JPL D-32590

Moon Mineralogy Mapper

Project Data Management and Archive Plan

Prepared by: Sarah Lundeen and John Diehl

Document Custodian: Sarah Lundeen

Revision: Version 2.8

June 24, 2010

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California 91109-8099

CHANGE LOG

Revision	Date	Description	Author
Draft	August 31, 2005	Working Draft	Sarah L./John D.
Draft	September 9, 2005	Peer Review Revisions	Sarah L./John D.
Draft	October 25, 2005	Combined Project Data Management Plan with the Archive Plan	Sarah L./John D.
Version 1.0	January 7, 2008	Update of entire document	Sarah L.
Version 2.0	January 14, 2008	Revisions based on review by JMD	Sarah L.
Version 2.1	January 17, 2008	Revisions based on review by JBoardman	Sarah L.
Version 2.2	January 25, 2008	Revision based on review by SMcLaughlin	Sarah L.
Version 2.3	January 31, 2008	Removal of ATLO/ground test data delivery to PDS	Sarah L.

TO BE DETERMINED

Date	Description
October 25, 2005	Mission Operations Concept Date and Version.
October 25, 2005	Number of days past end-of-mission when final PDS delivery will occur.

Moon Mineralogy Mapper
Project Data Management Plan

Prepared by:

Sarah Lundeen
M^3 Instrument Ground Data System
Jet Propulsion Laboratory

John Diehl
M^3 Instrument Ground Data System
Jet Propulsion Laboratory

Approved by:

Mary White
Project Manager
Jet Propulsion Laboratory

Robert O. Green
M^3 Instrument Scientist
Jet Propulsion Laboratory

TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Purpose

This document defines the plans for managing and archiving data from the Moon Mineralogy Mapper (M^3) mission. The data will be archived with NASA's Planetary Data System (PDS). This plan covers the design, generation, validation, and transfer of the data archive to the PDS. The archive will include raw and reduced instrument data; calibration and navigation data necessary for the interpretation of the instrument data; and documentation.

1.2 Scope

The plan covers the exchange of data elements between mission elements and the archiving of raw and reduced data sets and related information to be acquired or derived from the M^3 instrument during the Chandrayaan-1 mission.

Specific aspects addressed in this plan are:

Generation of high-level mission, spacecraft and instrument documentation, and instrument calibration reports.

Reduction of science packet data to reduced data records, including generation of data sets expressed in geophysical units, with associated documentation that records when and where the data were acquired and for what purpose.

Generation and validation of archive volumes containing (M^3) science and engineering data, documentation, and ancillary information.

Delivery to the PDS of validated (M^3) archives.

1.3 Contents

This plan begins with a summary of the Moon Mineralogy Mapper (M^3) instrument and the Instrument Ground Data System (IGDS) at JPL and the University of Maryland (UMD) in partnership with Applied Coherent Technology Corporation (ACT). Next, is an overview of the archiving flow and a schedule for delivery of the data archive. This section is followed by a description of the roles and responsibilities of each of the participants involved in the archiving of (M^3) data. Finally, a data release policy for the (M^3) instrument is presented.

1.4 Applicable Documents and Constraints

This Project Data Management and Archive Plan is responsive to the following Moon Mineralogy Mapper documents:

1. Moon Mineralogy Mapper (M3) ISRO/Chandrayaan-1 Project Operations Understanding Document, September 15, 2008, JPL D-46874.

