Lunar Reconnaissance Orbiter Project

LROC Instrument Team

Data Management and Archive Plan

01/05/2007

Signature Page

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Change Log

Rev Level	Description of Change	Date Approved
1st Draft	First draft	Aug 31, 2006
2nd Draft	Incorporation of comments from Sue Slavney (PDS) and Stan Scott (LRO)	Oct 30, 2006
3rd Draft	Incorporation of comments from LROC SOC Development Team	Oct 31, 2006
1.0	Initial Release	Dec 20, 2006
1.1	Updated Table 2 values for daily products, and clarified product format.	Jan 5, 2007

List of TBDs/TBRs

Item No.	Location	Summary	Ind./Org.	Due Date
1	Section 4.3	Adequate number of redundant Linux processing servers	EBC/LROC	Feb 22, 2007
2	Section 4.6, Table 4	Release frequency and elapsed time for LROC data products	EBC/LROC	Feb 22, 2007

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1 Introduction

1.1 Purpose

This document describes the data management plans by the Lunar Reconnaissance Orbiter Camera (LROC) Instrument Team throughout the project lifecycle phases, and the ultimate transfer of data to the Planetary Data System (PDS) for permanent archive.

1.2 Scope

This document describes the LROC team roles and responsibilities in terms of data management and software configuration. The roles and responsibilities of the PDS are also described.

This document also describes the Science Operations Center (SOC) data processing facility and operations concept, reprocessing plans, data validation, data release schedule, information technology security approach, plans for education and public outreach.

This document describes the data products produced by the LROC team in their Science Operations Center (SOC) as well as data used in the generation and validation of these data products. The specifications include estimates of the sizing of products sent to PDS for archive and distribution.

This document also lists the documentation to be prepared and submitted to PDS, in conformance with PDS documentation requirements for data archived and distributed by PDS.

1.3 Applicable Documents

The following documents (or latest revisions available) are applicable to the development and execution of this plan.

Table 1 Applicable documents.

Document Number	Document Title and Publication Date
431-RQMT-000004	LRO Mission Requirements
431-RQMT-000048	Detailed Mission Requirements LRO Ground System
431-OPS-000042	LRO Mission Concept of Operations
431-PLAN-000708	LRO Data Management and Archive Plan
431-ICD-000049	LRO Ground System ICD
431-ICD-000109	LROC to Spacecraft Data ICD
LROC_SOC_RQMTS_0001	LROC SOC Requirements Document
LROC_SOC_ICD_0001	LROC SOC to PDS ICD
JPL D-7669	PDS Standards Reference, Version 3.6, Part 2, Aug. 1, 2003
JPL D-7116	PDS Data Dictionary, Rev. E, Aug. 28, 2002
JPL D-26359	PDS Proposer's Archiving Guide, Ver. 1.0, Jun. 15, 2003
JPL D-31224	PDS Archive Preparation Guide, Ver. 1.1, Aug. 29, 2006

2 Roles and Responsibilities

This section describes the roles and responsibilities for personnel and organizations involved in LRO Mission Data archive, generation, validation, transfer, and distribution.

- LRO Project Office to provide project Data Management Plan and team coordination
- LRO Science Teams provide detailed product definitions, Interface Control Documents, Data Product and Archive Volume Software Interface Specifications (SISs), Data Management and Archive Plan, Science Operations Center (SOC) Requirements Document, SOC Test Plan, SOC Information Technology (IT) Security Plan, and science data production
- Planetary Data System (PDS) Team provide data archiving specifications, Integration & Test support, operational repository, and long term data archive and distribution

2.1 LRO Project Responsibilities

The LRO Project has overall responsibility for the acquisition, integration, launch, and operations of the LRO Observatory. The LRO Project is also responsible for distribution of Level 0 data and pertinent orbit data to the LROC Science Operations Center (SOC).

The LRO Project Science Data Manager is responsible for approval of this document.

