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Moon Mineralogy Mapper

ARCHIVE VOLUME SOFTWARE INTERFACE SPECIFICATION

Version 3.11

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DOCUMENT CHANGE LOG

Change	Date	Affected Portions
Change Level 1A to Level 1B	8/02/07	All
Change non-resampled to resampled	8/01/07	All
Update data quality image extension	8/16/07	Pages, 4, 5, 6, 13
Various updates to Section 5	9/6/07	14
Change file/directory names from lower to uppercase	9/6/07	4, 5, 8, 13, 14
Added Level 2 (McLaughlin)	12/10/07	All
Updates of several sections per S. McLauglin inputs	1/25/08	2, 3, 4, 5
Removed data quality images	3/19/08	
Updated file list in L1B and L2 DATA directories Added Decimal Day of Year	5/21/08	3, 4, 5, 6, 7, 8
Updated Table 3-1, Table 3-3, Table 3-6, Table 4-1	8/12/08	2, 8, 9, 14
Updated sections pertaining to Level 2; Renamed second Table 3-10 to 3-11 & 3-11 to 3-12; Separated several tables to make it more obvious that Level 2 will be produced and delivered separate from L0/1B; Revised archive delivery dates due to launch delays (S. McLaughlin)	8/22/08	Sections 1.3, 3.2.2, 3..3, 3.6, and 4.4; Tables 3-2, 3-3, 3-4, 3-6, 3-10, 3-11, 3-12, 4-1, 4-2, and 5-1.
Changed *TIM.TXT to *TIM.TAB	8/26/08	Sections 3.2.1 and Table 3-3a.
Removed "Levels 0, 1B, and 2" from the document title; Added JPL Doc # for Data Product SIS; Changed Table 3-3 references to 3-3a and 3.3b; For Level 2 label filenames, changed "RFL" string to "L2" to be consistent with naming convention for L0 and L1B labels. (S.McLaughlin)	8/28/08	Sections 1.3, 3.2.1 and 3.2.2; Tables 3-2, 3-3b, and 4.1
Updated start week nomenclature of data directory tree from YYYYMMDD_n to YYYYMMDD_nn	9/10/08	Section 3
Minor revisions to reflect changes to L2 calibration processing (S. McLaughlin).	9/19/08	Section 3.7.2; Tables 3-10 and 4-2; Table 4-1 (cell borders only)
Changed data storage type for L2 from 32-bit reals to 16-bit signed integers and expected L2 file sizes (S.McLaughlin)	11/20/08	
Added global band pass files to Calib directory contents tables	01/06/09	Section 3.7.1, 4.2.5
Added file info to EXTRAS table	07/01/09	Section 3.9
Added OP acronym	09/14/09	Acronyms and Abbreviations List
Revised directory structure	09/14/09	Sections 3.2.1, 3.2.2
Updated tables	10/12/09	Section 4.2.5, Section 4.3 and Table 5.1

Added "Level 0 and Level 1B products will be assigned…"	11/04/09	Section 3.2.1
Added the words "position and pointing as a function of ephemeris time:"	01/05/10	Section 3.8
Updated Table 5-2	06/24/10	Section 4.4

TBD ITEMS

Section	Description
3.7	Files to be included in CALIB directory
4.7	For Imaging Node: VOLUME_SET_ID range for L0/1B and L2 archive volumes

ACRONYMS AND ABBREVIATIONS

ACT	Applied Coherent Technology Corporation
ASCII	American Standard Code for Information Interchange
CD-ROM	Compact Disk – Read-Only Memory
CD-WO	Write-Once Compact Disk
CODMAC	Committee on Data Management, Archiving, and Computing
DN	Digital Number
IGDS	Instrument Ground Data System (JPL)
ISO	International Standards Organization
ISRO	Indian Space Research Organization
JPL	Jet Propulsion Laboratory
LCGWG	Lunar Geodesy and Cartography Working Group
MMM/M3	Moon Mineralogy Mapper
MODTRAN	Moderate Resolution Atmospheric Transmission
NSSDC	National Space Science Data Center (NASA Goddard)
ODL	Object Description Language
OP	Optical Period
PDS	Planetary Data System (NASA)
PSG	Project Science Group
SDVT	Science Data Validation Team
SIS	Software Interface Specification
TBD	To Be Determined
UMD	University of Maryland
UTC	Coordinated Universal Time

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*.

1. Introduction

1.1. Purpose and Scope

This Software Interface Specification is intended to be used by those who wish to understand the format and content of the Moon Mineralogy Mapper (M^3) Archive. Typically, these individuals would be software engineers, data analysts, or planetary scientists.

The specifications in this document apply to all M^3 standard product archive volumes that are generated by the M^3 Project.

1.2. Content Overview

This Archive Volume Software Interface Specification (SIS) describes the format, content, and generation of the M^3 archive. Section 2, Archive Volume Generation, describes the procedure for transferring data products to archive media. Section 3, Archive Volume Contents, describes the structure of the archive volumes and the contents of each file. Section 4, Archive Volume Format, describes the file formats used on the archive volumes. Finally, Section 5, Support Staff and Cognizant Persons, lists the individuals responsible for generating the archive volumes. The products are described in detail in the M^3 Data Product SIS [Applicable Document 3 below].

This SIS uses the Committee On Data Management And Computation (CODMAC) data level numbering system to describe the processing level of M^3 data products. Table 1-1 shows the description of the CODMAC data processing levels and the correlation with the NASA processing levels. All M^3 data products comply with NASA processing levels standards. The CODMAC system is used here because it is the standard used by the PDS.