The plan is also consistent with the following Planetary Data System documents:

2. Planetary Data System Data Preparation Workbook, February 17, 1995, Version 3.1, JPL D-7669, Part 1.

3. Planetary Data System Standards Reference, August 1, 2003, Version 3.6, JPL D-7669, Part 2.

The plan requires the generation of the following Project documents:

4. Data Product Software Interface Specification (SIS) for all Standard Products.

5. Archive Volume Software Interface Specification (SIS) for all Standard Products.

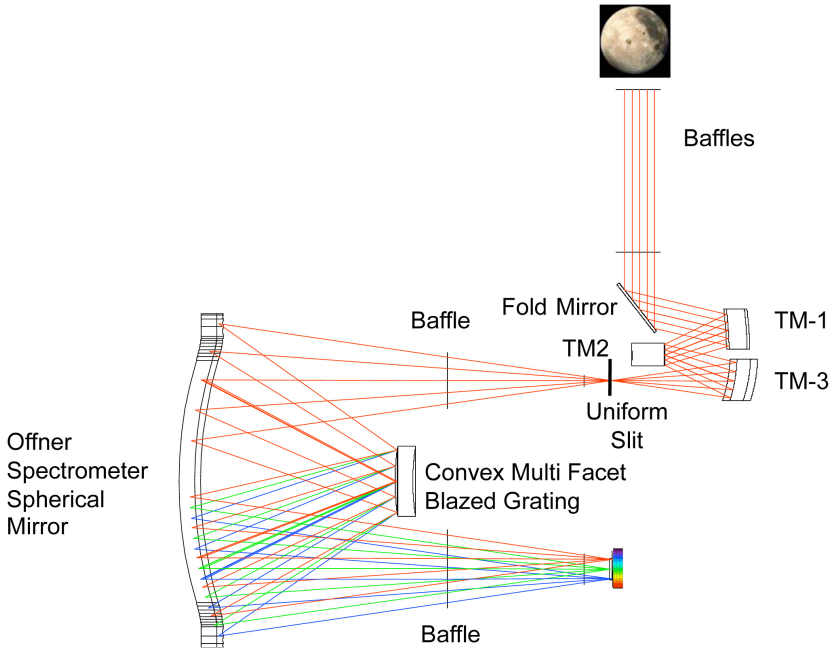
6. Interface Control Document (ICD) specifying relationships between Moon Mineralogy Mapper (M^3) Project, University of Maryland (UMD) in partnership with Applied Coherent Technology Corporation (ACT), and PDS Imaging Node.

2.0 OVERVIEW OF THE MOON MINERALOGY MAPPER INSTRUMENT

2.1 Instrument Overview

The Moon Mineralogy Mapper (M^3) was selected as a NASA Discovery Mission of Opportunity in February 2005. The M^3 instrument was launched on October 22, 2008 at 00:52:02 UTC from Shriharikota in India on board the Indian Space Research Organization (ISRO) Chandrayaan-1 spacecraft for a nominal two-year mission in a 100 km polar orbit. The M^3 instrument is a high uniformity and high signal-to-noise ratio imaging spectrometer that operates in the solar dominated portion of the electromagnetic spectrum with wavelengths from 430 nm to 3000 nm (0.43 to 3.0 microns) in a high-resolution Target Mode and in a reduced-resolution Global Mode. Target Mode pixel sizes are nominally 70 meters and Global pixels (binned 2 by 2) are 140 meters, from the planned 100 km orbit.

The Instrument is an Offner* style visible-infrared imaging spectrometer operating in a pushbroom fashion.



*Mouroulis P, Green RO, Chrien TG, "Design of push broom imaging spectrometers for optimum recovery of spectroscopic and spatial information," APPL OPTICS 39: (13) 2210-2220 MAY 1 2000

The M^3 image acquisition time will be divided into peak periods or Optical Periods (OP) when lighting is optimal for observation. The Optical Periods occur twice a year and are understood to have two central months of optimal illumination (solar beta angles -30° to +30°) with two optional two-week wing periods (solar beta angles ±30° to ±45°) on either side of the optimal 2 months (thus, one Optical Period equals 13 weeks). Each 13 week optical period is followed by a 13-week hiatus.

In August of 2009, the mission was cut short, just before the halfway point, when the spacecraft ceased operations. M^3 operations were sustained for two Optical Periods. Each Optical Period can be broken into sub-Ops based on instrument or spacecraft events and status. Table 1-1 provides an overview and description of each sub-OP.