The LRO Data Working Group (LDWG) will coordinate the planning of LRO data product generation, data validation, and provision of Planetary Data System (PDS)-compliant data to the PDS. The LDWG is a subgroup of the LRO Project and is chaired by the LRO Project Data System Manager. LDWG membership includes the SOC Managers, PDS LRO Lead, PDS Discipline Node representatives, LRO Deputy Project Scientist, and LRO Project staff. During the active mission the LDWG will provide coordination to ensure that archives are assembled, validated, and delivered according to schedule.

2.2 LROC Instrument Team Responsibilities

The LROC instrument team is responsible for data management functions described in detail in Section 4 of this document. These functions include:

- Algorithm development and peer review
- Data storage, internal transmission, backup
- Processing and reprocessing
- Data release process and timing
- Distribution as part of educational requirement
- Writing a Interface Control Document

- Writing a Software Interface Specification (SIS) for Data Products and for the Archive Volume
- Delivery of final LROC data archive to PDS Imaging Node

The LROC Principal Investigator and the LRO Project Science Office ensure that archives are planned, validated, and delivered. The generation and validation of archives for release to the PDS will be performed by the LROC SOC.

The Principal Investigator, working with the LRO Project Science Office, provides oversight of the archiving process for the LROC instrument. They will review data analysis plans to assure timely and adequate analysis of spacecraft data and delivery of documented, complete data to the PDS.

The LROC instrument team is responsible for providing specified documentation (as outlined in Table 3) to the LRO Project and archive-related, specified documentation to the applicable PDS Discipline Node.

2.3 Planetary Data System Responsibilities

The PDS is the designated long term archive for LRO Mission data. The PDS will work with the LDWG to ensure that the LRO archives are compatible with PDS standards and formats. The PDS Geosciences Node will provide overall coordination of PDS activities for LRO.

The PDS is responsible for generation, distribution, and maintenance of LRO archives for the NASA planetary science community once the LRO data have been delivered.

A Data Engineer from the PDS Engineering Node will work with the PDS Discipline Nodes involved with LRO Mission throughout the archive planning, generation, and validation phases.

3 Data Specification

This section identifies LROC data products and input data used in processing of the data products.

The data products in Table 2 are those generated at the LROC SOC.

Table 2. LROC Data Products

Data Product Name	Key/Physical Parameters included in Data Product	NASA Data Level	COD-MAC Data Level	Processing Inputs	Data Product Format	Data Product Estimated Size (MB/day)
NAC EDR	NAC observations	0	2	NAC Measurement file, LROC Housekeeping, LRO Housekeeping, LRO Definitive SPK, LRO Definitive CK, LRO SCLK	PDS Complaint Image Product	50,960[a,b]
NAC CDR	NAC observations with a radiometric calibration applied	1a	4	NAC EDR, NAC calibration constants, and calibration files	PDS Complaint Image Product	101,920[c]
WAC EDR	WAC observations	0	2	WAC Measurement file, LROC Housekeeping, LRO Housekeeping, LRO Definitive SPK, LRO Definitive CK, LRO SCLK	PDS Complaint Image Product	1,177[a,b]
WAC CDR	WAC observations with a radiometric calibration applied	1a	3	WAC EDR, WAC calibration constants, and calibration files	PDS Complaint Image Product	2,354[c]
Landing Site Assessment	Uncontrolled, best-effort mosaics of NASA identified future landing sites	1c	5	NAC CDR's, LRO, Definitive SPK, LRO Definitive CK, LRO SCLK	PDS Complaint Image Product	n/a