Table 1-1 Processing Levels for Science Data Sets

NASA Level	CODMAC Level	Description
Packet data	Raw – Level 1	Telemetry data stream as received at the ground station, with science and engineering data embedded.
0	Edited – Level 2	Instrument science packets (e.g., raw voltages, counts) at full resolution, time ordered, with duplicates and transmission errors removed. Corresponds to Space Science Board's Committee on Data Management and Computation (CODMAC) Edited Data (see National Academy press, 1986).
1A	Calibrated – Level 3	Level 0 data that have been located in space and may have been transformed (e.g. calibrated, rearranged) in a reversible manner and packaged with needed ancillary and auxiliary data (e.g., radiances with the calibration equations applied). Corresponds to CODMAC Calibrated Data.
1B	Resampled – Level 4	Irreversibly transformed (e.g., resampled, remapped, calibrated) values of the instrument measurements (e.g., radiances, magnetic field strength). Corresponds to CODMAC Resampled Data.
1C	Derived – Level 5	Level 1A or 1B data, that have been resampled and mapped onto, uniform space-time grids. The data are calibrated (i.e., radiometrically corrected) and may have additional corrections applied (e.g., terrain correction). Corresponds to CODMAC Derived Data.
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. Corresponds to CODMAC Derived Data.
3	Derived – Level 5	Geophysical parameters mapped onto uniform space-time grids. Corresponds to CODMAC Derived Data.
	Ancillary Data – Level 6	Data needed to generate calibrated or resampled data sets.

1.3. Applicable Documents and Constraints

This Archive Volume SIS is intended to be consistent with the following documents:

1. M^3 Project Data Management and Archive Plan, S. R. Lundeen and J. M. Diehl, Rev. 2.4, February 22, 2010.

2. M^3 Instrument Ground Data System (IGDS), UMD/ACT, and PDS Imaging Node Interface Control Document, Version 4.2, January 25, 2008 (JPL D-37304).

3. M^3 Data Product Software Interface Specification, S. R. Lundeen, Rev. 8.3, February 22, 2010, JPL D-38529.

4. *Planetary Data System Archive Preparation Guide*, June 4, 2008, Version 1.3, JPL D-31224.

5. *Planetary Data System Standards Reference*, March 20, 2006, Version 3.7. JPL D-7669, Part 2.

6. ISO 9660-1988, Information Processing - Volume and File Structure of CD-ROM for Information Exchange, April 15, 1988.

1.4. Relationships with Other Interfaces

This Archive Volume SIS could be affected by changes to the design of the M^3 standard data products [Applicable Document 3]. Although every attempt is made to make the two documents consistent, this one takes precedence on issues of archive structure whereas the Data Products SIS [Applicable Document 3] takes precedence in issues of archive content.

2. Archive Volume Structure

This section describes the overall structure of all M^3 archive volumes.

The M^3 archive will be made available online via Web and FTP servers. This will be the primary means of distribution. Therefore the archive will be organized as a set of virtual volumes. A single volume will consist of an M^3 optical period of data acquisition (see Table 3-2).

Each M^3 archive volume will contain at minimum the following directories below the root directory:

- CATALOG
- DATA
- INDEX
- DOCUMENT

In addition to these, an M^3 archive volume may include other directories:

- CALIB
- GEOMETRY
- EXTRAS
- LABEL

Section 3 describes the contents and required files for each directory.

3. Archive Volume Contents

This section describes the contents of the M^3 archive volumes, including the file names, file contents, file types, and organization responsible for providing the files. The

indication that a file is required means that it is required by the PDS standards for archive volumes, as specified in the PDS Standards Reference, [Applicable Document 5].

3.1. ROOT Directory Contents

Files in the ROOT Directory include an overview of the archive, a description of the volume for the PDS Catalog, and a list of errata or comments about the archive. The following files are contained in the ROOT Directory.

Table 3-1 ROOT Directory Contents

File Name	File Contents	File Provided By
AAREADME.TXT	Volume content and format information	M^3 Team
ERRATA.TXT	A cumulative listing of comments and updates concerning all archive volumes published to date (optional)	M^3 Team
VOLDESC.CAT	A description of the contents of this volume in a PDS format readable by both humans and computers	M^3 Team

3.2. DATA Directory Contents and Naming

3.2.1. Level 0 and 1B

Under the DATA directory there is a separate subdirectory based on the start and end times of a 13-week imaging period. Each imaging period subdirectory is further divided into subdirectories for each month of an Optical Period (OP) (see Table 3-2 for an overview of Optical Periods 1 and 2). Each OP month subdirectory is further divided based on the processing level (e.g. Level 0 or Level 1B). Level 0 and Level 1B products will be assigned to different data sets such that one archive volume will contain products from more than one data set.

Table 3-2 Overview of M^3 Operations by Optical Period

Sub-OP Name	Description	Time Period
OP1A	Commissioning phase through "warm" data	2008 Nov 18 to 2009 Jan 24
OP1B	Start of "cold" data through end of OP1	2009 Jan 09 to 2009 Feb 14
OP2A	100 km orbit with star trackers	2009 Apr 15 to 2009 Apr 27
OP2B	100 km orbit, no star trackers	2009 May 13 to 2009 May 16
OP2C	200 km orbit, no star trackers	2009 May 20 to 2009 Aug 16

The DATA directory may contain the following files:

- NASA Level 0 data consisting of raw, science data in units of DN

- NASA Level 1B data consisting of resampled calibrated data in units of spectral radiance

- Pixel center location file
- Observational geometry and illumination parameters
- File containing time of each image line in UTC and Decimal Day of Year (DDOY)

