECT = COLUMN
        NAME = "SCI_HDR "
        DATA_TYPE = ASCII_INTEGER
        START_BYTE = 31
        BYTES = 6
        DESCRIPTION = "
            Science frame header from HK stream"
END_OBJECT = COLUMN
    OBJECT = COLUMN
        NAME = "ACQ_MODE "
        DATA_TYPE = ASCII_INTEGER
        START_BYTE = 37
        BYTES = 2
        DESCRIPTION = "
            Acquisition type (0=pixellist, 1=histogram)"
END_OBJECT = COLUMN
    OBJECT = COLUMN
        NAME = "FRAME_NO "
        DATA_TYPE = ASCII_INTEGER

```

```

START_BYTE      = 39
BYTES           = 5
DESCRIPTION     = "
    Frame number (0-4095)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
NAME            = "APD_STATE  "
DATA_TYPE       = ASCII_INTEGER
START_BYTE      = 44
BYTES           = 2
DESCRIPTION     = "
    Aperture door state (1=error, 2=closed, 3=open, 4=between,
    5=variable)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
NAME            = "LTS_STATE  "
DATA_TYPE       = ASCII_INTEGER
START_BYTE      = 46
BYTES           = 2
DESCRIPTION     = "
    LTS state (1=day, 2=dark, 5=variable)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
NAME            = "STIM_STATE  "
DATA_TYPE       = ASCII_INTEGER
START_BYTE      = 48
BYTES           = 2
DESCRIPTION     = "
    STIM state (1=off, 2=on, 5=variable)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
NAME            = "HVPS_STATE  "
DATA_TYPE       = ASCII_INTEGER
START_BYTE      = 50
BYTES           = 2
DESCRIPTION     = "
    HVPS state (1=off, 2=A, 3=B, 4=both, 5=variable)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
NAME            = "HACK_RATE  "
DATA_TYPE       = ASCII_INTEGER
START_BYTE      = 52
BYTES           = 2
DESCRIPTION     = "
    Hack rate (0=N/A, 1=4 msec, 2=8 msec, ..., 8=512 msec)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
NAME            = "FR_PATTERN  "
DATA_TYPE       = ASCII_INTEGER
START_BYTE      = 54
BYTES           = 3
DESCRIPTION     = "
    Data pattern (0=data, 1=no frame, 2=test pattern)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
NAME            = "CHECKSUM  "
DATA_TYPE       = ASCII_INTEGER
START_BYTE      = 57
BYTES           = 8
DESCRIPTION     = "
    Frame data checksum (3 bytes)"

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LAMP Pipeline RDR Data Product SIS

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    END_OBJECT          = COLUMN
END_OBJECT             = ACQUISITION_LIST_TABLE

OBJECT                 = CAL_PIXELLIST_DATA_HEADER
  BYTES                 = 5760 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE           = FITS
  INTERCHANGE_FORMAT    = ASCII
  RECORDS                = 2
  DESCRIPTION           = "
    This is the FITS header for FITS extension number = 3, FITS
    extension name = CAL_PIXELLIST_DATA"
END_OBJECT             = CAL_PIXELLIST_DATA_HEADER

OBJECT                 = CAL_PIXELLIST_DATA_TABLE
  INTERCHANGE_FORMAT    = BINARY
  ROWS                  = 1000
  COLUMNS              = 23
  ROW_BYTES             = 87
  DESCRIPTION           = "
    This binary table contains one pixellist event per row, together
    with a number of auxiliary data values related to the instrumental
    calibration and spatial origin of the pixellist event."
  OBJECT                = COLUMN
  NAME                  = "HACK_TIME"
  DATA_TYPE            = MSB_UNSIGNED_INTEGER
  START_BYTE           = 1
  BYTES                 = 4
  DESCRIPTION           = "
    Hack time at pixellist event (wrap extended)"
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                  = "DETECTOR_X"
  DATA_TYPE            = MSB_UNSIGNED_INTEGER
  START_BYTE           = 5
  BYTES                 = 2
  DESCRIPTION           = "
    Detector X (spectral) position of pixellist event."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                  = "DETECTOR_Y"
  DATA_TYPE            = MSB_UNSIGNED_INTEGER
  START_BYTE           = 7
  BYTES                 = 2
  DESCRIPTION           = "
    Detector Y (spatial) position of pixellist event."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                  = "SPATIAL_ROW"
  DATA_TYPE            = MSB_UNSIGNED_INTEGER
  START_BYTE           = 9
  BYTES                 = 2
  DESCRIPTION           = "
    Detector Y (spatial) position of pixellist event corrected
    for geometric distortion."
END_OBJECT             = COLUMN
OBJECT                 = COLUMN
  NAME                  = "WAVELENGTH"
  DATA_TYPE            = IEEE_REAL
  START_BYTE           = 11
  BYTES                 = 4
  DESCRIPTION           = "

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```

    Wavelength of pixellist event"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
    NAME        = "SCUT_TIME"
    DATA_TYPE  = IEEE_REAL
    START_BYTE  = 15
    BYTES       = 8
    DESCRIPTION = ""
    Hack time converted into spacecraft UTC (seconds since 00:00 UTC,
    01 Jan 2001)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
    NAME        = "WEIGHTED_COUNT"
    DATA_TYPE  = IEEE_REAL
    START_BYTE  = 23
    BYTES       = 4
    DESCRIPTION = ""
    Weighted pixellist count"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
    NAME        = "WEIGHTED_VARIANCE"
    DATA_TYPE  = IEEE_REAL
    START_BYTE  = 27
    BYTES       = 4
    DESCRIPTION = ""
    Weighted pixellist count"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
    NAME        = "LATITUDE"
    DATA_TYPE  = IEEE_REAL
    START_BYTE  = 31
    BYTES       = 4
    DESCRIPTION = ""
    Selenographic latitude of photon origin on lunar surface"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
    NAME        = "LONGITUDE"
    DATA_TYPE  = IEEE_REAL
    START_BYTE  = 35
    BYTES       = 4
    DESCRIPTION = ""
    Selenographic longitude of photon origin on lunar surface"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
    NAME        = "LATITUDE_LL"
    DATA_TYPE  = IEEE_REAL
    START_BYTE  = 39
    BYTES       = 4
    DESCRIPTION = ""
    Selenographic latitude of lower left pixel corner on lunar surface"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
    NAME        = "LONGITUDE_LL"
    DATA_TYPE  = IEEE_REAL
    START_BYTE  = 43
    BYTES       = 4
    DESCRIPTION = ""
    Selenographic longitude of lower left pixel corner on lunar surface"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
    NAME        = "LATITUDE_UL"

```

```

DATA_TYPE          = IEEE_REAL
START_BYTE         = 47
BYTES              = 4
DESCRIPTION        = "
    Selenographic latitude of upper left pixel corner on lunar surface"
END_OBJECT          = COLUMN
OBJECT             = COLUMN
NAME               = "LONGITUDE_UL"
DATA_TYPE          = IEEE_REAL
START_BYTE         = 51
BYTES              = 4
DESCRIPTION        = "
    Selenographic longitude of upper left pixel corner on lunar surface"
END_OBJECT          = COLUMN
OBJECT             = COLUMN
NAME               = "LATITUDE_UR"
DATA_TYPE          = IEEE_REAL
START_BYTE         = 55
BYTES              = 4
DESCRIPTION        = "
    Selenographic latitude of upper right pixel corner on lunar surface"
END_OBJECT          = COLUMN
OBJECT             = COLUMN
NAME               = "LONGITUDE_UR"
DATA_TYPE          = IEEE_REAL
START_BYTE         = 59
BYTES              = 4
DESCRIPTION        = "
    Selenographic longitude of upper right pixel corner on lunar surface"
END_OBJECT          = COLUMN
OBJECT             = COLUMN
NAME               = "LATITUDE_LR"
DATA_TYPE          = IEEE_REAL
START_BYTE         = 63
BYTES              = 4
DESCRIPTION        = "
    Selenographic latitude of lower right pixel corner on lunar surface"
END_OBJECT          = COLUMN
OBJECT             = COLUMN
NAME               = "LONGITUDE_LR"
DATA_TYPE          = IEEE_REAL
START_BYTE         = 67
BYTES              = 4
DESCRIPTION        = "
    Selenographic longitude of lower right pixel corner on lunar surface"
END_OBJECT          = COLUMN
OBJECT             = COLUMN
NAME               = "ALTITUDE"
DATA_TYPE          = IEEE_REAL
START_BYTE         = 71
BYTES              = 4
DESCRIPTION        = "
    Spacecraft altitude above lunar surface at time of photon
    detection"
END_OBJECT          = COLUMN
OBJECT             = COLUMN
NAME               = "INCIDENCE_ANGLE"
DATA_TYPE          = IEEE_REAL
START_BYTE         = 75
BYTES              = 4
DESCRIPTION        = "

```

```

        Incidence angle of solar radiation at detected photon location"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
NAME            = "EMISSION_ANGLE"
DATA_TYPE       = IEEE_REAL
START_BYTE      = 79
BYTES           = 4
DESCRIPTION     = "
        Emission angle of detected photon"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
NAME            = "DEADTIME_FACTOR"
DATA_TYPE       = IEEE_REAL
START_BYTE      = 83
BYTES           = 4
DESCRIPTION     = "
        Deadtime calibration factor"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
NAME            = "PIX_DATA_QUAL"
DATA_TYPE       = MSB_UNSIGNED_INTEGER
START_BYTE      = 87
BYTES           = 1
DESCRIPTION     = "
        Pixel data quality flag"
END_OBJECT      = COLUMN
END_OBJECT      = CAL_PIXELLIST_DATA_TABLE