Data Product Name	Key/Physical Parameters included in Data Product	NASA Data Level	COD-MAC Data Level	Processing Inputs	Data Product Format	Data Product Estimated Size (MB/day)
Polar Illumination Characterization	Uncontrolled, best-effort Polar mosaics	1c	5	WAC CDR's, Definitive SPK, LRO Definitive CK, LRO SCLK	PDS Complaint Image Product	n/a
Meter-scale Polar Illumination Conditions	Uncontrolled multi-temporal NAC observations, as time-lapse movie	1c	5	NAC CDR's, Definitive SPK, LRO Definitive CK, LRO SCLK	PDS Complaint Image Product, MPEG Movie	n/a
High Resolution Topography	Test DEMs, Image complement list	1c	5	NAC CDR's, Definitive SPK, LRO Definitive CK, LRO SCLK	PDS Complaint Image Product	n/a
Global Multi-spectral Observations	Uncontrolled, best-effort global multi-spectral mosaics	1c	5	WAC CDR's, Definitive SPK, LRO Definitive CK, LRO SCLK	PDS Complaint Image Product	n/a
Uncontrolled Best Effort Global BW Basemap	Uncontrolled, best-effort global BW mosaic	1c	5	WAC CDR's LRO, Definitive SPK, LRO Definitive CK, LRO SCLK	PDS Complaint Image Product	n/a
Regolith Characterization	Uncontrolled, best-effort mosaics of targeted observations to characterize lunar regolith	1c	5	NAC CDR's, Definitive SPK, LRO Definitive CK, LRO SCLK	PDS Complaint Image Product	n/a

Data Product Name	Key/Physical Parameters included in Data Product	NASA Data Level	COD-MAC Data Level	Processing Inputs	Data Product Format	Data Product Estimated Size (MB/day)
Impact Rate	Targeted observations overlapping Apollo Panoramic images	1c	5	NAC CDR's, Definitive SPK, LRO Definitive CK, LRO SCLK	PDS Complaint Image Product	n/a
a – SOC scaled for 300Gbit per day downlink (8 NAC obsv pair and ~60min of WAC operations per orbit, 12.74 orbits per day), actual LRO allocation is 427.18Gbit per day; b – assume 2:1 compression ratio, average may be more like 1.5:1; c – increase is due to de-campanding of data						

4 SOC Data Management

4.1 LROC Team Data Management Functions

The overarching goal of the LROC SOC is to deliver EDR, CDR, and RDR products to the PDS within schedule constraints. Successful completion of this goal requires a heavy reliance on automation to shepherd the measurements through the processing pipeline. The organization of the LROC SOC and measurement data product software development team is shown in Figure 1. Also shown are the major software components for which each group has lead responsibility.