The following is a map of the DATA directory structure:

```
--- /DATA        Contains all data in a branching tree structure of
                 subdirectories. Subdirectory names are based on
                 TBD and filenames are based on the time stamp of
                 the first frame of data.

   - start  end  DATA subdirectory containing files
                 between the start date in the format of
                 YYYYMMDD of a 13-week Optical Period
                 and the end date in the same format of
                 YYYYMMDD of a 13-week Optical Period.

      - OP_month DATA subdirectory containing files for each
                 month of an Optical Period (OP) in the format
                 YYYYMM where YYYY is the year and MM is
                 the month.

         - L0    DATA subdirectory containing raw science
                 data. See Table 3-2 for file name definition.
                 See Table 3-3a for file contents.

            -    M3MYYYYMMDDTHHMMSS_VNN_L0.IMG
                 M3MYYYYMMDDTHHMMSS_VNN_L0.HDR

            -    M3MYYYYMMDDTHHMMSS_VNN_L0.LBL

         - L1B   DATA subdirectory containing Level 1B
                 data products. See Table 3-2 for file
                 name definition. See Table 3-3a for file
                 contents.

            -    M3MYYYYMMDDTHHMMSS_VNN_RDN.IMG

            -    M3MYYYYMMDDTHHMMSS_VNN_RDN.HDR

            -    M3MYYYYMMDDTHHMMSS_VNN_L1B.LBL

            -    M3MYYYYMMDDTHHMMSS_VNN_LOC.IMG

            -    M3MYYYYMMDDTHHMMSS_VNN_LOC.HDR

            -    M3MYYYYMMDDTHHMMSS_VNN_OBS.IMG

            -    M3MYYYYMMDDTHHMMSS_VNN_OBS.HDR

            -    M3MYYYYMMDDTHHMMSS_VNN_TIM.TAB
```
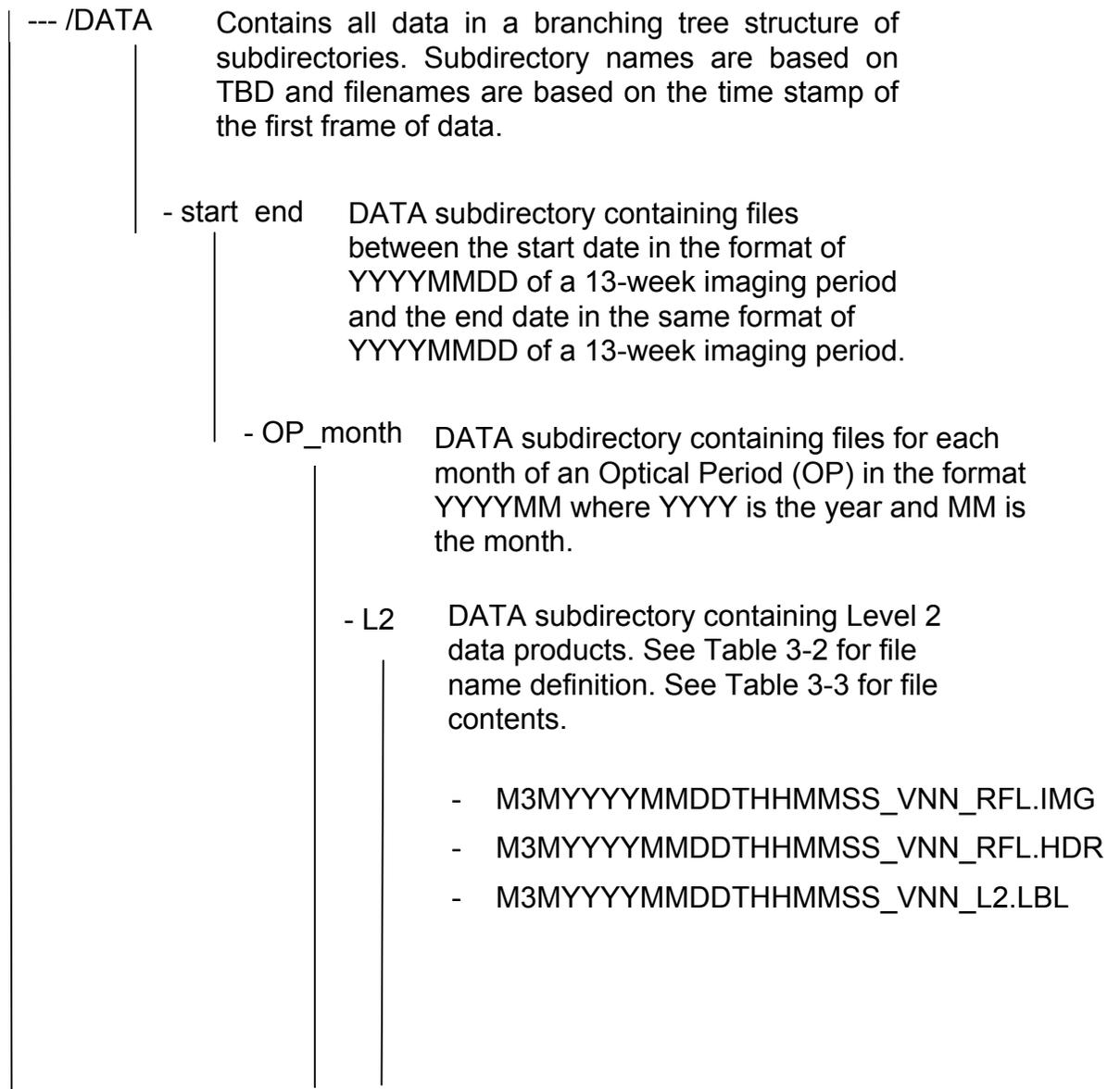
3.2.2. Level 2

The DATA directory structure for the Level 2 will match that for L0/L1B: Under the DATA directory there is a separate subdirectory based on the start and end times of a 13-week imaging period. Each imaging period subdirectory is further divided into subdirectories for each month of an Optical Period (OP). Each OP month subdirectory is further divided based on the processing level (e.g. Level 2).

The DATA directory may contain the following files:

- NASA Level 2 data consisting of Level 1B radiance data that have been photometrically corrected and converted to reflectance image cubes (unitless) along with detached ENVI headers and PDS labels.

The following is a map of the DATA directory structure:

--- /DATA   Contains all data in a branching tree structure of subdirectories. Subdirectory names are based on TBD and filenames are based on the time stamp of the first frame of data.

    - start   end   DATA subdirectory containing files between the start date in the format of YYYYMMDD of a 13-week imaging period and the end date in the same format of YYYYMMDD of a 13-week imaging period.