Table 1-1

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

M^3 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 M^3 archive volumes for all Level 2 data products will be delivered to the PDS Imaging Node in June 2011.

2.2 Data Flow

The M^3 IGDS converts the raw spacecraft data stream to science data products, including those that are archived with the Planetary Data System. The Ground Data System consists of the M^3 Mission Operations System and the M^3 IGDS at JPL. The M^3 MOS is responsible for: monitoring the status of the instrument; generating M^3 instrument command requests; and facilitating instrument science planning. The M^3 MOS is distributed between the Jet Propulsion Laboratory in Pasadena, California and Indian Space Research Organization (ISRO) in India. The MOS at JPL receives housekeeping packets from ISRO and analyzes these to determine the instrument's health. The IGDS receives telemetry packets and navigation data from ISRO and produces Level 0 and Level 1B data products (see Appendix C for NASA data level definitions). The Level 0 and Level 1B data products are distributed on hard media such as external disks, provided by the M^3 team. UMD/ACT receives the Level 1B data products from the JPL IGDS for processing. UMD in partnership with ACT produces and archives Level 2 and delivers these products using a media such as external disks provided by the M^3 team.

The Level 0 and Level 1B science data products are generated in PDS-compatible formats by the IGDS. Level 2 science data products are generated in PDS-compatible formats by ACT for UMD. Complete archive volumes including these data products,

documentation, and ancillary materials are assembled on external hard drives and delivered to the designated PDS Node. PDS personnel work closely with the IGDS, UMD/ACT and science team members to ensure a smooth transfer. All M^3 archive collections are assembled according to designs specified in Archive Volume Software Interface Specification (SIS) document.

A comprehensive description of the M^3 Ground Data System is provided in the M^3 Mission Operations Concept (Ref. 1).

2.3 Data Volume

Table 2-1 shows the data volumes for M^3 data products. The downlinked data volume from M^3 is estimated to be 800 GB during the primary mission. The total volume of estimates will be refined based on further mission scenario development and data product definitions.

Table 2-1
Data Volumes by Data Product

Archive Component	Data Type	Data Volume (TB)
Level 0 Data Products	M3 time-sequenced packet data	0.88 TB to 1.8 TB
Level 1B Data Products	Spectral image cubes, Calibrated and Selenolocated	1.6 TB to 3.3 TB
Level 2 Data Products	Photometrically-corrected image cubes, converted to reflectance	1.6 TB to 3.3 TB
Geometry	Location information	.0005
Documentation		.0005
Total archive		4.1 TB to 8.4 TB

2.4 Data Validation

Data validation falls into two categories, validation of the data itself for scientific integrity and validation of the archive for compliance with PDS standards. The M^3 Science Team will carry out the first type of validation, and the second will be overseen by the PDS, in coordination with the M^3 Science Team.

Archive compliancy validation is finalized with an external peer review. The peer review will be coordinated by the PDS. The peer review process may result in "liens"–actions recommended by the reviewers or by PDS personnel to correct the archive. Liens are generally cleared prior to the delivery of the archive products. In some cases liens can remain open during a delivery. All liens must be resolved prior to PDS accepting the final delivery.

2.5 The Data Set Collections

Table 2-2 shows the contents of the M^3 data set collections.

Table 2-2
The M^3 Data Set Collection

Data Sets	Data Products
Level 0	Time-sequenced raw image cubes
Level 1B	Radiometrically-corrected image cubes with selenolocation and observation geometry
Level 2	Photometrically-corrected image cubes converted to reflectance

2.6 Data Delivery Schedule

The principal archive elements, namely the science data products defined in Table 2-2, will be generated during the course of the mission, as will many ancillary products such as Geometry files. The general guideline for Discovery missions is that they deliver archive quality volumes to PDS at six-month intervals no later than one year after receipt of the data used to make the products contained on the volume.

The planned timeline for archive delivery to PDS is shown in Table 3. Level 0 and Level 1B data products will be delivered to PDS at six-month intervals over the life of the mission Separate M^3 archive volumes for all Level 2 data products will be delivered to the PDS Imaging Node in June 2011.