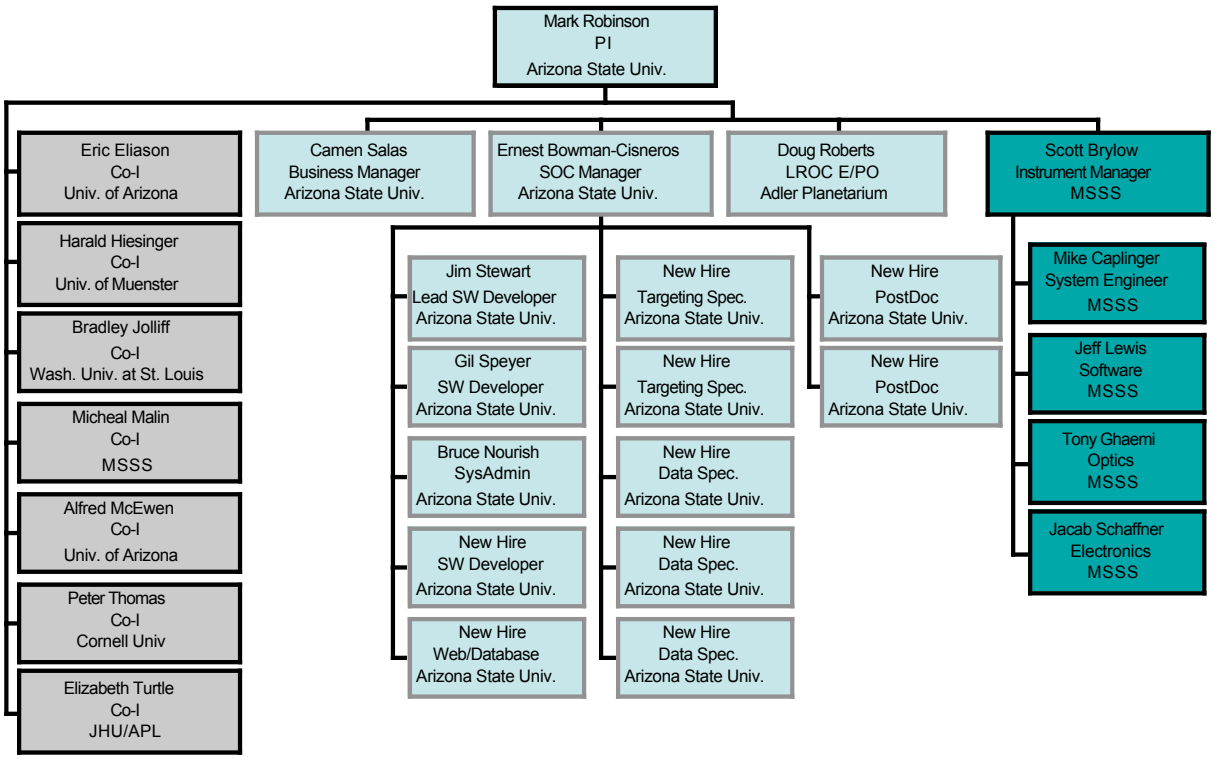

Figure 1. LROC SOC and Data Team Organization and Responsibilities

Science team is responsible for observation plans relating to the eight LROC observation goals, as stated in the LROC proposal and outlined in the SOC requirements document, and developing processing algorithms for generation of RDR products. The Science team is responsible for validating that collected and processed observations are suitable for the generation of RDR products.

SOC Operations team is responsible for the systematic processing of all LROC measurement data into EDR and CDR data products. They will perform the day to day

monitoring of the processing pipeline, and handle the remediation of fault conditions within the pipeline.

The schedule for developing the SOC and testing it with the LRO ground system and PDS is in Table 3.

Table 3. SOC Data Management Schedule

Activity or Document	2006 J	F	M	A	M	J	J	A	S	O	N	D	2007 J	F	M	A	M	J	J	A	S	O	N	D	2008 J	F	M	A	M	J	J	A	S	O	N	D
SOC SRR (Nov 29, 2005)																																				
SOC Requirements doc					1		2																													
ICD: SOC-PDS Discipline							1		2																											
SOC DM&AP								1		2																										
GS Single Design Review													X																							
SOC Test Plan (due dates TBD)																																				
SOC SDR														X																						
SOC IT Security Plan														1		2																				
SOC Algorithm Peer Review															X																					
Database Peer Review																	X																			
SOC->PDS: EDR Data Prod SIS															1		2																			
EDR Data Prod SIS Peer Review																X	X																			
SOC->PDS: EDR ArchiveVol SIS															1		2																			
SOC S/W Release 1																			X																	
SOC->PDS: RDR DataProd SIS																							1			2										
RDR Data Prod SIS Peer Review																								X	X	X										
SOC->PDS: RDR ArchiveVol SIS																							1			2										
SOC S/W Release 2																											X									
I/F Tests: SOC internal																				X	X	X														
ETE Tests: SOC internal																				X	X	X														
I/F Tests: SOC-PDS Node																											X	X	X							
I/F Tests: MOC-SOC																							X	X	X	X	X	X	X	X						
Tests: Ground System																						X	X	X	X	X	X	X	X	X	X	X	X	X		
Tests: Operations																								X	X	X	X	X	X	X	X	X	X			
SOC->PDS: INST.CAT, DATASET.CAT, PERSON.CAT, REF.CAT																															X					
SOC->PDS: DP method&algorithm																																X				
SOC Operations																																		X	X	X

4.2 SOC Configuration Management

Data configuration management at the SOC will closely follow the configuration management approach utilized for measurement data product software. As with the software, data configuration management will depend upon the level of criticality. For example, archive data products will be subject to the highest level of configuration management. At the other extreme, data items belonging to individual researchers as part of scientific analysis are the responsibility of that researcher.

4.3 SOC Data Processing Facility

The LROC SOC will provide the computing environment for production of the LROC Data Products, funded for a data rate of 300Gbit per day. This environment includes the computation resources necessary to produce the products, and the necessary storage infrastructure.