      - OP_month   DATA subdirectory containing files for each month of an Optical Period (OP) in the format YYYYMM where YYYY is the year and MM is the month.

        - L2   DATA subdirectory containing Level 2 data products. See Table 3-2 for file name definition. See Table 3-3 for file contents.

            - M3MYYYYMMDDTHHMMSS_VNN_RFL.IMG

            - M3MYYYYMMDDTHHMMSS_VNN_RFL.HDR

            - M3MYYYYMMDDTHHMMSS_VNN_L2.LBL

Table 3-3 File Name Definition

File Name Character	File Name Character Definition	Example
M3	The instrument.	M3
M	The imaging mode. G for global mode and T for target mode.	G or T
YYYY	The year of the time stamp from the first image frame of the image.	2007
MM	The month of the time stamp from the first image frame of the image.	03
DD	The day of the time stamp from the first frame of the image.	16
T	A single character string that precedes the UTC time of the time stamp from the first frame of the image.	T
HHMMSS	The hour, minute within the hour, and the second within the minute in UTC of the time stamp from the first frame of the image.	055623
VNN	The version number of the product.	V10
L0, L1B, L2, RDN, LOC, OBS, TIM, RFL	The type of data product. L0, L1B, and L2 are used in the label file names.	RDN or RFL

Table 3-4a Contents of Files Located in DATA Directory for Level 0

File Name	File Contents
M3MYYYYMMDDTHHMMSS_VNN_L0.IMG	Decompressed, raw image data in units of DN.
M3MYYYYMMDDTHHMMSS_VNN_L0.HDR	ENVI header associated with the raw image data.
M3MYYYYMMDDTHHMMSS_VNN_L0.LBL	PDS compliant label associated with the raw image data.

Table 3-4b Contents of Files Located in DATA Directory for Level 1B

File Name	File Contents
M3MYYYYMMDDTHHMMSS_VNN_RDN.IMG	Image data converted to units of spectral radiance.
M3MYYYYMMDDTHHMMSS_VNN_RDN.HDR	ENVI header associated with the spectral radiance image data.
M3MYYYYMMDDTHHMMSS_VNN_L1B.LBL	PDS compliant label which points to the spectral radiance image data (*_RDN), pixel location data (*_LOC), observation geometry data (*_OBS), and the UTC timing data (*_TIM).
M3MYYYYMMDDTHHMMSS_VNN_LOC.IMG	Pixel location data containing lunar longitude, lunar latitude, and radius associated with the spectral radiance image data.
M3MYYYYMMDDTHHMMSS_VNN_LOC.HDR	ENVI header associated with the pixel location (*_LOC) data.
M3MYYYYMMDDTHHMMSS_VNN_OBS.IMG	Observational and illumination parameters associated with the spectral radiance image data.
M3MYYYYMMDDTHHMMSS_VNN_OBS.HDR	ENVI header associated with the observational and illumination parameters (*_OBS) data.
M3MYYYYMMDDTHHMMSS_VNN_TIM.TAB	UTC timing information for every image line in the associated spectral radiance image data.

Table 3-4c Contents of Files Located in DATA Directory for Level 2

File Name	File Contents
M3MYYYYMMDDTHHMMSS_VNN_RFL.IMG	Level 1B radiance image cubes that have been photometrically corrected and converted to reflectance (unitless).
M3MYYYYMMDDTHHMMSS_VNN_RFL.HDR	ENVI header associated with the reflectance image data.
M3MYYYYMMDDTHHMMSS_VNN_L2.LBL	PDS compliant label associated with the reflectance image data.

3.3. INDEX Directory Contents

Files in the INDEX Directory are provided to help the user locate products on this archive volume and on previously released volumes in the archive. The following files are contained in the INDEX Directory. If the Level 0/1B archive is divided among two or more physical volumes, the files L0_INDEX.TAB and L1B_INDEX.TAB list the contents of an individual volume, and CUMINDEX.TAB lists the contents of all the volumes. This

requirement also applies to the L2_INDEX.TAB and CUMINDEX.TAB files for the Level 2 archive.

Table 3-5a INDEX Directory Contents for Levels 0/1B

File Name	File Contents	File Provided By
INDXINFO.TXT	A description of the contents of this directory	M^3 Team
L0_INDEX.TAB	A table listing all L0 data products on this volume	M^3 Team
L0_INDEX.LBL	A PDS detached label that describes L0_INDEX.TAB	M^3 Team
L1B_INDEX.TAB	A table listing all L1B data products on this volume	M^3 Team
L1B_INDEX.LBL	A PDS detached label that describes L1B_INDEX.TAB	M^3 Team
CUMINDEX.TAB	A cumulative listing of all data products on this volume and on previous volumes in this set	M^3 Team
CUMINDEX.LBL	A PDS detached label that describes CUMINDEX.TAB	M^3 Team

Table 3-5b INDEX Directory Contents for Level 2

File Name	File Contents	File Provided By
INDXINFO.TXT	A description of the contents of this directory	M^3 Team
L2_INDEX.TAB	A table listing all L2 data products on this volume	M^3 Team
L2_INDEX.LBL	A PDS detached label that describes L2_INDEX.TAB	M^3 Team
CUMINDEX.TAB	A cumulative listing of all data products on this volume and on previous volumes in this set	M^3 Team
CUMINDEX.LBL	A PDS detached label that describes CUMINDEX.TAB	M^3 Team

3.4. DOCUMENT Directory Contents

The DOCUMENT Directory contains documentation to help the user understand and use the archive data. The following files are contained in the DOCUMENT Directory.