OBJECT          = ANCILLARY_DATA_HEADER
BYTES           = 5760 /* RECORD_BYTES x RECORDS */
HEADER_TYPE     = FITS
INTERCHANGE_FORMAT = ASCII
RECORDS         = 2
DESCRIPTION     = "
        This is the FITS header for FITS extension number = 4, FITS
        extension name = ANCILLARY_DATA"
END_OBJECT      = ANCILLARY_DATA_HEADER

OBJECT          = ANCILLARY_DATA_TABLE
INTERCHANGE_FORMAT = BINARY
ROWS            = 4
COLUMNS        = 25
ROW_BYTES       = 89
DESCRIPTION     = "
        This binary table contains a number of auxiliary data values
        related to spacecraft location and instrument pointing at a
        cadence of one row per minute."
OBJECT          = COLUMN
NAME            = "SCUT_TIME_SLOW"
DATA_TYPE       = IEEE_REAL
START_BYTE      = 1
BYTES           = 8
DESCRIPTION     = "
        Hack time converted into spacecraft UTC (seconds since 00:00 UTC,
        01 Jan 2001)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
NAME            = "ORBIT_NUMBER"
DATA_TYPE       = MSB_UNSIGNED_INTEGER
START_BYTE      = 9
BYTES           = 2

```

```

    DESCRIPTION          = "
        LRO orbit number"
END_OBJECT              = COLUMN
OBJECT                  = COLUMN
    NAME                  = "SOLAR_ZENITH_ANGLE"
    DATA_TYPE            = IEEE_REAL
    START_BYTE            = 11
    BYTES                  = 4
    DESCRIPTION          = "
        Solar zenith angle at the row sample time"
END_OBJECT              = COLUMN
OBJECT                  = COLUMN
    NAME                  = "SC_SHADOW_FLAG"
    DATA_TYPE            = MSB_UNSIGNED_INTEGER
    START_BYTE            = 15
    BYTES                  = 1
    DESCRIPTION          = "
        Spacecraft in shadow flag (0=no, 1=yes)"
END_OBJECT              = COLUMN
OBJECT                  = COLUMN
    NAME                  = "SUBSOLAR_LATITUDE"
    DATA_TYPE            = IEEE_REAL
    START_BYTE            = 16
    BYTES                  = 4
    DESCRIPTION          = "
        Selenographic latitude of subsolar point"
END_OBJECT              = COLUMN
OBJECT                  = COLUMN
    NAME                  = "SUBSOLAR_LONGITUDE"
    DATA_TYPE            = IEEE_REAL
    START_BYTE            = 20
    BYTES                  = 4
    DESCRIPTION          = "
        Selenographic longitude of subsolar point"
END_OBJECT              = COLUMN
OBJECT                  = COLUMN
    NAME                  = "SUBSC_LATITUDE"
    DATA_TYPE            = IEEE_REAL
    START_BYTE            = 24
    BYTES                  = 4
    DESCRIPTION          = "
        Selenographic latitude of subspacecraft point"
END_OBJECT              = COLUMN
OBJECT                  = COLUMN
    NAME                  = "SUBSC_LONGITUDE"
    DATA_TYPE            = IEEE_REAL
    START_BYTE            = 28
    BYTES                  = 4
    DESCRIPTION          = "
        Selenographic longitude of subspacecraft point"
END_OBJECT              = COLUMN
OBJECT                  = COLUMN
    NAME                  = "SC_ZENITH_ANGLE"
    DATA_TYPE            = IEEE_REAL
    START_BYTE            = 32
    BYTES                  = 4
    DESCRIPTION          = "
        Spacecraft zenith angle at sample time"
END_OBJECT              = COLUMN
OBJECT                  = COLUMN
    NAME                  = "EARTH_PHASE_ANGLE"

```

```
DATA_TYPE          = IEEE_REAL
START_BYTE         = 36
BYTES              = 4
DESCRIPTION        = "
    Earth phase angle at sample time"
END_OBJECT         = COLUMN
OBJECT             = COLUMN
NAME               = "PHASE_ANGLE"
DATA_TYPE          = IEEE_REAL
START_BYTE         = 40
BYTES              = 4
DESCRIPTION        = "
    Illumination phase angle at sample time"
END_OBJECT         = COLUMN
OBJECT             = COLUMN
NAME               = "AZIMUTH_ANGLE"
DATA_TYPE          = IEEE_REAL
START_BYTE         = 44
BYTES              = 4
DESCRIPTION        = "
    Illumination azimuth angle at sample time"
END_OBJECT         = COLUMN
OBJECT             = COLUMN
NAME               = "RA"
DATA_TYPE          = IEEE_REAL
START_BYTE         = 48
BYTES              = 4
DESCRIPTION        = "
    Boresight right ascension"
END_OBJECT         = COLUMN
OBJECT             = COLUMN
NAME               = "DEC"
DATA_TYPE          = IEEE_REAL
START_BYTE         = 52
BYTES              = 4
DESCRIPTION        = "
    Boresight declination"
END_OBJECT         = COLUMN
OBJECT             = COLUMN
NAME               = "ECLIPTIC_X"
DATA_TYPE          = IEEE_REAL
START_BYTE         = 56
BYTES              = 4
DESCRIPTION        = "
    Spacecraft ecliptic X position"
END_OBJECT         = COLUMN
OBJECT             = COLUMN
NAME               = "ECLIPTIC_Y"
DATA_TYPE          = IEEE_REAL
START_BYTE         = 60
BYTES              = 4
DESCRIPTION        = "
    Spacecraft ecliptic Y position"
END_OBJECT         = COLUMN
OBJECT             = COLUMN
NAME               = "ECLIPTIC_Z"
DATA_TYPE          = IEEE_REAL
START_BYTE         = 64
BYTES              = 4
DESCRIPTION        = "
    Spacecraft ecliptic Z position"
```

```

END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "STIM_DRIFT1"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 68
  BYTES              = 4
  DESCRIPTION        = "
    Detector X drift position of STIM pixel 1"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "STIM_DRIFT2"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 72
  BYTES              = 4
  DESCRIPTION        = "
    Detector X drift position of STIM pixel 2"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "OTHER_INST_INTERF"
  DATA_TYPE        = MSB_UNSIGNED_INTEGER
  START_BYTE        = 76
  BYTES              = 1
  DESCRIPTION        = "
    Other instrument interference flag"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "GLOBAL_DATA_QUAL"
  DATA_TYPE        = MSB_UNSIGNED_INTEGER
  START_BYTE        = 77
  BYTES              = 2
  DESCRIPTION        = "
    Global data quality flag"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "HEURISTIC_QUALITY"
  DATA_TYPE        = MSB_UNSIGNED_INTEGER
  START_BYTE        = 79
  BYTES              = 2
  DESCRIPTION        = "
    Heuristic data quality flag"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "DARK_FACTOR"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 81
  BYTES              = 4
  DESCRIPTION        = "
    Dark current calibration factor"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "STRAY_FACTOR"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 85
  BYTES              = 4
  DESCRIPTION        = "
    Stray light calibration factor"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "OFF_NADIR_POINTING"
  DATA_TYPE        = MSB_UNSIGNED_INTEGER
  START_BYTE        = 89

```

```

        BYTES = 1
        DESCRIPTION = "
            Off-nadir pointing flag"
    END_OBJECT = COLUMN
END_OBJECT = ANCILLARY_DATA_TABLE

OBJECT = CAL_HISTOGRAM_DATA_HEADER
    BYTES = 2880 /* RECORD_BYTES x RECORDS */
    HEADER_TYPE = FITS
    INTERCHANGE_FORMAT = ASCII
    RECORDS = 1
    DESCRIPTION = "
        This is the FITS header for FITS extension number = 5, FITS
        extension name = CAL_HISTOGRAM_DATA"
END_OBJECT = CAL_HISTOGRAM_DATA_HEADER

OBJECT = CAL_CALCULATED_COUNTRATE_HEADER
    BYTES = 5760 /* RECORD_BYTES x RECORDS */
    HEADER_TYPE = FITS
    INTERCHANGE_FORMAT = ASCII
    RECORDS = 2
    DESCRIPTION = "
        This is the FITS header for FITS extension number = 6, FITS
        extension name = CAL_CALCULATED_COUNTRATE"
END_OBJECT = CAL_CALCULATED_COUNTRATE_HEADER

OBJECT = CAL_CALCULATED_COUNTRATE_TABLE
    INTERCHANGE_FORMAT = BINARY
    ROWS = 12498
    COLUMNS = 3
    ROW_BYTES = 16
    OBJECT = COLUMN
        NAME = "HACK_TIME"
        DATA_TYPE = MSB_UNSIGNED_INTEGER
        START_BYTE = 1
        BYTES = 4
        DESCRIPTION = "
            Hack time at start of interval (wrap extended)"
    END_OBJECT = COLUMN
    OBJECT = COLUMN
        NAME = "SCUT_TIME"
        DATA_TYPE = IEEE_REAL
        START_BYTE = 5
        BYTES = 8
        DESCRIPTION = "
            Hack time converted into spacecraft UTC (seconds since 00:00 UTC,
            01 Jan 2001)"
    END_OBJECT = COLUMN
    OBJECT = COLUMN
        NAME = "COUNT_RATE"
        DATA_TYPE = MSB_UNSIGNED_INTEGER
        START_BYTE = 13
        BYTES = 4
        DESCRIPTION = "
            Countrate for the interval (Hz)"
    END_OBJECT = COLUMN
END_OBJECT = CAL_CALCULATED_COUNTRATE_TABLE