The SOC will be located on the ASU Tempe campus, with computing resources spread across three separate buildings: Admin-A, Goldwater and ITSB #1.

The SOC personnel offices and LROC operations room will be located in the Admin-A building. The operations room will contain the LROC targeting workstations which will be used to generate the instrument command files, and the LROC data validation workstations which will be used to monitor data processing queues, review measurement data, and other tasks associated with systematic LROC data processing.

The primary SOC computing resources will be located in the Goldwater Building HPC machine room. These resources include:

- Operations storage array – enterprise grade data storage with tiered storage, snapshots, and replication functionality, accessible to the other SOC computer systems, used in data processing and daily SOC operations.

- Operations database server – database to support LROC SOC operational tasks, such as instrument commanding, data processing and archive generation.

- Operations data processing cluster – multi-core, large memory Linux server performing LROC data processing.

- SOC data exchange server – used as the gateway for data transfers in/out of the SOC, able to operate autonomously from the other SOC components.

- PDS Data Node Web server – web server(s) to support the LROC PDS Data Node web site.

- PDS Data Node storage array – storage to support the LROC PDS Data Node web site.

- PDS Data Node database server – database server to support the LROC PDS Data Node web site.

The redundant SOC computing resources will be located in the ITSB #1 building machine room. These resources include:

- Redundant Operations storage array – enterprise grade data storage replicated from the primary storage array, accessible to the other SOC computer systems, used in data processing and daily SOC operations.

- Redundant Operations database server – database replicated from the primary database server, to support LROC SOC operational tasks, such as instrument commanding, data processing and archive generation, replicated from the primary database server.

- Redundant Operations data processing cluster – a minimum number (TBR) of multi-core, large memory Linux servers to handle incoming LROC data processing.

- Redundant SOC data exchange server – used as the gateway for data transfers in/out of the SOC, able to operate autonomously from the other SOC components.

All SOC computing resources will be connected (internally) via the ASU HPC research network, which provides for high-speed data (1Gbps) transfers over a fiber network, across the Tempe campus. External connections are via the ASU campus backbone network.

4.4 SOC Operations Concept

The SOC Operations Concept is centered on a highly automated processing pipeline system, that handles the ingestion, identification and processing of incoming products from the MOC, scaled to a data rate of 300 Gbits per day and designed for potential growth in data rate. All image data products will be stored on a large capacity (~200TB) enterprise grade storage array, available to the processing cluster as a single name space. Ancillary and meta data will stored within an high performance, transactional capable SQL database, accessed by the individual pipeline processes as needed.

Incoming telemetry and housekeeping data (real time or asynchronous) will be ingested into a database, where information will be requested by the appropriate procedure in our processing pipeline.

Incoming measurement data will be handled in a sequential, cascading manner by the processing pipeline, based on instrument or observation type. At the completion of each

step, the product filename is added to the next processing queue. Failure to complete a specific step is recorded and will be added to the daily list of automated reporting, or will show up in a manual report request.

PDS data node products will accumulate into a queue for steps related to release of data to the public. Files in the queue will be copied to the data node, and new archive volumes will be generated, as needed, as part of that process. This step will be automatically invoked at the appropriate date to generate a new release, which will become visible to the public if all validations tests are passed.

There are no inherent blocking activities (manual steps) within the processing pipeline, expect when responding to fault conditions within the pipeline. Fault conditions can be failure of a procedure to complete the processing of an individual file, failure of a product to pass a validation check, systematic failure of a pipeline procedure, or large-scale systematic failure of processing or supporting hardware.