Table 3-6 DOCUMENT Directory Contents

File Name	File Contents	File Provided By
DOCINFO.TXT	A description of the contents of this directory	M^3 Team
DPSIS.TXT or .HTM	The Data Product SIS as text or hypertext	M^3 Team
DPSIS.PDF	The Data Product SIS as a PDF file	M^3 Team
DPSIS.LBL	A PDS detached label that describes both DPSIS.TXT(HTM) and DPSIS.PDF	M^3 Team
ARCHSIS.TXT or .HTM	The Archive Volume SIS (this document) as text or hypertext	M^3 Team
ARCHSIS.PDF	The Archive Volume SIS (this document) as a PDF file	M^3 Team

ARCHSIS.LBL	A PDS detached label that describes both ARCHSIS.TXT(HTM) and ARCHSIS.PDF.	M³ Team
L1B_NAV_DESC.ASC	Description of the spacecraft orientation, attitude models, and keywords as relevant to L1B data products found in CH1M3_0002 volume.	M³ Team
M3_COVERAGE_BY_OP_FIG2_4.JPG	Figure of the M3 coverage of the lunar surface by optical period as included in the M3 Data Product SIS document.	M³ Team
M3_COVERAGE_BY_OP_FIG2_4.LBL	A PDS detached label that describes the M3 coverage figure.	M³ Team
M3_L0_TIME_DECODING.ASC	Detailed description of format and usage of M3 raw time data.	M³ Team
M3_OPTICAL_DESIGN_FIG2_2.JPG	M3 optical design figure as included in the M3 Data Product SIS document.	M³ Team
M3_OPTICAL_DESIGN_FIG2_2.LBL	A PDS detached label that describes the M3 optical design figure.	M³ Team
M3_OP_INFO.ASC	Contains the file name of the first and the last M3 image acquisition that span each Optical Period.	M³ Team
M3_OP_INFO.LBL	A PDS detached label that describes the optical period overview document.	M³ Team
MINERAL_RFL_SPECTRA_FIG2_1.JPG	Plot of selected M3 reflectance spectra of lunar minerals as included in the M3 DataProduct SIS document.	M³ Team
MINERAL_RFL_SPECTRA_FIG2_1.LBL	A PDS detached label that describes the M3 reflectance spectra graph.	M³ Team

3.5. CATALOG Directory Contents

The files in the CATALOG Directory provide a top-level understanding of the mission, spacecraft, instruments, and data sets. The files in this directory are coordinated with the PDS data engineer, who is responsible for loading them into the PDS catalog. The following files are found in the CATALOG Directory.

Table 3-7a CATALOG Directory Contents for Levels 0/1B

File Name	File Contents	File Provided By
CATINFO.TXT	A description of the contents of this directory	M³ Team
L0_DS.CAT	Level 0 data set information for the PDS catalog	M³ Team
L1B_VN_DS.CAT	Level 1B data set information for the PDS catalog	M³ Team
INSTHOST.CAT	Instrument host (i.e., spacecraft) information for the PDS catalog	ISRO
INST.CAT	Instrument information for the PDS catalog	M³ Team
MISSION.CAT	Mission information for the PDS catalog	ISRO
PERSON.CAT	Personnel information for the PDS catalog (Team and PDS personnel responsible for generating the archive)	M³ Team
REF.CAT	References mentioned in other *.CAT files	M³ Team

Table 3-7b CATALOG Directory Contents for Level 2

File Name	File Contents	File Provided By
CATINFO.TXT	A description of the contents of this directory	M^3 Team
L2_DS.CAT	Level 2 data set information for the PDS catalog	M^3 Team
INSTHOST.CAT	Instrument host (i.e., spacecraft) information for the PDS catalog	M^3 Team
INST.CAT	Instrument information for the PDS catalog	M^3 Team
MISSION.CAT	Mission information for the PDS catalog	M^3 Team
PERSON.CAT	Personnel information for the PDS catalog (Team and PDS personnel responsible for generating the archive)	M^3 Team
REF.CAT	References mentioned in other *.CAT files	M^3 Team

3.6. CALIB Directory Contents

3.6.1. Level 0 and 1B

The CALIB Directory contains calibration files used to process the Level 0 and 1B data products, or calibration data needed to use the Level 0 and 1B data products. The following files are contained in the CALIB Directory on archive volumes for Level 0 and 1B data products.

Table 3-10 CALIB Directory Contents for Levels 0/1B

File Name	File Contents	File Provided By
CALINFO.TXT	A description of the contents of this directory	M^3 Team
M3MYYYYMMDD_RDN_CAL.TAB	Radiometric calibration data	M^3 Team
M3MYYYYMMDD_RDN_CAL.LBL	PDS compliant label associated with the radiometric calibration data	M^3 Team
M3MYYYYMMDD_RDN_SPC.TAB	Spectral calibration data	M^3 Team
M3MYYYYMMDD_RDN_SPC.LBL	PDS compliant label associated with the spectral calibration data	M^3 Team
M3MYYYYMMDD_RDN_GAIN.TAB	Radiometric gain factor data	M^3 Team
M3MYYYYMMDD_RDN_GAIN.LBL	PDS compliant label associated with the radiometric gain factor data	M^3 Team
M3MYYYYMMDD_RDN_BPF.IMG	Global band pass (generated by averaging target mode best-fit Gaussians which are normalized to unit sum 86 global bands)	M^3 Team
M3MYYYYMMDD_RDN_BPF.HDR	ENVI header associated with the global band pass data	M^3 Team
M3MYYYYMMDD_RDN_BPF.LBL	PDS compliant label associated with the global band pass data	M^3 Team

M3_DET_TEMP.TAB	Table of M3 images and corresponding detector temperature	M^3 Team
M3_DET_TEMP.LBL	PDS compliant label associated with the M3 detector temperature table	M^3 Team

3.6.2. Level 2

The CALIB Directory contains calibration files applied by the Level 2 pipeline to the Level 1B radiance data to produce the Level 2 reflectance data products, or calibration data needed to use the Level 2 data products. The following files are contained in the CALIB Directory on archive volumes for Level 2 data products.