OBJECT = LTS_DATA_HEADER
    BYTES = 5760 /* RECORD_BYTES x RECORDS */
    HEADER_TYPE = FITS

```

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```

INTERCHANGE_FORMAT      = ASCII
RECORDS                  = 2
DESCRIPTION              = "
    This is the FITS header for FITS extension number = 7, FITS
    extension name = LTS_DATA"
END_OBJECT               = LTS_DATA_HEADER

OBJECT                   = LTS_DATA_TABLE
INTERCHANGE_FORMAT      = BINARY
ROWS                    = 2700
COLUMNS                = 4
ROW_BYTES               = 14
OBJECT                 = COLUMN
NAME                   = "HACK_TIME"
DATA_TYPE               = MSB_UNSIGNED_INTEGER
START_BYTE              = 1
BYTES                  = 4
DESCRIPTION             = "
    Hack time at start of interval (wrap extended)"
END_OBJECT              = COLUMN
OBJECT                 = COLUMN
NAME                   = "SCUT_TIME"
DATA_TYPE               = IEEE_REAL
START_BYTE              = 5
BYTES                  = 8
DESCRIPTION             = "
    Hack time converted into spacecraft UTC (seconds since 00:00 UTC,
    01 Jan 2001)"
END_OBJECT              = COLUMN
OBJECT                 = COLUMN
NAME                   = "LTS_A"
DATA_TYPE               = MSB_UNSIGNED_INTEGER
START_BYTE              = 13
BYTES                  = 1
DESCRIPTION             = "
    LTS A high rate scaled value"
END_OBJECT              = COLUMN
OBJECT                 = COLUMN
NAME                   = "LTS_B"
DATA_TYPE               = MSB_UNSIGNED_INTEGER
START_BYTE              = 14
BYTES                  = 1
DESCRIPTION             = "
    LTS B high rate scaled value"
END_OBJECT              = COLUMN
END_OBJECT              = LTS_DATA_TABLE

OBJECT                   = HOUSEKEEPING_HEADER
BYTES                   = 14400 /* RECORD_BYTES x RECORDS */
HEADER_TYPE             = FITS
INTERCHANGE_FORMAT      = ASCII
RECORDS                 = 5
DESCRIPTION             = "
    This is the FITS header for FITS extension number = 8, FITS
    extension name = HOUSEKEEPING"
END_OBJECT              = HOUSEKEEPING_HEADER

OBJECT                   = HOUSEKEEPING_TABLE
INTERCHANGE_FORMAT      = BINARY
ROWS                    = 270
COLUMNS                = 37

```

```

ROW_BYTES                = 229
OBJECT                    = COLUMN
  NAME                    = "SCUT_TIME"
  DATA_TYPE              = IEEE_REAL
  START_BYTE              = 1
  BYTES                   = 8
  DESCRIPTION             = "
    Spacecraft UTC (seconds since epoch from HK)"
END_OBJECT                = COLUMN
OBJECT                    = COLUMN
  NAME                    = "HACK_TIME"
  DATA_TYPE              = MSB_UNSIGNED_INTEGER
  START_BYTE              = 9
  BYTES                   = 4
  DESCRIPTION             = "
    Extended instrument hack time (since HK on)"
END_OBJECT                = COLUMN
OBJECT                    = COLUMN
  NAME                    = "PACK_CNT"
  DATA_TYPE              = MSB_UNSIGNED_INTEGER
  START_BYTE              = 13
  BYTES                   = 2
  DESCRIPTION             = "
    14-bit packet count (since HK on)"
END_OBJECT                = COLUMN
OBJECT                    = COLUMN
  NAME                    = "PACKET_DATA"
  DATA_TYPE              = MSB_UNSIGNED_INTEGER
  START_BYTE              = 15
  BYTES                   = 122
  ITEMS                   = 122
  ITEM_BYTES              = 1
  DESCRIPTION             = "
    This column contains the 122 bytes of the raw housekeeping
    telemetry packet generated by the LAMP instrument. Detailed
    information needed to decommutate and interpret the packet
    contents can be found in the LAMP Software User's Manual."
END_OBJECT                = COLUMN
OBJECT                    = COLUMN
  NAME                    = "INST_STATE"
  DATA_TYPE              = MSB_UNSIGNED_INTEGER
  START_BYTE              = 137
  BYTES                   = 1
  DESCRIPTION             = "
    Instrument state (2,6=SAFE, 1,5=CHK, 3=PIX, 7=HIS)"
END_OBJECT                = COLUMN
OBJECT                    = COLUMN
  NAME                    = "LAST_SAFETY"
  DATA_TYPE              = MSB_UNSIGNED_INTEGER
  START_BYTE              = 138
  BYTES                   = 1
  DESCRIPTION             = "
    Last safety (0=none)"
END_OBJECT                = COLUMN
OBJECT                    = COLUMN
  NAME                    = "LVPS_STAT"
  DATA_TYPE              = MSB_UNSIGNED_INTEGER
  START_BYTE              = 139
  BYTES                   = 1
  DESCRIPTION             = "
    Active LVPS (1=A, 2=B, 3=both)"

```

```

END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "HVPS_STAT"
  DATA_TYPE        = MSB_UNSIGNED_INTEGER
  START_BYTE        = 140
  BYTES              = 1
  DESCRIPTION        = "
    Active HVPS (0=off, 1=A, 2=B, 3=both)"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "MIRR_TMP_SET"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 141
  BYTES              = 4
  DESCRIPTION        = "
    Mirror temperature set point (degrees C)"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "GRAT_TMP_SET"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 145
  BYTES              = 4
  DESCRIPTION        = "
    Grating temperature set point (degrees C)"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "MIRR_HTR_STAT"
  DATA_TYPE        = MSB_UNSIGNED_INTEGER
  START_BYTE        = 149
  BYTES              = 1
  DESCRIPTION        = "
    Mirror heater status (0=off, 1=A, 2=B, 3=both)"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "GRAT_HTR_STAT"
  DATA_TYPE        = MSB_UNSIGNED_INTEGER
  START_BYTE        = 150
  BYTES              = 1
  DESCRIPTION        = "
    Grating heater status (0=off, 1=A, 2=B, 3=both)"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "MIRR_A_TMP"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 151
  BYTES              = 4
  DESCRIPTION        = "
    Mirror temperature A (primary) (degrees C)"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "MIRR_B_TMP"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 155
  BYTES              = 4
  DESCRIPTION        = "
    Mirror temperature B (redundant) (degrees C)"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "GRAT_A_TMP"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 159

```

```
        BYTES = 4
        DESCRIPTION = "
            Grating temperature A (primary) (degrees C)"
    END_OBJECT = COLUMN
    OBJECT = COLUMN
        NAME = "GRAT_B_TMP"
        DATA_TYPE = IEEE_REAL
        START_BYTE = 163
        BYTES = 4
        DESCRIPTION = "
            Grating temperature B (redundant) (degrees C)"
    END_OBJECT = COLUMN
    OBJECT = COLUMN
        NAME = "CDH_ELEC_TMP"
        DATA_TYPE = IEEE_REAL
        START_BYTE = 167
        BYTES = 4
        DESCRIPTION = "
            C&DH electronics temperature (degrees C)"
    END_OBJECT = COLUMN
    OBJECT = COLUMN
        NAME = "DET_HOUS_TMP"
        DATA_TYPE = IEEE_REAL
        START_BYTE = 171
        BYTES = 4
        DESCRIPTION = "
            Detector housing temperature (degrees C)"
    END_OBJECT = COLUMN
    OBJECT = COLUMN
        NAME = "APDOOR"
        DATA_TYPE = MSB_UNSIGNED_INTEGER
        START_BYTE = 175
        BYTES = 1
        DESCRIPTION = "
            Aperture door state (1=closed, 2=open, 3=between)"
    END_OBJECT = COLUMN
    OBJECT = COLUMN
        NAME = "LTS_DARK"
        DATA_TYPE = MSB_UNSIGNED_INTEGER
        START_BYTE = 176
        BYTES = 1
        DESCRIPTION = "
            LTS dark status (0=light, 1=dark)"
    END_OBJECT = COLUMN
    OBJECT = COLUMN
        NAME = "STIM_STAT"
        DATA_TYPE = MSB_UNSIGNED_INTEGER
        START_BYTE = 177
        BYTES = 1
        DESCRIPTION = "
            STIM status (0=off, 1=on)"
    END_OBJECT = COLUMN
    OBJECT = COLUMN
        NAME = "HV_SETPNT"
        DATA_TYPE = IEEE_REAL
        START_BYTE = 178
        BYTES = 4
        DESCRIPTION = "
            Detector HVPS setpoint (kVolt)"
    END_OBJECT = COLUMN
    OBJECT = COLUMN
```

```

NAME                = "MCPV1"
DATA_TYPE            = IEEE_REAL
START_BYTE           = 182
BYTES                = 4
DESCRIPTION           = "
    Detector MCP voltage 1 (kVolt)"
END_OBJECT           = COLUMN
OBJECT               = COLUMN
NAME                 = "ANODEV1"
DATA_TYPE            = IEEE_REAL
START_BYTE           = 186
BYTES                = 4
DESCRIPTION           = "
    Detector anode voltage 1 (kVolt)"
END_OBJECT           = COLUMN
OBJECT               = COLUMN
NAME                 = "STRIPI1"
DATA_TYPE            = IEEE_REAL
START_BYTE           = 190
BYTES                = 4
DESCRIPTION           = "
    Detector strip current 1 (uA)"
END_OBJECT           = COLUMN
OBJECT               = COLUMN
NAME                 = "MCPV2"
DATA_TYPE            = IEEE_REAL
START_BYTE           = 194
BYTES                = 4
DESCRIPTION           = "
    Detector MCP voltage 2 (kVolt)"
END_OBJECT           = COLUMN
OBJECT               = COLUMN
NAME                 = "ANODEV2"
DATA_TYPE            = IEEE_REAL
START_BYTE           = 198
BYTES                = 4
DESCRIPTION           = "
    Detector anode voltage 2 (kVolt)"
END_OBJECT           = COLUMN
OBJECT               = COLUMN
NAME                 = "STRIPI2"
DATA_TYPE            = IEEE_REAL
START_BYTE           = 202
BYTES                = 4
DESCRIPTION           = "
    Detector strip current 2 (uA)"
END_OBJECT           = COLUMN
OBJECT               = COLUMN
NAME                 = "MAX_MCPV"
DATA_TYPE            = IEEE_REAL
START_BYTE           = 206
BYTES                = 4
DESCRIPTION           = "
    Maximum MCP voltage last second (kVolt)"
END_OBJECT           = COLUMN
OBJECT               = COLUMN
NAME                 = "MAX_STRIPI"
DATA_TYPE            = IEEE_REAL
START_BYTE           = 210
BYTES                = 4
DESCRIPTION           = "