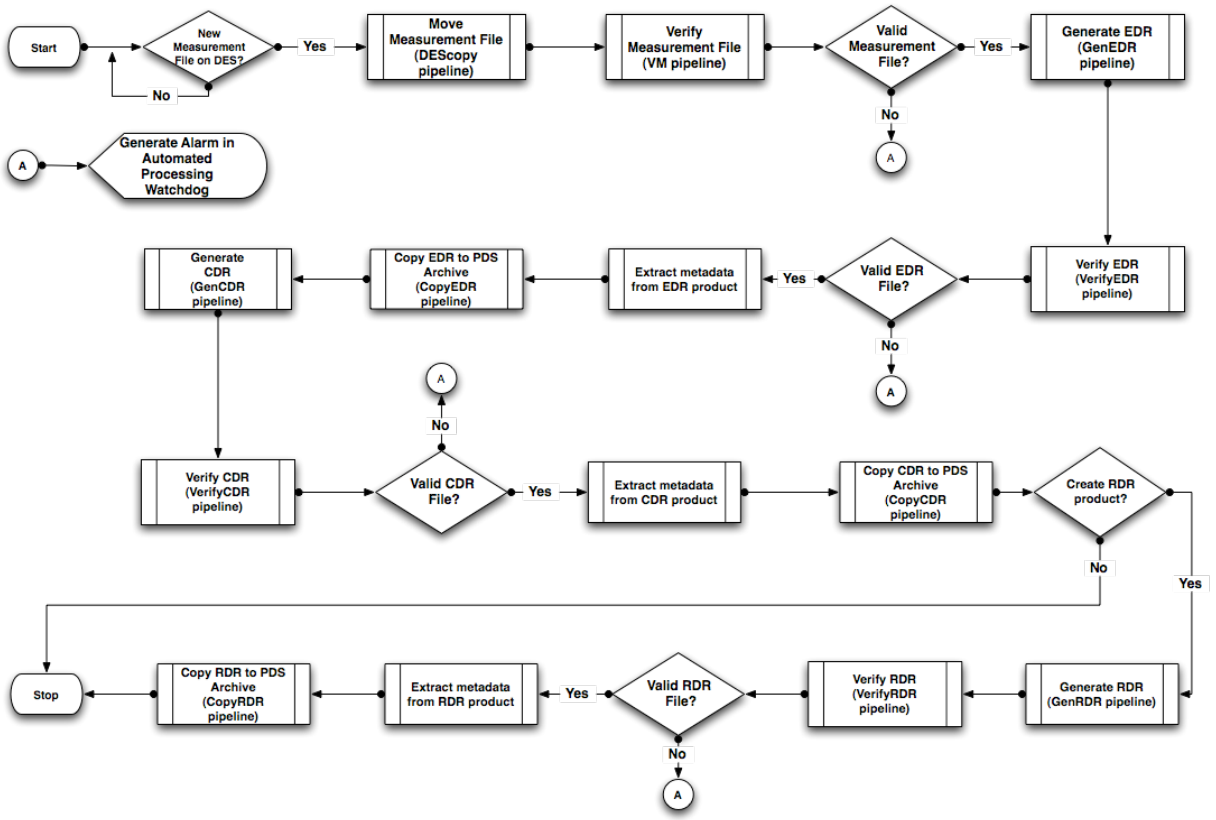

Figure 2. SOC Automated Processing Data Flow

4.5 Availability of Data for Processing

The LRO Mission Operations Center (MOC) will provide the SOC with Level 0 data and SPICE kernels necessary for LROC data processing. These data will be provided via the standard MOC – SOC interface, as defined in the LRO Ground System ICD.

4.6 Data Release Schedule

The release schedule for LROC data product archives is strictly within the nominal six-month period for data processing, data validation, archive generation, delivery to the PDS, validation of the delivery by PDS, and PDS archive release to the public. The schedule allows sufficient time for PDS validation, ingest, and release of an archive volume delivery from the SOC, where this validation, ingest, and release process typically requires two to four weeks. Data product deliveries to PDS will be transferred with the frequencies and elapsed times since observation listed in Table 4.

Table 4. Data Product Release Frequency

Product Name	Release Frequency	Elapsed Time since Observation*
NAC and WAC EDR	3 months	3 months
NAC and WAC CDR	3 months	3 months
Landing Site Assessment	TBD	TBD
Polar Illumination Characterization	1 release	20 months post orbit insertion
Meter-scale Polar Illumination Conditions	TBD	TBD
High Resolution Topography	TBD	TBD
Global Multi-spectral Observations	TBD	TBD
Global BW WAC mosaic	1 release	20 months post orbit insertion
Regolith Characterization	TBD	TBD
Impact Rate	TBD	TBD

* Mosaic products time of completion.