Table 3-11 CALIB Directory Contents for Level 2

File Name	File Contents	File Provided By
CALINFO.TXT	A description of the contents of this directory	M^3 Team
M3MYYYYMMDD_SOLAR_SPEC.TAB	Table of the MODTRAN solar spectrum by wavelength applied as the I/F conversion from Level 1B to Level 2 reflectance data	M^3 Team
M3MYYYYMMDD_ SOLAR_SPEC.LBL	PDS compliant label associated with the solar spectrum table	M^3 Team
M3MYYYYMMDD_PHOT_CORR.TAB	Table of photometric correction factors by phase angle and wavelength used to normalize the phase angle of the L1B data to the Apollo 16 phase angle	M^3 Team
M3MYYYYMMDD_ PHOT_CORR.LBL	PDS compliant label associated with the photometric correction table	M^3 Team
M3MYYYYMMDD_APOLLO16_CORR.TAB	Table of Apollo 16 ground-truth correction factors by wavelength applied by the L2 reflectance process	M^3 Team
M3MYYYYMMDD_APOLLO16_CORR.LBL	PDS compliant label associated with the Apollo 16 correction table	M^3 Team

3.7. GEOMETRY Directory Contents

The GEOMETRY Directory contains a single file, GEOMINFO.TXT, which directs the reader to the various SPICE kernels that contain the data necessary to interpret observation geometry.

Three SPICE kernels, along with the data-derived roll, pitch and yaw reported in each Level 1B Label, are used to calculate M^3's position and pointing as a function of ephemeris time and across-track sample number:

- CH-1 (Chandrayaan-1) ephemeris (spacecraft location and velocities relative to J2000 system) as SPICE BSP kernel, produced by JPL Nav Group,

- CH-1 spacecraft clock kernel (relates spacecraft clock tics to ET/UTC times) as SPICE SCLK kernel, produced by M^3 Science Team,
- CH-1 Instrument kernel that describes the polygonal field of view for the 608 active samples in Target Mode.

Table 3-12 GEOMETRY Directory Contents

File Name	File Contents	File Provided By
GEOMINFO.TXT	A description of the contents of this directory	M^3 Team
CH-1-JPL-MERGED-23-MARCH-2010-1220.BSP	SPICE BSP kernel - CH-1 ephemeris	JPL Nav Team
AIG_CH1_SCLK_COMPLETE_BIASED_M1P816.TSC	SPICE SCLK kernel - CH-1 spacecraft clock	M^3 Team
AIG_CH1_SCLK_COMPLETE_BIASED_M1P816.LBL	PDS compliant label associated with SPICE SCLK kernel	M^3 Team
M3_TARGET_MODE_CAMERA.IK	SPICE IK kernel - M3 Target Mode Camera FOV and boresights as derived in-flight	M^3 Team
M3_TARGET_MODE_CAMERA.LBL	PDS compliant label associated with SPICE IK kernel	M^3 Team

3.8. EXTRAS Directory Contents

The EXTRAS Directory contains documentation, utility programs, or other materials that the user may find helpful, but that are beyond the scope of the required elements of the archive. The contents of this directory are exempt from PDS requirements for labeling, etc. The EXTRAS Directory is intended for "value-added" material, handy to have but not crucial for understanding the data. (If it's crucial, it is in one of the standard directories.) The following files are contained in the Extras Directory.

Table 3-13 EXTRAS Directory Contents

File Name	File Contents	File Provided By
EXTRINFO.TXT	A description of the contents of this directory	M^3 Team
M3MYYYYMMDD_LABFF.IMG	Laboratory based flat field.	M^3 Team
M3MYYYYMMDD_LABFF.HDR	ENVI header associated with the laboratory flat field image file	M^3 Team
M3MYYYYMMDDHHMMSS_VNN_FF.IMG	Image-based flat field with cross-track low frequency preserved.	M^3 Team

M3MYYYYMMDDHHMMSS_VNN_FF.HDR	ENVI header associated with the flat field image file	M³ Team
M3MYYYYMMDDHHMMSS_VNN_BDE.IMG	Bad detector elements map	M³ Team
M3MYYYYMMDDHHMMSS_VNN_BDE.HDR	ENVI header associated with bad detector elements map file	M³ Team
/LOGS subdirectory	Subdirectory of EXTRAS containing data lost to poor compression or complete packet loss are noted in the M3MYYYYMMDDHHMMSS_L0_VNN.LOG files.	M³ Team
/BROWSE subdirectory	Subdirectory of EXTRAS containing a single-band albedo JPEG image (M3MYYYYMMDDHHMMSS_VNN_QL_B046.JPG) and a single-band thermal JPEG image (M3MYYYYMMDDHHMMSS_VNN_QL_B084.JPG) for each M3 radiance image cube	M³ Team
LunConstantsModels_2005_jpl_d32296.pdf	Lunar Constants and Models Document	JPL
LunCoordWhitePaper-10-08.pdf	A Standardized Lunar Coordinate System for the Lunar Reconnaissance Orbiter and Lunar Datasets	LGCWG

3.9. LABEL Directory Contents

The Label Directory contains .fmt files that describe data format and organization. These files are referred to in the PDS labels that accompany the data products. These FMT files are to be parsed like include files as if they were part of the PDS labels that refer to them. The following files are contained in the Label Directory.

Table 3-13 LABEL Directory Contents

File Name	File Contents	File Provided By
LABINFO.TXT	A description of the contents of this directory	M³ Team
LN_PRFX_HDR.FMT	The file that describes the structure of the 1280-byte line prefix header of a L0 image cube (L0.IMG)	M³ Team

4. Archive Volume Format

This section describes the format of M³ archive Volumes. Data that comprise the Archive are formatted in accordance with Planetary Data System specifications [Applicable Documents 4 and 5].

4.1. Disk Format

Archive Volumes are formatted so that when written to CD or DVD media according to PDS policy, the media are compatible with most commonly used computer operating systems including Windows, UNIX, and Macintosh systems. The CD volume format is in accordance with ISO 9660 Level 2 Interchange Standard [Applicable Document 6]. The

DVD volume format is in accordance with the UDF Standard with ISO 9660 Level 2 compatibility.