```

```

        Maximum summed strip current last second (uA) "
END_OBJECT      = COLUMN
OBJECT          = COLUMN
NAME           = "DISCRIM"
DATA_TYPE      = IEEE_REAL
START_BYTE     = 214
BYTES          = 4
DESCRIPTION    = "
        Detector discriminator voltage (volt) "
END_OBJECT      = COLUMN
OBJECT          = COLUMN
NAME           = "COUNT_RATE"
DATA_TYPE      = MSB_UNSIGNED_INTEGER
START_BYTE     = 218
BYTES          = 4
DESCRIPTION    = "
        Analog (raw) countrate (Hz) "
END_OBJECT      = COLUMN
OBJECT          = COLUMN
NAME           = "RAW_LTS_A"
DATA_TYPE      = MSB_UNSIGNED_INTEGER
START_BYTE     = 222
BYTES          = 2
DESCRIPTION    = "
        Raw LTS A (14 bits, raw counts) "
END_OBJECT      = COLUMN
OBJECT          = COLUMN
NAME           = "RAW_LTS_B"
DATA_TYPE      = MSB_UNSIGNED_INTEGER
START_BYTE     = 224
BYTES          = 2
DESCRIPTION    = "
        Raw LTS B (14 bits, raw counts) "
END_OBJECT      = COLUMN
OBJECT          = COLUMN
NAME           = "LTS_CYCLES"
DATA_TYPE      = MSB_UNSIGNED_INTEGER
START_BYTE     = 226
BYTES          = 1
DESCRIPTION    = "
        LTS safing cycles in acquisition "
END_OBJECT      = COLUMN
OBJECT          = COLUMN
NAME           = "SAFETY"
DATA_TYPE      = MSB_UNSIGNED_INTEGER
START_BYTE     = 227
BYTES          = 1
DESCRIPTION    = "
        Current safety status (0=none pending) "
END_OBJECT      = COLUMN
OBJECT          = COLUMN
NAME           = "SAFE_TIMER"
DATA_TYPE      = MSB_UNSIGNED_INTEGER
START_BYTE     = 228
BYTES          = 2
DESCRIPTION    = "
        Safety timeout timer (seconds remaining) "
END_OBJECT      = COLUMN
END_OBJECT      = HOUSEKEEPING_TABLE

OBJECT          = WAVELENGTH_LOOKUP_HEADER

```

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```
BYTES                      = 2880 /* RECORD_BYTES x RECORDS */
HEADER_TYPE                = FITS
INTERCHANGE_FORMAT        = ASCII
RECORDS                    = 1
DESCRIPTION                = "
    This is the FITS header for FITS extension number = 9, FITS
    extension name = WAVELENGTH_LOOKUP_TABLE"
END_OBJECT                 = WAVELENGTH_LOOKUP_HEADER

OBJECT                     = WAVELENGTH_LOOKUP_IMAGE
SAMPLE_BITS               = 32
SAMPLE_TYPE               = IEEE_REAL
AXIS_ORDER_TYPE           = FIRST_INDEX_FASTEST
LINE_DISPLAY_DIRECTION    = UP
SAMPLE_DISPLAY_DIRECTION  = RIGHT
LINE_SAMPLES              = 1024
LINES                     = 32
INTERCHANGE_FORMAT        = BINARY
OFFSET                    = 0
SCALING_FACTOR            = 1.00000
DESCRIPTION                = "
    Wavelength lookup image for the LAMP calibration.  The value of
    each pixel is the wavelength (in Angstroms) associated with that
    pixel."
END_OBJECT                 = WAVELENGTH_LOOKUP_IMAGE
END
```

APPENDIX F – EXAMPLE PDS LABEL #2

An example PDS label for the LAMP Pipeline RDR data product with histogram mode data.

```
PDS_VERSION_ID          = PDS3
DD_VERSION_ID           = PDSCAT1R65
LABEL_REVISION_NOTE     = "2008-02-15, David E. Kaufmann (SwRI), V0.1;"

/* FILE CHARACTERISTIC DATA ELEMENTS */

DATA_FORMAT             = FITS
FILE_NAME               = "LAMP_SCI_0223940575_00.FIT"
FILE_RECORDS            = 303
RECORD_BYTES            = 2880 /* FITS standard record length */
RECORD_TYPE             = FIXED_LENGTH

/* DATA OBJECT POINTERS */

^CAL_SPECTRAL_IMAGE_DOOR_OPEN_HEADER = ("LAMP_SCI_0223940575_00.FIT", 1)
^CAL_SPECTRAL_IMAGE_DOOR_OPEN_IMAGE = ("LAMP_SCI_0223940575_00.FIT", 6)
^CAL_SPECTRAL_IMAGE_DOOR_CLOSED_HEADER = ("LAMP_SCI_0223940575_00.FIT", 52)
^CAL_SPECTRAL_IMAGE_DOOR_CLOSED_IMAGE = ("LAMP_SCI_0223940575_00.FIT", 53)
^ACQUISITION_LIST_HEADER = ("LAMP_SCI_0223940575_00.FIT", 99)
^ACQUISITION_LIST_TABLE = ("LAMP_SCI_0223940575_00.FIT", 101)
^CAL_PIXELLIST_DATA_HEADER = ("LAMP_SCI_0223940575_00.FIT", 104)
^CAL_PIXELLIST_DATA_TABLE = ("LAMP_SCI_0223940575_00.FIT", 106)
^ANCILLARY_DATA_HEADER = ("LAMP_SCI_0223940575_00.FIT", 138)
^ANCILLARY_DATA_TABLE = ("LAMP_SCI_0223940575_00.FIT", 140)
^CAL_HISTOGRAM_DATA_HEADER = ("LAMP_SCI_0223940575_00.FIT", 141)
^CAL_HISTOGRAM_DATA_1_IMAGE = ("LAMP_SCI_0223940575_00.FIT", 406081 <BYTES>)
^CAL_HISTOGRAM_ERROR_1_IMAGE = ("LAMP_SCI_0223940575_00.FIT", 537153 <BYTES>)
^CAL_CALCULATED_COUNTRATE_HEADER = ("LAMP_SCI_0223940575_00.FIT", 234)
^CAL_CALCULATED_COUNTRATE_TABLE = ("LAMP_SCI_0223940575_00.FIT", 236)
^LTS_DATA_HEADER = ("LAMP_SCI_0223940575_00.FIT", 306)
^LTS_DATA_TABLE = ("LAMP_SCI_0223940575_00.FIT", 308)
^HOUSEKEEPING_HEADER = ("LAMP_SCI_0223940575_00.FIT", 322)
^HOUSEKEEPING_TABLE = ("LAMP_SCI_0223940575_00.FIT", 327)
^WAVELENGTH_LOOKUP_HEADER = ("LAMP_SCI_0223940575_00.FIT", 349)
^WAVELENGTH_LOOKUP_IMAGE = ("LAMP_SCI_0223940575_00.FIT", 350)

/* IDENTIFICATION DATA ELEMENTS */

DATA_SET_ID             = "LRO-L-LAMP-3-RDR-V1.0"
INSTRUMENT_HOST_NAME    = "LUNAR RECONNAISSANCE ORBITER"
INSTRUMENT_NAME         = "LYMAN ALPHA MAPPING PROJECT"
PRODUCT_CREATION_TIME   = 2008-02-14T19:12:46
PRODUCT_ID              = "LAMP_SCI_0223940575_00.FIT"
SPACECRAFT_CLOCK_START_COUNT = "223940575.900"
SPACECRAFT_CLOCK_STOP_COUNT = "223940846.375"
START_TIME              = 2008-02-05T21:42:55.900
STOP_TIME               = 2008-02-05T21:47:26.375
TARGET_NAME             = "MOON"

/* DESCRIPTIVE DATA ELEMENTS */

DATA_QUALITY_ID         = 0
DATA_QUALITY_DESC       = "Data quality is nominal"
DATA_SET_NAME           = "LRO MOON LAMP 3 REDUCED DATA RECORD V1.0"
EXPOSURE_DURATION       = 199.990 <s>
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INSTRUMENT_HOST_ID      = "LRO"
INSTRUMENT_ID           = "LAMP"
INSTRUMENT_MODE_ID      = "PIXEL" /* PIXEL, HISTO, MIXED */
INSTRUMENT_MODE_DESC    = "PIXELLIST"
INSTRUMENT_TYPE         = "SPECTROGRAPH"
MISSION_ID              = "LRO"
MISSION_NAME            = "LUNAR RECONNAISSANCE ORBITER"
MISSION_PHASE_NAME      = "PRIMARY MISSION"
PRODUCER_FULL_NAME      = "DAVID E. KAUFMANN"
PRODUCER_ID             = "LRO_LAMP"
PRODUCER_INSTITUTION_NAME = "SOUTHWEST RESEARCH INSTITUTE"
PRODUCT_TYPE            = "RDR" /* CODMAC Data Level 3 */
SOFTWARE_NAME           = "LAMP-MIKE"
SPACECRAFT_NAME         = "LUNAR RECONNAISSANCE ORBITER"
TARGET_DESC             = "MOON"
TARGET_TYPE             = "SATELLITE"