The planned timeline for archive delivery to PDS and public release of M3 data products is shown in Table 3.

Table 3
Timeline for M^3 Project Archiving

Delivery date	Public Release	Archive Products
June 2010	2 weeks following delivery to PDS	Optical Period 1 Level 0 data products Optical Period 1 Level 1B data products
December 2010	2 weeks following delivery to PDS	Optical Period 2 Level 0 data products Optical Period 2 Level 1B data products
June 2011	2 weeks following delivery to PDS	All Level 2 data products

Prior to delivery, is a several-month-long period in which the data will be peer reviewed by PDS. The M^3 Instrument Ground Data System, UMD/ACT, and the appropriate science team members will rectify any liens that are identified by the peer review process before they cease operation (expected to be **TBD** days after the end of mission for science team). The M^3 Instrument Ground Data System, UMD/ACT, and the appropriate science team members are responsible for resolving all liens against the final archive delivery. Final acceptance of the data by PDS will occur only after all liens have been cleared. Pre-launch data is delivered to the PDS as "safed" data. The delivery of pre-launch data to the PDS will help to identify early in the mission any potential problems that can be addressed before the final archive is generated, thus avoiding liens on the data that require significant resources to correct.

2.7 Online Access to M^3 Archives

When data products have been delivered to the PDS, they are regarded as publicly available. It is expected that the data will be made available to the public online through the PDS online distribution system and in the form of the Planetary Image Atlas. The system will allow selection based on various search criteria, browsing of data, and downloading in various formats. The system can be used both by mission personnel and by the general science community to view and download data products that have been made public.

2.8 M^3 Archive Components

The M^3 archive shall have the top-level directory structure shown in Table 4.

Table 4
Top-Level Components of a Moon Mineralogy Mapper Archive Volume

Directories	Contents
DOCUMENT	Text files serving as documentation for the archive.
CATALOG	The catalog objects required by PDS to document the mission, spacecraft, instruments, and data sets.
INDEX	Index to enable searching of products using keyword values. Created during PDS ingestion.
CALIB	Calibration files. Calibrations may also be included within individual data sets.
GEOMETRY	Data necessary to describe the observing geometry.
DATA	Data products including observing geometry files.

EXTRAS	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.

2.9 Volume Documentation Files

PDS requires a number of volume documentation files for each archive volume.

readme.txt	a text file describing the contents of the volume
voldesc.cat	a catalog of all the files residing on the volume.

Each of the sub-directories under the top-level directory also requires one or more files to document the contents of that directory. The details of these files are specified in the PDS Standards Reference (Ref. 3).

3.0 The Archive Generation Process

The major steps to be followed in generation of the M^3 archive are described in this section. Responsibilities for generating archive components are specified in Section 4.

3.1 Archive Preparation

Science data products will be generated in PDS-compatible formats. This requires that each data file be in a format approved by PDS and be accompanied by a PDS "label." For M^3, the PDS label will be a detached descriptive header file describing the content and structure of the accompanying data file. Ancillary data describing the observing conditions and spacecraft state when science data were acquired will be extracted from the packet data and placed in these PDS labels.

The parties generating the data will prepare files documenting the archive components. In general, all information necessary to interpret and use the data is to be included in the archive.

PDS standards call for the documentation of the mission, spacecraft, instrument, and data products with special files called “catalog objects.” Catalog objects must be filled out with prescribed information. The required catalog objects are:

the mission catalog, mission.cat, describing the Chandrayaan-1 mission as a whole,
the instrument host catalog, insthost.cat, describing the spacecraft
the instrument catalog, inst.cat, for the M^3 instrument
the data set catalog, dataset.cat, describing the data set.

These catalog objects contain much of the information necessary to document the archive, and should make it possible for scientists to make correct use of the data in the

future when the mission personnel are not available to support them. M^3 personnel will create these files with help from PDS personnel and the Chandrayaan-1 mission team.