4.2. File Formats

This section describes file formats for the kinds of files contained on Archive Volumes.

4.2.1. Document File Format

Document files with the .TXT suffix exist in the ROOT, INDEX, CATALOG, DOCUMENT and LABEL directories. They are ASCII files which may have embedded PDS labels. Lines in a .TXT file end with a carriage return character (ASCII 13) and a line feed character (ASCII 10). This allows the files to be readable under various operating systems.

Some documents in the DOCUMENT directory may contain formatting and figures that cannot be rendered as ASCII text. Therefore each document is given in PDF format. PDF (Portable Document Format) is a proprietary format of Adobe Systems Incorporated that is frequently used for distributing documents. Adobe offers free software, Acrobat Reader, for viewing PDF files. ASCII text versions of these documents are included.

4.2.2. Tabular File Format

Tabular files (.TAB suffix) exist in the INDEX directory. Tabular files are ASCII files formatted for direct reading into many database management systems on various computers. All fields are separated by commas and character fields are enclosed in double quotation marks ("). (Character fields are padded with spaces to keep quotation marks in the same columns of successive records.) Both character fields and numeric fields are left justified. The "start byte" and "bytes" values listed in the labels do not include the commas between fields or the quotation marks surrounding character fields. The records are of fixed length and the last two bytes of each record contain the ASCII carriage return and line feed characters. This allows a table to be treated as a fixed length record file on computers that support this file type and as a text file with embedded line delimiters on those that don't.

Every M^3 tabular file is described by a detatched PDS label with the same name as the data file it describes and the extension .LBL. For example, the file INDEX.TAB is accompanied by the detached label file INDEX.LBL in the same directory.

4.2.3. PDS Label Format

All data files in the M^3 archive have PDS labels, detached in a separate file. For examples of PDS labels for each type of data product, see the Data Product SIS [Applicable Document 3].

A PDS label provides descriptive information about the associated file. The PDS label is an object-oriented structure consisting of sets of 'keyword=value' declarations. The object to which the label refers (e.g. IMAGE, TABLE, etc.) is denoted by a statement of the form:

^object = location

in which the carat character (^, also called a pointer in this context) indicates where to find the object. In an embedded label, the location is an integer representing the starting record number of the object (the first record in the file is record 1). In a detached label, the location denotes the name of the file containing the object, along with the starting record or byte number, if there is more than one object in the file. For example:

^HEADER = ("F01.IMG",1)

^IMAGE = ("F01.IMG",1025 <BYTES>)

indicates that the IMAGE object begins at byte 1025 of the file F01.IMG, in the same directory as the detached label file. Below is a list of the possible formats for the ^object definition.

^object   = n

^object   = n<BYTES>

^object   = "filename.ext"

^object   = ("filename.ext",n)

^object   = ("[dirlist]filename.ext",n)

^object   = ("filename.ext",n<BYTES>)

^object   = ("[dirlist]filename.ext",n<BYTES>)

where

n is the starting record or byte number of the object, counting from the beginning of the file (record 1, byte 1),

<BYTES> indicates that the number given is in units of bytes,

filename is the up to 8 character, alphanumeric upper-case file name,

ext is the 3 character upper-case file extension,

dirlist is a period-delimited path-list of parent directories, in upper case, that specifies the object file directory (used only when the object is not in the same directory as the label file). The list begins at the directory level below the root directory of the CD-ROM. '[dirlist]' may be omitted when the object being described is located either in the same directory as the detached label, or in a subdirectory named LABEL that is located in a higher level of the directory tree, typically the CD-ROM root itself.

Lines of text in detached labels end with a carriage return character (ASCII 13) and a line feed character (ASCII 10). This allows the files to be readable under various operating systems.

4.2.4. Catalog File Format

Catalog files (suffix .CAT) exist in the ROOT and CATALOG directories. They are text files formatted in an object-oriented structure consisting of sets of 'keyword=value' declarations.

4.2.5. Science Data File Formats

The M^3 archive consists of science and ancillary data in varying formats. See Tables 4-1, 4-2, and 4-3 for descriptions of data file formats.

Table 4-1 Data Formats of Files Located in DATA Directories for Level 0

File Name	Type of Data	Data Volume Per Product
M3MYYYYMMDDTHHMMSS_VNN_L0.IMG	Signed integer, raw science data	Global = 1.5 GB Target = Variable (15 MB to 600 MB)
M3MYYYYMMDDTHHMMSS_VNN_L0.HDR	ASCII	320 Bytes
M3MYYYYMMDDTHHMMSS_VNN_L0.LBL	ASCII	6 KB
MISSION TOTAL FOR LEVEL 0		0.88 TB to 1.8 TB

Table 4-2 Data Formats of Files Located in DATA Directories for Level 1B

File Name	Type of Data	Data Volume Per Product
M3MYYYYMMDDTHHMMSS_VNN_RDN.IMG	4-byte, floating point, calibrated radiance, spectral image data	Global = 2.8 GB Target = Variable (30 MB to 1000 MB)
M3MYYYYMMDDTHHMMSS_VNN_RDN.HDR	ASCII	Global = 3 KB Target = 8 KB
M3MYYYYMMDDTHHMMSS_VNN_L1B.LBL	ASCII	23 KB
M3MYYYYMMDDTHHMMSS_VNN_LOC.IMG	24-byte, double precision, multi-band image data	Global = 700 KB Target = Variable (700 KB to 25 MB)
M3MYYYYMMDDTHHMMSS_VNN_LOC.HDR	ASCII	375 Bytes
M3MYYYYMMDDTHHMMSS_VNN_OBS.IMG	32-byte, floating point, multi-band image data	Global = 1.2 MB Target = Variable (20 MB to 1.2 MB)
M3MYYYYMMDDTHHMMSS_VNN_OBS.HDR	ASCII	710 Bytes
M3MYYYYMMDDTHHMMSS_VNN_TIM.TAB	ASCII	Global = 1.4 MB Target = Variable (45 KB to 3 KB)
MISSION TOTAL FOR LEVEL 1B		1.6 TB to 3.3 TB