/* DATA OBJECT DEFINITIONS */

OBJECT                  = CAL_SPECTRAL_IMAGE_DOOR_OPEN_HEADER
  BYTES                  = 14400 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE            = FITS
  INTERCHANGE_FORMAT     = ASCII
  RECORDS                = 5
  DESCRIPTION            = "
    FITS header for LRO LAMP calibrated (CODMAC Data Level 3)
    observation."
END_OBJECT              = CAL_SPECTRAL_IMAGE_DOOR_OPEN_HEADER

OBJECT                  = CAL_SPECTRAL_IMAGE_DOOR_OPEN_IMAGE
  SAMPLE_BITS            = 32
  SAMPLE_TYPE            = IEEE_REAL
  AXIS_ORDER_TYPE        = FIRST_INDEX_FASTEST
  LINE_DISPLAY_DIRECTION = UP
  SAMPLE_DISPLAY_DIRECTION = RIGHT
  LINE_SAMPLES           = 1024
  LINES                  = 32
  INTERCHANGE_FORMAT     = BINARY
  OFFSET                 = 0
  SCALING_FACTOR          = 1.00000
  DESCRIPTION            = "
    Reconstructed histogram image for LRO LAMP calibrated (CODMAC Data
    Level 3) pixel list data taken with the instrument aperture door
    open, or first histogram image if all data taken in histogram
    mode. Units are calibrated counts."
END_OBJECT              = CAL_SPECTRAL_IMAGE_DOOR_OPEN_IMAGE

OBJECT                  = CAL_SPECTRAL_IMAGE_DOOR_CLOSED_HEADER
  BYTES                  = 2880 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE            = FITS
  INTERCHANGE_FORMAT     = ASCII
  RECORDS                = 1
  DESCRIPTION            = "
    This is the FITS header for FITS extension number = 1, FITS
    extension name = CAL_SPECTRAL_IMAGE_DOOR_CLOSED"
END_OBJECT              = CAL_SPECTRAL_IMAGE_DOOR_CLOSED_HEADER

OBJECT                  = CAL_SPECTRAL_IMAGE_DOOR_CLOSED_IMAGE
  SAMPLE_BITS            = 32
  SAMPLE_TYPE            = IEEE_REAL
  AXIS_ORDER_TYPE        = FIRST_INDEX_FASTEST

```

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LINE_DISPLAY_DIRECTION      = UP
SAMPLE_DISPLAY_DIRECTION    = RIGHT
LINE_SAMPLES                 = 1024
LINES                       = 32
INTERCHANGE_FORMAT          = BINARY
OFFSET                      = 0
SCALING_FACTOR              = 1.00000
DESCRIPTION                  = "
    Reconstructed histogram image for LRO LAMP calibrated (CODMAC Data
    Level 3) pixel list data taken with the instrument aperture door
    closed, or second histogram image if all data taken in histogram
    mode. Units are calibrated counts."
END_OBJECT                  = CAL_SPECTRAL_IMAGE_DOOR_CLOSED_IMAGE

OBJECT                      = ACQUISITION_LIST_HEADER
BYTES                      = 5760 /* RECORD_BYTES x RECORDS */
HEADER_TYPE                 = FITS
INTERCHANGE_FORMAT          = ASCII
RECORDS                     = 2
DESCRIPTION                  = "
    This is the FITS header for FITS extension number = 2, FITS
    extension name = ACQUISITION_LIST"
END_OBJECT                  = ACQUISITION_LIST_HEADER

OBJECT                      = ACQUISITION_LIST_TABLE
INTERCHANGE_FORMAT          = ASCII
ROWS                        = 38
COLUMNS                    = 12
ROW_BYTES                   = 64
OBJECT                      = COLUMN
    NAME                    = "START_TIME  "
    DATA_TYPE               = ASCII_REAL
    START_BYTE               = 1
    BYTES                    = 15
    DESCRIPTION              = "
        Start time of acquisition (seconds since 00:00 UTC, 01 Jan 2001)"
END_OBJECT                  = COLUMN
OBJECT                      = COLUMN
    NAME                    = "STOP_TIME  "
    DATA_TYPE               = ASCII_REAL
    START_BYTE               = 16
    BYTES                    = 15
    DESCRIPTION              = "
        Stop time of acquisition (seconds since 00:00 UTC, 01 Jan 2001)"
END_OBJECT                  = COLUMN
OBJECT                      = COLUMN
    NAME                    = "SCI_HDR  "
    DATA_TYPE               = ASCII_INTEGER
    START_BYTE               = 31
    BYTES                    = 6
    DESCRIPTION              = "
        Science frame header from HK stream"
END_OBJECT                  = COLUMN
OBJECT                      = COLUMN
    NAME                    = "ACQ_MODE  "
    DATA_TYPE               = ASCII_INTEGER
    START_BYTE               = 37
    BYTES                    = 2
    DESCRIPTION              = "
        Acquisition type (0=pixellist, 1=histogram)"
END_OBJECT                  = COLUMN

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OBJECT          = COLUMN
  NAME          = "FRAME_NO  "
  DATA_TYPE    = ASCII_INTEGER
  START_BYTE    = 39
  BYTES         = 5
  DESCRIPTION   = "
    Frame number (0-4095)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
  NAME          = "APD_STATE  "
  DATA_TYPE    = ASCII_INTEGER
  START_BYTE    = 44
  BYTES         = 2
  DESCRIPTION   = "
    Aperture door state (1=error, 2=closed, 3=open, 4=between,
    5=variable)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
  NAME          = "LTS_STATE  "
  DATA_TYPE    = ASCII_INTEGER
  START_BYTE    = 46
  BYTES         = 2
  DESCRIPTION   = "
    LTS state (1=day, 2=dark, 5=variable)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
  NAME          = "STIM_STATE  "
  DATA_TYPE    = ASCII_INTEGER
  START_BYTE    = 48
  BYTES         = 2
  DESCRIPTION   = "
    STIM state (1=off, 2=on, 5=variable)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
  NAME          = "HVPS_STATE  "
  DATA_TYPE    = ASCII_INTEGER
  START_BYTE    = 50
  BYTES         = 2
  DESCRIPTION   = "
    HVPS state (1=off, 2=A, 3=B, 4=both, 5=variable)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
  NAME          = "HACK_RATE  "
  DATA_TYPE    = ASCII_INTEGER
  START_BYTE    = 52
  BYTES         = 2
  DESCRIPTION   = "
    Hack rate (0=N/A, 1=4 msec, 2=8 msec, ..., 8=512 msec)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
  NAME          = "FR_PATTERN  "
  DATA_TYPE    = ASCII_INTEGER
  START_BYTE    = 54
  BYTES         = 3
  DESCRIPTION   = "
    Data pattern (0=data, 1=no frame, 2=test pattern)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
  NAME          = "CHECKSUM  "
  DATA_TYPE    = ASCII_INTEGER
  START_BYTE    = 57

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        BYTES                = 8
        DESCRIPTION          = "
            Frame data checksum (3 bytes)"
    END_OBJECT              = COLUMN
END_OBJECT                 = ACQUISITION_LIST_TABLE

OBJECT                    = CAL_PIXELLIST_DATA_HEADER
    BYTES                  = 5760 /* RECORD_BYTES x RECORDS */
    HEADER_TYPE            = FITS
    INTERCHANGE_FORMAT     = ASCII
    RECORDS                = 2
    DESCRIPTION            = "
        This is the FITS header for FITS extension number = 3, FITS
        extension name = CAL_PIXELLIST_DATA"
END_OBJECT                = CAL_PIXELLIST_DATA_HEADER

OBJECT                    = CAL_PIXELLIST_DATA_TABLE
    INTERCHANGE_FORMAT     = BINARY
    ROWS                   = 1000
    COLUMNS               = 23
    ROW_BYTES              = 87
    DESCRIPTION            = "
        This binary table contains one pixellist event per row, together
        with a number of auxiliary data values related to the instrumental
        calibration and spatial origin of the pixellist event."
    OBJECT                 = COLUMN
        NAME               = "HACK_TIME"
        DATA_TYPE         = MSB_UNSIGNED_INTEGER
        START_BYTE         = 1
        BYTES              = 4
        DESCRIPTION        = "
            Hack time at pixellist event (wrap extended)"
    END_OBJECT             = COLUMN
    OBJECT                 = COLUMN
        NAME               = "DETECTOR_X"
        DATA_TYPE         = MSB_UNSIGNED_INTEGER
        START_BYTE         = 5
        BYTES              = 2
        DESCRIPTION        = "
            Detector X (spectral) position of pixellist event."
    END_OBJECT             = COLUMN
    OBJECT                 = COLUMN
        NAME               = "DETECTOR_Y"
        DATA_TYPE         = MSB_UNSIGNED_INTEGER
        START_BYTE         = 7
        BYTES              = 2
        DESCRIPTION        = "
            Detector Y (spatial) position of pixellist event."
    END_OBJECT             = COLUMN
    OBJECT                 = COLUMN
        NAME               = "SPATIAL_ROW"
        DATA_TYPE         = MSB_UNSIGNED_INTEGER
        START_BYTE         = 9
        BYTES              = 2
        DESCRIPTION        = "
            Detector Y (spatial) position of pixellist event corrected
            for geometric distortion."
    END_OBJECT             = COLUMN
    OBJECT                 = COLUMN
        NAME               = "WAVELENGTH"
        DATA_TYPE         = IEEE_REAL

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START_BYTE          = 11
BYTES               = 4
DESCRIPTION         = "
    Wavelength of pixellist event"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
NAME                = "SCUT_TIME"
DATA_TYPE           = IEEE_REAL
START_BYTE          = 15
BYTES               = 8
DESCRIPTION         = "
    Hack time converted into spacecraft UTC (seconds since 00:00 UTC,
    01 Jan 2001)"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
NAME                = "WEIGHTED_COUNT"
DATA_TYPE           = IEEE_REAL
START_BYTE          = 23
BYTES               = 4
DESCRIPTION         = "
    Weighted pixellist count"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
NAME                = "WEIGHTED_VARIANCE"
DATA_TYPE           = IEEE_REAL
START_BYTE          = 27
BYTES               = 4
DESCRIPTION         = "
    Weighted pixellist count"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
NAME                = "LATITUDE"
DATA_TYPE           = IEEE_REAL
START_BYTE          = 31
BYTES               = 4
DESCRIPTION         = "
    Selenographic latitude of photon origin on lunar surface"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
NAME                = "LONGITUDE"
DATA_TYPE           = IEEE_REAL
START_BYTE          = 35
BYTES               = 4
DESCRIPTION         = "
    Selenographic longitude of photon origin on lunar surface"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
NAME                = "LATITUDE_LL"
DATA_TYPE           = IEEE_REAL
START_BYTE          = 39
BYTES               = 4
DESCRIPTION         = "
    Selenographic latitude of lower left pixel corner on lunar surface"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
NAME                = "LONGITUDE_LL"
DATA_TYPE           = IEEE_REAL
START_BYTE          = 43
BYTES               = 4
DESCRIPTION         = "
    Selenographic longitude of lower left pixel corner on lunar surface"

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END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "LATITUDE_UL"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 47
  BYTES              = 4
  DESCRIPTION        = "
    Selenographic latitude of upper left pixel corner on lunar surface"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "LONGITUDE_UL"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 51
  BYTES              = 4
  DESCRIPTION        = "
    Selenographic longitude of upper left pixel corner on lunar surface"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "LATITUDE_UR"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 55
  BYTES              = 4
  DESCRIPTION        = "
    Selenographic latitude of upper right pixel corner on lunar surface"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "LONGITUDE_UR"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 59
  BYTES              = 4
  DESCRIPTION        = "
    Selenographic longitude of upper right pixel corner on lunar surface"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "LATITUDE_LR"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 63
  BYTES              = 4
  DESCRIPTION        = "
    Selenographic latitude of lower right pixel corner on lunar surface"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "LONGITUDE_LR"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 67
  BYTES              = 4
  DESCRIPTION        = "
    Selenographic longitude of lower right pixel corner on lunar surface"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "ALTITUDE"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 71
  BYTES              = 4
  DESCRIPTION        = "
    Spacecraft altitude above lunar surface at time of photon
    detection"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "INCIDENCE_ANGLE"
  DATA_TYPE        = IEEE_REAL

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    START_BYTE          = 75
    BYTES                = 4
    DESCRIPTION          = "
        Incidence angle of solar radiation at detected photon location"
END_OBJECT              = COLUMN
OBJECT                 = COLUMN
    NAME                = "EMISSION_ANGLE"
    DATA_TYPE          = IEEE_REAL
    START_BYTE          = 79
    BYTES                = 4
    DESCRIPTION          = "
        Emission angle of detected photon"
END_OBJECT              = COLUMN
OBJECT                 = COLUMN
    NAME                = "DEADTIME_FACTOR"
    DATA_TYPE          = IEEE_REAL
    START_BYTE          = 83
    BYTES                = 4
    DESCRIPTION          = "
        Deadtime calibration factor"
END_OBJECT              = COLUMN
OBJECT                 = COLUMN
    NAME                = "PIX_DATA_QUAL"
    DATA_TYPE          = MSB_UNSIGNED_INTEGER
    START_BYTE          = 87
    BYTES                = 1
    DESCRIPTION          = "
        Pixel data quality flag"
END_OBJECT              = COLUMN
END_OBJECT              = CAL_PIXELLIST_DATA_TABLE

OBJECT                 = ANCILLARY_DATA_HEADER
    BYTES                = 5760 /* RECORD_BYTES x RECORDS */
    HEADER_TYPE          = FITS
    INTERCHANGE_FORMAT   = ASCII
    RECORDS              = 2
    DESCRIPTION          = "
        This is the FITS header for FITS extension number = 4, FITS
        extension name = ANCILLARY_DATA"
END_OBJECT              = ANCILLARY_DATA_HEADER

OBJECT                 = ANCILLARY_DATA_TABLE
    INTERCHANGE_FORMAT   = BINARY
    ROWS                 = 4
    COLUMNS             = 25
    ROW_BYTES            = 89
    DESCRIPTION          = "
        This binary table contains a number of auxiliary data values
        related to spacecraft location and instrument pointing at a
        cadence of one row per minute."
OBJECT                 = COLUMN
    NAME                = "SCUT_TIME_SLOW"
    DATA_TYPE          = IEEE_REAL
    START_BYTE          = 1
    BYTES                = 8
    DESCRIPTION          = "
        Hack time converted into spacecraft UTC (seconds since 00:00 UTC,
        01 Jan 2001)"
END_OBJECT              = COLUMN
OBJECT                 = COLUMN
    NAME                = "ORBIT_NUMBER"