3.2 Archive Packaging and Delivery

The formal validation of data content, adequacy of documentation, and adherence to PDS archiving standards is finalized with an external peer review. The peer review will be coordinated by the PDS. The peer review process may result in "liens"–actions recommended by the reviewers or by PDS personnel to correct the archive. Liens are generally cleared prior to the delivery of the archive products. In some cases liens can remain open during a delivery. All liens must be resolved prior to PDS accepting the final delivery.

Archive updates of Level 0 and 1B data products will be delivered to PDS at six-month intervals over the life of the mission. The final version of Level 2 data products will be delivered to PDS only once, after the end of the mission.

4.0 Roles and Responsibilities

This section describes the roles and responsibilities of the personnel and organizations involved in generating, validating, transferring, archiving and distributing the M^3 archive.

4.1 M^3 Responsibilities

The M^3 archive consists of products generated by the Instrument Ground Data System and the Instrument Science Team. The Instrument Science Team consists of Dr. Carle Pieters (Principle Investigator, Brown University), Robert Green (JPL), Stephanie Tompkins (SAIC), Jessica Sunshine (UMD), Cassandra Runyon (College of Charleston), Joe Boardman (Analytical Imaging and Geophysics LLC), Matt Staid (Planetary Science Institute), James Head (Brown University), Tom McCord (University of Hawai'i), Roger Clark (USGS), Larry Taylor (University of Tennessee), Bonnie Buratti (JPL), and Jack Mustard (Brown University).

Essentially all elements of the M^3 operations team at JPL and UMD/ACT contribute–directly or indirectly–to the M^3 archive. Major archiving responsibilities are described below.

a) The M^3 IGDS is responsible for delivery of Level 0 data products and Level 1B data products and supporting documentation.

b) The M^3 IGDS is responsible for delivery of Level 0 and Level 1B data products on the required hard media to PDS.

c) The M^3 IGDS is responsible for delivery of the geometry information and supporting documentation.

d) UMD/ACT and the Science Team are responsible for delivering Level 2 data products and supporting documentation on the required hard media to PDS.

4.2 Responsibilities of the PDS

The Imaging Node (IN) is the lead PDS node for interfacing with the M^3 mission and will be supported by the Engineering Node. Specific functions of PDS are listed below.

a) Consult on Archive Generation

b) Support the generation of the archive by advising the project/science teams on PDS archive standards, requirements and documentation needs. The IN will support the data validation activity to ensure that the formal peer review process, a requirement for data ingestion into PDS, proceeds with a minimum of problems.

c) Conduct a formal peer review of the archive. This is a PDS mandated step before any data can be ingested into PDS.

d) Offer support to the PI, M^3, UMD/ACT and Science Team in the resolution of liens that arise in the course of the peer review.

e) Maintain the M^3 archive collection on-line for access by the planetary science community. PDS is also to offer expert advice to customers requesting help with the use of these products.

f) Replicate archive volumes for distribution to the NASA supported science community whenever physical media are judged to be appropriate

g) Provide a copy of the archive volume set to the National Space Science Data Center (NSSDC) for deep archive purposes, and for replication to serve any requests coming from the general public.

5.0 Data Release Policy

There are no proprietary data rights for the M^3 Mission. Science Team members do have a limited amount of exclusive time–not to exceed one year–for validation of data prior to delivery to the PDS.

M^3 will produce fully reduced, calibrated and corrected data products for delivery to PDS per the schedule shown in Table 3. The PI and CoIs are responsible for coordinating all scientific investigations involving the use of calibrated data and ensuring that all science data products are delivered in a timely fashion.