Table 4-3 Data Formats of Files Located in DATA Directories for Level 2

File Name	Type of Data	Data Volume Per Product
M3MYYYYMMDDTHHMMSS_VNN_RFL.IMG	4-byte, floating point, calibrated reflectance, spectral image data	Global = 2.8 GB Target = Variable (30 MB to 1000 MB)
M3MYYYYMMDDTHHMMSS_VNN_RFL.HDR	ASCII	Global = 3 KB Target = 8 KB
M3MYYYYMMDDTHHMMSS_VNN_L2.LBL	ASCII	23 KB
MISSION TOTAL FOR LEVEL 2		1.6 TB to 3.3 TB

Table 4-4 Data Formats of Files Located in CALIB Directories for

Level 0, Level 1B and Level 2

File Name	Type of Data	Data Volume
M3YYYYMMDD_RDN_CAL.TAB	ASCII	2 KB
M3YYYYMMDD_RDN_CAL.LBL	ASCII	5 KB
		Global = 900 Bytes
M3YYYYMMDD_RDN_GAIN.TAB	ASCII	Target = 3 KB
M3YYYYMMDD_RDN_GAIN.LBL	ASCII	5 KB
		Global = 2 KB
M3YYYYMMDD_RDN_SPC.TAB	ASCII	Target = 6 KB
M3YYYYMMDD_RDN_SPC.LBL	ASCII	5 KB
M3MYYYYMMDD_RDN_BPF.IMG	BIN	1 MB
M3MYYYYMMDD_RDN_BPF.HDR	ASCII	0.5 KB
M3MYYYYMMDD_RDN_BPF.LBL	ASCII	5 KB
M3YYYYMMDD_SOLAR_SPEC.TAB	ASCII	1 MB max
M3YYYYMMDD_SOLAR_SPEC.LBL	ASCII	10 KB max
M3YYYYMMDD_PHOT_CORR.TAB	ASCII	1 MB max
M3YYYYMMDD_PHOT_CORR.LBL	ASCII	10 KB max
M3YYYYMMDD_APOLLO_CORR.TAB	ASCII	1 MB max
M3YYYYMMDD_APOLLO_CORR.LBL	ASCII	10 KB max

For more information about the format and content of the data products, see the Data Product SIS [Applicable Document 3].

Archive Volume Generation

4.3. Data Transfer and Validation Methods

M[3] data products (up to Level 1B) will be generated by the M[3] Instrument Ground Data System (IGDS); Level 2 data products will be generated by UMD in partnership with ACT. The Level 0, 1B, and 2 data products will be delivered on media such as external hard disks to the PDS Imaging Node according to the schedule in the M[3] Project Data Management and Archive Plan [Applicable Document 1]

M[3] archive volumes will be assembled by the M3 project (with assistance by the PDS Imaging Node) and validated by the PDS Imaging Node and made available to the public via the Imaging Node web site. The Imaging Node will also transfer M[3] archive volumes to the National Space Science Data Center (NSSDC) for long term storage, according to PDS policy, using a transfer medium agreed upon by PDS and NSSDC.

4.4. Data Product Sizes and Delivery Rates

Table 5-1 summarizes expected sizes and production rates for the M³ Standard Products.

Table 5-1 Standard Product Sizes and Delivery Rates

Product	Product Size (GB)	# of Products Produced per Optical Period	Number of Products for Primary Mission	Total Data Volume for Primary Mission (TB)
Level 0	1.5	300 to 600	600 to 1200	0.88 to 1.8
Level 1B	2.8	300 to 600	600 to 1200	1.6 to 3.3
Level 2	2.8	300 to 600	600 to 1200	1.6 to 3.3

M³ archive volumes for the combined Level 0 and Level 1B data products will be delivered to the PDS Imaging Node at approximately 6-month intervals. The first delivery is scheduled for June 2010 and will consist of Level 0 and Level 1B data acquired during Optical Period 1. The second delivery is scheduled for December 2010 and will consist of Level 0 and Level 1B data acquired during Optical Period 2. Separate M³ archive volumes for all Level 2 data products will be delivered to the PDS Imaging Node in June 2011 (see Table 5-2). For more information about the M³ data product release schedule, see Article 5, Archive Collections and Volumes [Applicable Document 1].

Table 5-2 Timeline for M³ Data Product Archiving

PDS Peer Review	Delivery to PDS	Public Release	Archive Products
Jan-Mar, 2010	June 2010	2 weeks following delivery to PDS	Optical Period 1 Level 0 data products Optical Period 1 Level 1B data products
Jan-Mar, 2010	December 2010	2 weeks following delivery to PDS	Optical Period 2 Level 0 data products Optical Period 2 Level 1B data products
Aug-Oct, 2010	June 2011	2 weeks following delivery to PDS	All Level 2 data products

4.5. Interface Media Characteristics

All volumes in the M³ Standard Product Archive conform to ISO 9660 standards Level 1 and Level 2 specifications for file names. [ISO 9660, 1988].

4.6. Backup and Duplicates

The M³ IGDS will maintain a backup copy of all Level 0 and Level 1B data delivered to the Imaging Node until the end of the Chandrayaan-1 Mission. UMD/ACT will maintain a backup copy of all Level 2 data delivered to the Imaging Node after the end of the

mission. The Imaging Node will maintain a backup copy of all M^3 data released by PDS as part of the Node's regular data repository backups.

4.7. Labeling and Identification

The M^3 archive volume labeling and identification schemes are divided according to ground testing and imaging period (there are a total of 4 imaging periods).

Table 5-2 M^3 Archive Volume Identification

Volume ID	Mission Phase
USA_NASA_PDS_CH1M3_0XXX	Operations

5. Support Staff and Cognizant Persons

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