```

```

DATA_TYPE          = MSB_UNSIGNED_INTEGER
START_BYTE         = 9
BYTES              = 2
DESCRIPTION        = "
    LRO orbit number"
END_OBJECT         = COLUMN
OBJECT             = COLUMN
NAME              = "SOLAR_ZENITH_ANGLE"
DATA_TYPE          = IEEE_REAL
START_BYTE         = 11
BYTES              = 4
DESCRIPTION        = "
    Solar zenith angle at the row sample time"
END_OBJECT         = COLUMN
OBJECT             = COLUMN
NAME              = "SC_SHADOW_FLAG"
DATA_TYPE          = MSB_UNSIGNED_INTEGER
START_BYTE         = 15
BYTES              = 1
DESCRIPTION        = "
    Spacecraft in shadow flag (0=no, 1=yes)"
END_OBJECT         = COLUMN
OBJECT             = COLUMN
NAME              = "SUBSOLAR_LATITUDE"
DATA_TYPE          = IEEE_REAL
START_BYTE         = 16
BYTES              = 4
DESCRIPTION        = "
    Selenographic latitude of subsolar point"
END_OBJECT         = COLUMN
OBJECT             = COLUMN
NAME              = "SUBSOLAR_LONGITUDE"
DATA_TYPE          = IEEE_REAL
START_BYTE         = 20
BYTES              = 4
DESCRIPTION        = "
    Selenographic longitude of subsolar point"
END_OBJECT         = COLUMN
OBJECT             = COLUMN
NAME              = "SUBSC_LATITUDE"
DATA_TYPE          = IEEE_REAL
START_BYTE         = 24
BYTES              = 4
DESCRIPTION        = "
    Selenographic latitude of subspacecraft point"
END_OBJECT         = COLUMN
OBJECT             = COLUMN
NAME              = "SUBSC_LONGITUDE"
DATA_TYPE          = IEEE_REAL
START_BYTE         = 28
BYTES              = 4
DESCRIPTION        = "
    Selenographic longitude of subspacecraft point"
END_OBJECT         = COLUMN
OBJECT             = COLUMN
NAME              = "SC_ZENITH_ANGLE"
DATA_TYPE          = IEEE_REAL
START_BYTE         = 32
BYTES              = 4
DESCRIPTION        = "
    Spacecraft zenith angle at sample time"

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END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "EARTH_PHASE_ANGLE"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 36
  BYTES              = 4
  DESCRIPTION        = "
    Earth phase angle at sample time"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "PHASE_ANGLE"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 40
  BYTES              = 4
  DESCRIPTION        = "
    Illumination phase angle at sample time"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "AZIMUTH_ANGLE"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 44
  BYTES              = 4
  DESCRIPTION        = "
    Illumination azimuth angle at sample time"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "RA"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 48
  BYTES              = 4
  DESCRIPTION        = "
    Boresight right ascension"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "DEC"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 52
  BYTES              = 4
  DESCRIPTION        = "
    Boresight declination"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "ECLIPTIC_X"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 56
  BYTES              = 4
  DESCRIPTION        = "
    Spacecraft ecliptic X position"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "ECLIPTIC_Y"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 60
  BYTES              = 4
  DESCRIPTION        = "
    Spacecraft ecliptic Y position"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "ECLIPTIC_Z"
  DATA_TYPE        = IEEE_REAL
  START_BYTE        = 64
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    BYTES = 4
    DESCRIPTION = "
        Spacecraft ecliptic Z position"
END_OBJECT = COLUMN
OBJECT = COLUMN
    NAME = "STIM_DRIFT1"
    DATA_TYPE = IEEE_REAL
    START_BYTE = 68
    BYTES = 4
    DESCRIPTION = "
        Detector X drift position of STIM pixel 1"
END_OBJECT = COLUMN
OBJECT = COLUMN
    NAME = "STIM_DRIFT2"
    DATA_TYPE = IEEE_REAL
    START_BYTE = 72
    BYTES = 4
    DESCRIPTION = "
        Detector X drift position of STIM pixel 2"
END_OBJECT = COLUMN
OBJECT = COLUMN
    NAME = "OTHER_INST_INTERF"
    DATA_TYPE = MSB_UNSIGNED_INTEGER
    START_BYTE = 76
    BYTES = 1
    DESCRIPTION = "
        Other instrument interference flag"
END_OBJECT = COLUMN
OBJECT = COLUMN
    NAME = "GLOBAL_DATA_QUAL"
    DATA_TYPE = MSB_UNSIGNED_INTEGER
    START_BYTE = 77
    BYTES = 2
    DESCRIPTION = "
        Global data quality flag"
END_OBJECT = COLUMN
OBJECT = COLUMN
    NAME = "HEURISTIC_QUALITY"
    DATA_TYPE = MSB_UNSIGNED_INTEGER
    START_BYTE = 79
    BYTES = 2
    DESCRIPTION = "
        Heuristic data quality flag"
END_OBJECT = COLUMN
OBJECT = COLUMN
    NAME = "DARK_FACTOR"
    DATA_TYPE = IEEE_REAL
    START_BYTE = 81
    BYTES = 4
    DESCRIPTION = "
        Dark current calibration factor"
END_OBJECT = COLUMN
OBJECT = COLUMN
    NAME = "STRAY_FACTOR"
    DATA_TYPE = IEEE_REAL
    START_BYTE = 85
    BYTES = 4
    DESCRIPTION = "
        Stray light calibration factor"
END_OBJECT = COLUMN
OBJECT = COLUMN
```