Appendix A Acronym List

ACT	Applied Coherent Technology Corporation
AFS	Andrew File System – JPL's file service
BIL	Band Interleaved by Line
C&DH	Command and Data Handling
CCSDS	Consultative Committee on Space Data Systems
CD	Compact Disc
CODMAC	Committee on Data Management and Computation
Co-I	Co-Investigator
DVD	Digital Versatile Disc
FTP	File Transfer Protocol
ENVI	Environment for Visualizing Images
GB	Gigabyte(s)
IGDS	M^3 Instrument Ground Data System
IN	Imaging Node of the Planetary Data System
ISRO	Indian Space Research Organization
JPL	Jet Propulsion Laboratory
M^3	Moon Mineralogy Mapper
MOS	M^3 Mission Operations System
NSSDC	National Space Science Data Center
PDS	Planetary Data System (of NASA)
PI	Principal Investigator
SAIC	Science Applications International Corporation
SIS	Software Interface Specification
TB	Terabyte(s)
TBD	To Be Determined
UMD	University of Maryland
USGS	United States Geological Survey

Appendix B Glossary of Terms

Catalog object	A PDS-required file formally documenting the details of a mission, spacecraft, instrument, or data set
Data product	A single instance of the output of an instrument, such as an image or spectra. A product is described as a PDS data object.
Data set	Normally a collection of data products of a single type– such as raw, Level 0 or Level 1 data products.
Data set collection	A collection of data sets typically covering an entire mission
Label	An attached or detached header describing the structure and content of a data product
Lien	An action recommended by reviewers or PDS personnel to correct the archive
Volume	A single CD, DVD, or other volume of a storage medium
Volume set collection	A complete collection of all the individual volumes comprising the entire data set collection

Appendix C Data Level Definitions

NASA Level	Description:
0	Instrument science packets (e.g. raw voltages, counts) at full resolution, time ordered, with duplicates and transmission errors removed. Corresponds to CODMAC level 1
1A	Level 0 data which 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. Corresponds to CODMAC level 2.
1B	Irreversibly transformed (e.g. resampled, remapped, calibrated) values of the instrument measurements (e.g. radiances, magnetic field strength). Corresponds to CODMAC Resampled Data.
1C	Level 1A or 1B data, which have been resampled and mapped onto, uniform space-time grids. The data are calibrated (i.e. radiometrically corrected) and may have additional corrections applied. Corresponds to CODMAC Derived Data.
2	Irreversibly transformed (e.g., resampled, remapped, calibrated) values of the instrument measurements (e.g., radiances, magnetic field strength). Corresponds to CODMAC Resampled Data.
3	Geophysical parameters mapped onto uniform space-time grids. Corresponds to CODMAC Derived Data.