Actual delivery of LROC data to the PDS will occur within the EOM+6 months outlined by the mission for final PDS archive generation and delivery.

4.7 Reprocessing Plan

The LROC SOC plan to perform minimal reprocessing, only as necessitated by updated instrument calibrations.

NAC and WAC EDRs will be reprocessed into CDR products, as needed, at the end of the LRO mission, using final instrument calibration files. Reprocessing will occur within the 6 months allocated for the final PDS archive creation.

The polar movies and global BW mosaic will be reprocessed at the end of the LRO mission, using the final LRO SPICE, LOLA shape models, and final instrument calibration files. Reprocessing will occur within the 6 months allocated for the creation of the final PDS archive.

4.8 Data Validation Plan

Data validation will occur as an integral part of the SOC processing pipeline, with automated and manual reporting mechanisms. The SOC will validate product formats at the point a new product is generated, to insure adherence to documented file formats. The SOC will also perform limited validation of data values, at key points in the processing pipeline.

The LROC SOC will coordinate with the PDS Imaging Node to integrate PDS validation routines into the processing pipeline, with automatic and manual reporting mechanisms.

4.9 Algorithm Peer Review Process

A peer review will be conducted for the NAC and WAC calibration algorithms. No panel will be convened, but rather participants will be invited to review documentation and code, and provide comments or ask questions via some collaboration mechanism (email, online wiki or discussion board).

4.10 Information Technology Security Planning

The LROC team will perform the necessary information technology security planning as specified in NASA NPR 2810.1 and provide the LRO Project with a Security Plan that describes the team approach to securing their computer systems and networks. The plan will be provided to the LRO Project by encrypted electronic transfer since it contains Administratively Controlled Information.

4.11 Education and Public Outreach Data Distribution

The LROC Team is committed to bringing the excitement of lunar exploration to the public and into varied educational environments. We have assembled an experienced EPO team who will work with the PI and measurement team to engage the public with the LROC. The Adler Planetarium and Astronomy Museum in Chicago will manage all E/PO efforts, including coordination partners and consultants. The DePaul Space Science Center (NASA Broker/Facilitator) will manage an educational program targeting minority- serving Chicago area colleges and outreach to the small planetarium community. The primary goals of this E/PO program are: · Communicate the goals and results of the LROC to the public. · Provide tools to enable various audiences to view and analyze images from LROC. · Contribute to the E/PO activities of the NASA forums and brokers and the LROC mission as a whole through GSFC. The specific objectives of this E/PO project are:

- Create the Lunar Imaging Workbench (LIW), a set of web-tools for browsing, retrieving, visualizing and analyzing image data from the LROC mission.
- Integrate the LIW into an educational program to support independent investigation at Chicago-area minority-serving colleges.

- Create an educator kit showing how to use the Moon and LROC images to support standards for middle school education.
- Carry out a workshop to show amateur astronomers how to use the educator kit, and partner with the trained amateurs to support a workshop showing middle school teachers how to use the educator kit in the classroom.
- Use the LIW to make a kiosk application suitable for use in small planetaria.
- Create an interactive, high-resolution display system at the Adler to enable public visitors to browse and analyze the mission images.
- Support the use of the LIW in other parts of the mission, once the other instruments and educational teams are selected.

The LROC E/PO team will create a software system for public and educational audiences to allow web-based image retrieval, visualization, and analysis of these data. This system will be built upon the same image tools and database query system developed for the LROC web based distribution system. These electronic tools will be deployed on the web, at the Adler, at small planetaria, at minority-serving colleges, at amateur societies, and in schools. The tools will be created in the form of a workbench, in which each component can be put together in a custom fashion to service the needs of a particular audience. The web-based tools will be designed with similar functionality to those created for THEMIS aboard Mars Odyssey, but with a more capable image viewer. The workbench will provide:

- Image retrieval. Various levels of data access will be built into the image archive. Images from the mission will be large (256 MB), thus most users will want to retrieve full-resolution windows of specific locations or subsampled images of larger areas.
- Web-based visualization and basic image analysis, based on HST Image Workbench [VISLAB-HST, 2004] tools such as panning, zooming, and adjusting color/contrast/bright Custom visualization tools for Adler's Moon Wall exhibit.
- Tools for educational activities, such as counting craters, measuring distance, identifying Apollo artifacts, and identifying lighting conditions.