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NAME = "OFF_NADIR_POINTING"
DATA_TYPE = MSB_UNSIGNED_INTEGER
START_BYTE = 89
BYTES = 1
DESCRIPTION = "
    Off-nadir pointing flag"
END_OBJECT = COLUMN
END_OBJECT = ANCILLARY_DATA_TABLE

OBJECT = CAL_HISTOGRAM_DATA_HEADER
BYTES = 2880 /* RECORD_BYTES x RECORDS */
HEADER_TYPE = FITS
INTERCHANGE_FORMAT = ASCII
RECORDS = 1
DESCRIPTION = "
    This is the FITS header for FITS extension number = 5, FITS
    extension name = CAL_HISTOGRAM_DATA"
END_OBJECT = CAL_HISTOGRAM_DATA_HEADER

OBJECT = CAL_HISTOGRAM_DATA_1_IMAGE
SAMPLE_BITS = 32
SAMPLE_TYPE = IEEE_REAL
AXIS_ORDER_TYPE = FIRST_INDEX_FASTEST
LINE_DISPLAY_DIRECTION = UP
SAMPLE_DISPLAY_DIRECTION = RIGHT
LINE_SAMPLES = 1024
LINES = 32
INTERCHANGE_FORMAT = BINARY
OFFSET = 0
SCALING_FACTOR = 1.00000
DESCRIPTION = "
    Data image for calibrated histogram mode frame #1."
END_OBJECT = CAL_HISTOGRAM_DATA_1_IMAGE

OBJECT = CAL_HISTOGRAM_ERROR_1_IMAGE
SAMPLE_BITS = 32
SAMPLE_TYPE = IEEE_REAL
AXIS_ORDER_TYPE = FIRST_INDEX_FASTEST
LINE_DISPLAY_DIRECTION = UP
SAMPLE_DISPLAY_DIRECTION = RIGHT
LINE_SAMPLES = 1024
LINES = 32
INTERCHANGE_FORMAT = BINARY
OFFSET = 0
SCALING_FACTOR = 1.00000
DESCRIPTION = "
    Image of propagated errors for calibrated histogram mode frame #1."
END_OBJECT = CAL_HISTOGRAM_ERROR_1_IMAGE

OBJECT = CAL_CALCULATED_COUNTRATE_HEADER
BYTES = 5760 /* RECORD_BYTES x RECORDS */
HEADER_TYPE = FITS
INTERCHANGE_FORMAT = ASCII
RECORDS = 2
DESCRIPTION = "
    This is the FITS header for FITS extension number = 6, FITS
    extension name = CAL_CALCULATED_COUNTRATE"
END_OBJECT = CAL_CALCULATED_COUNTRATE_HEADER

OBJECT = CAL_CALCULATED_COUNTRATE_TABLE
INTERCHANGE_FORMAT = BINARY

```

```

ROWS = 12498
COLUMNS = 3
ROW_BYTES = 16
OBJECT = COLUMN
  NAME = "HACK_TIME"
  DATA_TYPE = MSB_UNSIGNED_INTEGER
  START_BYTE = 1
  BYTES = 4
  DESCRIPTION = "
    Hack time at start of interval (wrap extended)"
END_OBJECT = COLUMN
OBJECT = COLUMN
  NAME = "SCUT_TIME"
  DATA_TYPE = IEEE_REAL
  START_BYTE = 5
  BYTES = 8
  DESCRIPTION = "
    Hack time converted into spacecraft UTC (seconds since 00:00 UTC,
    01 Jan 2001)"
END_OBJECT = COLUMN
OBJECT = COLUMN
  NAME = "COUNT_RATE"
  DATA_TYPE = MSB_UNSIGNED_INTEGER
  START_BYTE = 13
  BYTES = 4
  DESCRIPTION = "
    Countrate for the interval (Hz)"
END_OBJECT = COLUMN
END_OBJECT = CAL_CALCULATED_COUNTRATE_TABLE

OBJECT = LTS_DATA_HEADER
  BYTES = 5760 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE = FITS
  INTERCHANGE_FORMAT = ASCII
  RECORDS = 2
  DESCRIPTION = "
    This is the FITS header for FITS extension number = 7, FITS
    extension name = LTS_DATA"
END_OBJECT = LTS_DATA_HEADER

OBJECT = LTS_DATA_TABLE
  INTERCHANGE_FORMAT = BINARY
  ROWS = 2700
  COLUMNS = 4
  ROW_BYTES = 14
  OBJECT = COLUMN
    NAME = "HACK_TIME"
    DATA_TYPE = MSB_UNSIGNED_INTEGER
    START_BYTE = 1
    BYTES = 4
    DESCRIPTION = "
      Hack time at start of interval (wrap extended)"
  END_OBJECT = COLUMN
  OBJECT = COLUMN
    NAME = "SCUT_TIME"
    DATA_TYPE = IEEE_REAL
    START_BYTE = 5
    BYTES = 8
    DESCRIPTION = "
      Hack time converted into spacecraft UTC (seconds since 00:00 UTC,
      01 Jan 2001)"

```

```

END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "LTS_A"
  DATA_TYPE        = MSB_UNSIGNED_INTEGER
  START_BYTE        = 13
  BYTES              = 1
  DESCRIPTION        = "
    LTS A high rate scaled value"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
  NAME              = "LTS_B"
  DATA_TYPE        = MSB_UNSIGNED_INTEGER
  START_BYTE        = 14
  BYTES              = 1
  DESCRIPTION        = "
    LTS B high rate scaled value"
END_OBJECT          = COLUMN
END_OBJECT          = LTS_DATA_TABLE

OBJECT              = HOUSEKEEPING_HEADER
  BYTES              = 14400 /* RECORD_BYTES x RECORDS */
  HEADER_TYPE        = FITS
  INTERCHANGE_FORMAT = ASCII
  RECORDS             = 5
  DESCRIPTION        = "
    This is the FITS header for FITS extension number = 8, FITS
    extension name = HOUSEKEEPING"
END_OBJECT          = HOUSEKEEPING_HEADER

OBJECT              = HOUSEKEEPING_TABLE
  INTERCHANGE_FORMAT = BINARY
  ROWS                = 270
  COLUMNS            = 37
  ROW_BYTES           = 229
  OBJECT              = COLUMN
    NAME              = "SCUT_TIME"
    DATA_TYPE        = IEEE_REAL
    START_BYTE        = 1
    BYTES              = 8
    DESCRIPTION        = "
      Spacecraft UTC (seconds since epoch from HK)"
  END_OBJECT          = COLUMN
  OBJECT              = COLUMN
    NAME              = "HACK_TIME"
    DATA_TYPE        = MSB_UNSIGNED_INTEGER
    START_BYTE        = 9
    BYTES              = 4
    DESCRIPTION        = "
      Extended instrument hack time (since HK on)"
  END_OBJECT          = COLUMN
  OBJECT              = COLUMN
    NAME              = "PACK_CNT"
    DATA_TYPE        = MSB_UNSIGNED_INTEGER
    START_BYTE        = 13
    BYTES              = 2
    DESCRIPTION        = "
      14-bit packet count (since HK on)"
  END_OBJECT          = COLUMN
  OBJECT              = COLUMN
    NAME              = "PACKET_DATA"
    DATA_TYPE        = MSB_UNSIGNED_INTEGER

```