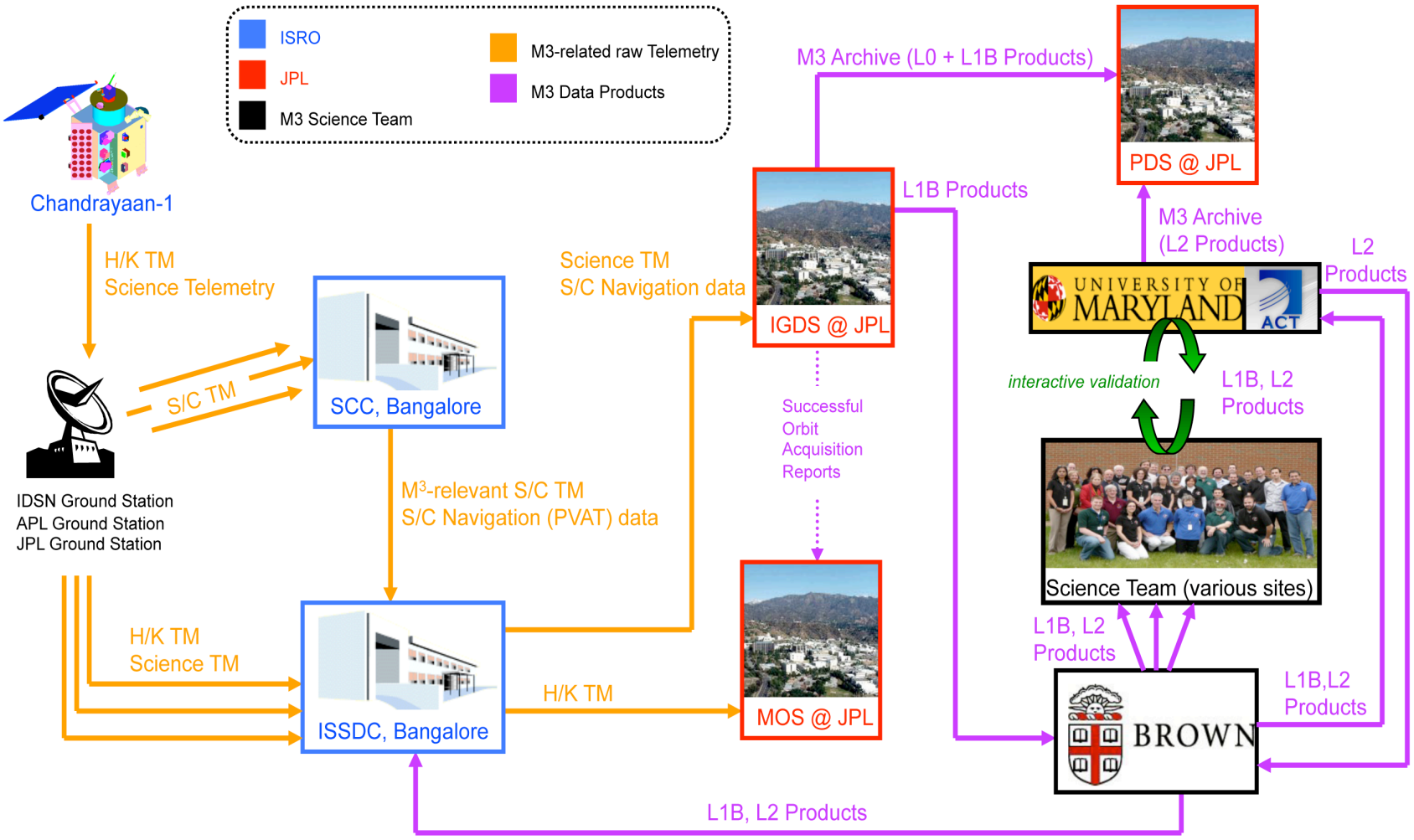


Figure 1. M³ Ground Data System—Downlink Data Flows

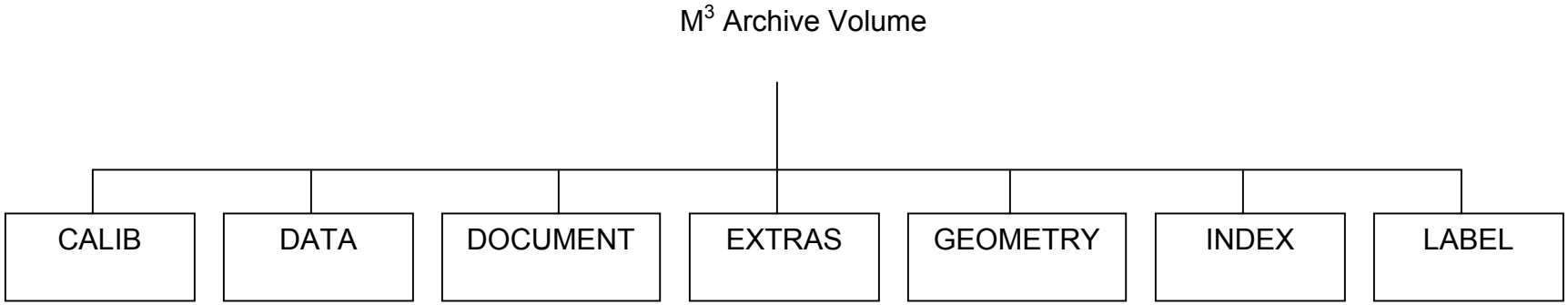


Figure 2. Structure of a Typical Hard Media Volume of the Moon Mineralogy Mapper M^3 Archive