```

START_BYTE          = 15
BYTES               = 122
ITEMS               = 122
ITEM_BYTES          = 1
DESCRIPTION          = "
    This column contains the 122 bytes of the raw housekeeping
    telemetry packet generated by the LAMP instrument. Detailed
    information needed to decommutate and interpret the packet
    contents can be found in the LAMP Software User's Manual."
END_OBJECT           = COLUMN
OBJECT              = COLUMN
NAME                 = "INST_STATE"
DATA_TYPE            = MSB_UNSIGNED_INTEGER
START_BYTE          = 137
BYTES               = 1
DESCRIPTION          = "
    Instrument state (2,6=SAFE, 1,5=CHK, 3=PIX, 7=HIS)"
END_OBJECT           = COLUMN
OBJECT              = COLUMN
NAME                 = "LAST_SAFETY"
DATA_TYPE            = MSB_UNSIGNED_INTEGER
START_BYTE          = 138
BYTES               = 1
DESCRIPTION          = "
    Last safety (0=none)"
END_OBJECT           = COLUMN
OBJECT              = COLUMN
NAME                 = "LVPS_STAT"
DATA_TYPE            = MSB_UNSIGNED_INTEGER
START_BYTE          = 139
BYTES               = 1
DESCRIPTION          = "
    Active LVPS (1=A, 2=B, 3=both)"
END_OBJECT           = COLUMN
OBJECT              = COLUMN
NAME                 = "HVPS_STAT"
DATA_TYPE            = MSB_UNSIGNED_INTEGER
START_BYTE          = 140
BYTES               = 1
DESCRIPTION          = "
    Active HVPS (0=off, 1=A, 2=B, 3=both)"
END_OBJECT           = COLUMN
OBJECT              = COLUMN
NAME                 = "MIRR_TMP_SET"
DATA_TYPE            = IEEE_REAL
START_BYTE          = 141
BYTES               = 4
DESCRIPTION          = "
    Mirror temperature set point (degrees C)"
END_OBJECT           = COLUMN
OBJECT              = COLUMN
NAME                 = "GRAT_TMP_SET"
DATA_TYPE            = IEEE_REAL
START_BYTE          = 145
BYTES               = 4
DESCRIPTION          = "
    Grating temperature set point (degrees C)"
END_OBJECT           = COLUMN
OBJECT              = COLUMN
NAME                 = "MIRR_HTR_STAT"
DATA_TYPE            = MSB_UNSIGNED_INTEGER

```

```

START_BYTE          = 149
BYTES               = 1
DESCRIPTION         = "
    Mirror heater status (0=off, 1=A, 2=B, 3=both)"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
NAME                = "GRAT_HTR_STAT"
DATA_TYPE           = MSB_UNSIGNED_INTEGER
START_BYTE         = 150
BYTES               = 1
DESCRIPTION         = "
    Grating heater status (0=off, 1=A, 2=B, 3=both)"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
NAME                = "MIRR_A_TMP"
DATA_TYPE           = IEEE_REAL
START_BYTE         = 151
BYTES               = 4
DESCRIPTION         = "
    Mirror temperature A (primary) (degrees C)"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
NAME                = "MIRR_B_TMP"
DATA_TYPE           = IEEE_REAL
START_BYTE         = 155
BYTES               = 4
DESCRIPTION         = "
    Mirror temperature B (redundant) (degrees C)"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
NAME                = "GRAT_A_TMP"
DATA_TYPE           = IEEE_REAL
START_BYTE         = 159
BYTES               = 4
DESCRIPTION         = "
    Grating temperature A (primary) (degrees C)"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
NAME                = "GRAT_B_TMP"
DATA_TYPE           = IEEE_REAL
START_BYTE         = 163
BYTES               = 4
DESCRIPTION         = "
    Grating temperature B (redundant) (degrees C)"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
NAME                = "CDH_ELEC_TMP"
DATA_TYPE           = IEEE_REAL
START_BYTE         = 167
BYTES               = 4
DESCRIPTION         = "
    C&DH electronics temperature (degrees C)"
END_OBJECT          = COLUMN
OBJECT              = COLUMN
NAME                = "DET_HOUS_TMP"
DATA_TYPE           = IEEE_REAL
START_BYTE         = 171
BYTES               = 4
DESCRIPTION         = "
    Detector housing temperature (degrees C)"
END_OBJECT          = COLUMN

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```
OBJECT          = COLUMN
  NAME          = "APDOOR"
  DATA_TYPE    = MSB_UNSIGNED_INTEGER
  START_BYTE    = 175
  BYTES         = 1
  DESCRIPTION   = "
    Aperture door state (1=closed, 2=open, 3=between)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
  NAME          = "LTS_DARK"
  DATA_TYPE    = MSB_UNSIGNED_INTEGER
  START_BYTE    = 176
  BYTES         = 1
  DESCRIPTION   = "
    LTS dark status (0=light, 1=dark)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
  NAME          = "STIM_STAT"
  DATA_TYPE    = MSB_UNSIGNED_INTEGER
  START_BYTE    = 177
  BYTES         = 1
  DESCRIPTION   = "
    STIM status (0=off, 1=on)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
  NAME          = "HV_SETPNT"
  DATA_TYPE    = IEEE_REAL
  START_BYTE    = 178
  BYTES         = 4
  DESCRIPTION   = "
    Detector HVPS setpoint (kVolt)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
  NAME          = "MCPV1"
  DATA_TYPE    = IEEE_REAL
  START_BYTE    = 182
  BYTES         = 4
  DESCRIPTION   = "
    Detector MCP voltage 1 (kVolt)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
  NAME          = "ANODEV1"
  DATA_TYPE    = IEEE_REAL
  START_BYTE    = 186
  BYTES         = 4
  DESCRIPTION   = "
    Detector anode voltage 1 (kVolt)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
  NAME          = "STRIP1"
  DATA_TYPE    = IEEE_REAL
  START_BYTE    = 190
  BYTES         = 4
  DESCRIPTION   = "
    Detector strip current 1 (uA)"
END_OBJECT      = COLUMN
OBJECT          = COLUMN
  NAME          = "MCPV2"
  DATA_TYPE    = IEEE_REAL
  START_BYTE    = 194
  BYTES         = 4
```

```

DESCRIPTION          = "
    Detector MCP voltage 2 (kVolt) "
END_OBJECT           = COLUMN
OBJECT               = COLUMN
NAME                 = "ANODEV2"
DATA_TYPE            = IEEE_REAL
START_BYTE           = 198
BYTES                = 4
DESCRIPTION          = "
    Detector anode voltage 2 (kVolt) "
END_OBJECT           = COLUMN
OBJECT               = COLUMN
NAME                 = "STRIPI2"
DATA_TYPE            = IEEE_REAL
START_BYTE           = 202
BYTES                = 4
DESCRIPTION          = "
    Detector strip current 2 (uA) "
END_OBJECT           = COLUMN
OBJECT               = COLUMN
NAME                 = "MAX_MCPV"
DATA_TYPE            = IEEE_REAL
START_BYTE           = 206
BYTES                = 4
DESCRIPTION          = "
    Maximum MCP voltage last second (kVolt) "
END_OBJECT           = COLUMN
OBJECT               = COLUMN
NAME                 = "MAX_STRIPI"
DATA_TYPE            = IEEE_REAL
START_BYTE           = 210
BYTES                = 4
DESCRIPTION          = "
    Maximum summed strip current last second (uA) "
END_OBJECT           = COLUMN
OBJECT               = COLUMN
NAME                 = "DISCRIM"
DATA_TYPE            = IEEE_REAL
START_BYTE           = 214
BYTES                = 4
DESCRIPTION          = "
    Detector discriminator voltage (volt) "
END_OBJECT           = COLUMN
OBJECT               = COLUMN
NAME                 = "COUNT_RATE"
DATA_TYPE            = MSB_UNSIGNED_INTEGER
START_BYTE           = 218
BYTES                = 4
DESCRIPTION          = "
    Analog (raw) countrate (Hz) "
END_OBJECT           = COLUMN
OBJECT               = COLUMN
NAME                 = "RAW_LTS_A"
DATA_TYPE            = MSB_UNSIGNED_INTEGER
START_BYTE           = 222
BYTES                = 2
DESCRIPTION          = "
    Raw LTS A (14 bits, raw counts) "
END_OBJECT           = COLUMN
OBJECT               = COLUMN
NAME                 = "RAW_LTS_B"

```

```

DATA_TYPE          = MSB_UNSIGNED_INTEGER
START_BYTE         = 224
BYTES              = 2
DESCRIPTION        = "
    Raw LTS B (14 bits, raw counts)"
END_OBJECT         = COLUMN
OBJECT             = COLUMN
NAME               = "LTS_CYCLES"
DATA_TYPE          = MSB_UNSIGNED_INTEGER
START_BYTE         = 226
BYTES              = 1
DESCRIPTION        = "
    LTS safing cycles in acquisition"
END_OBJECT         = COLUMN
OBJECT             = COLUMN
NAME               = "SAFETY"
DATA_TYPE          = MSB_UNSIGNED_INTEGER
START_BYTE         = 227
BYTES              = 1
DESCRIPTION        = "
    Current safety status (0=none pending)"
END_OBJECT         = COLUMN
OBJECT             = COLUMN
NAME               = "SAFE_TIMER"
DATA_TYPE          = MSB_UNSIGNED_INTEGER
START_BYTE         = 228
BYTES              = 2
DESCRIPTION        = "
    Safety timeout timer (seconds remaining)"
END_OBJECT         = COLUMN
END_OBJECT         = HOUSEKEEPING_TABLE

OBJECT             = WAVELENGTH_LOOKUP_HEADER
BYTES              = 2880 /* RECORD_BYTES x RECORDS */
HEADER_TYPE        = FITS
INTERCHANGE_FORMAT = ASCII
RECORDS            = 1
DESCRIPTION        = "
    This is the FITS header for FITS extension number = 9, FITS
    extension name = WAVELENGTH_LOOKUP_TABLE"
END_OBJECT         = WAVELENGTH_LOOKUP_HEADER

OBJECT             = WAVELENGTH_LOOKUP_IMAGE
SAMPLE_BITS        = 32
SAMPLE_TYPE        = IEEE_REAL
AXIS_ORDER_TYPE    = FIRST_INDEX_FASTEST
LINE_DISPLAY_DIRECTION = UP
SAMPLE_DISPLAY_DIRECTION = RIGHT
LINE_SAMPLES       = 1024
LINES              = 32
INTERCHANGE_FORMAT = BINARY
OFFSET             = 0
SCALING_FACTOR     = 1.00000
DESCRIPTION        = "
    Wavelength lookup image for the LAMP calibration.  The value of
    each pixel is the wavelength (in Angstroms) associated with that
    pixel."
END_OBJECT         = WAVELENGTH_LOOKUP_IMAGE
END

```