5 Archive Plan

The LROC SOC will provide storage and distribution of the LROC data products during the LRO mission, as a PDS Data Node. The LROC Data Node will include a user access interface, advertisement of data availability, and the necessary user support.

PDS will be responsible for maintaining permanent archival of the LROC instrument telemetry and derived data products at EOM. This will include any necessary updates of storage media and suitable physical storage space for these media.

5.1 Archive Generation

An Interface Control Document (ICD) between the LROC SOC and the PDS Imaging Discipline Node will be jointly developed by the SOC staff and PDS Discipline staff. The ICD will include:

- Description of the management interface between the two entities
- Roles and responsibilities of each side
- Policies and procedures that govern the flow of data from the SOC to PDS
- Description of the data transferred across the interface along with data sizing for each transfer and frequency of transfer
- Description of the networks used for electronic transfer of data and the sizing of the network to support the data flows.

Each type of data product to be delivered to PDS will be described in a Data Product Software Interface Specification (SIS). The SIS will include an example of the PDS label for the data product. In addition, an Archive Volume SIS will describe the contents and organization of the complete archive to be delivered to PDS, including data products, indices, documentation, software, and other supporting materials.

Documentation to be provided to PDS from the SOC also includes:

- High-level instrument description (INST.CAT)
- High-level data set description (DATASET.CAT)
- Key personnel (PERSON.CAT)
- References (REF.CAT)
- Data processing production methodology and algorithms, including calibration
- References to instrument papers published in scientific journals

The archives associated with LROC data products will be assembled at the LROC SOC, using archive volume SISs that define the elements of archives and the associations among the elements. Archive volume SISs will pertain both to online archives and to any physical volumes that may be made and transferred to the PDS.

5.2 Validation and Peer Review

LDWG will provide oversight and coordination of validation of archives. The validation process includes the following components:

- A quality control activity is included as part of the generation of data products at the SOC.
- Scientific analysis of the data products constitutes another form of validation since problems will be uncovered during the course of work.
- SOC processing staff will check the data products for conformance to SIS documents. The data product SIS and volume SIS serve as the definitive documents for defining the contents, structure, and organization of the data deliveries to the PDS.
- Assembly into archive volumes and checking for conformance to Archive Volume SIS documents is an additional validation step performed by the SOC and by the PDS node that receives the data.
- Generation of data products and volumes, together with validation, will be completed within the required validation period of six months from the availability of processing input data.

PDS requires data sets to be peer reviewed before they can be accepted as PDS archives. A typical PDS peer review includes a committee of a few scientists who are knowledgeable about the type of data under review, along with representatives from the data provider and the PDS. The committee is asked to review the data set for completeness and scientific utility. The result of a peer review is a list of liens against the data set that must be resolved before PDS can accept it.

For data products from ongoing missions that are delivered periodically, the peer review takes place as follows.

- Before data production begins, the committee reviews a representative sample of data products along with associated documentation, software, and other ancillary files that will make up the archive to be submitted to PDS. This is done early to allow time for the data provider to make any necessary changes to the product design, and to ensure that sufficient ancillary materials (e.g., software) are provided so that the typical user can access and interpret the data.
- The committee also reviews the data "pipeline"; that is, the procedures that the provider will use to generate standard products during the mission. With the reviewers' approval of a sample of the product and the method for generating it, the PDS can be reasonably sure that future products generated in the same way will be equally valid.
- Reviewers have an opportunity to view revised products and supporting materials to ensure that the liens have been resolved. Data Product SIS documents are updated as necessary to describe the revised products.
- With each delivery of data products, the appropriate PDS node performs a standard set of validation procedures to ensure that products conform to the Data Product and Archive Volume SISs. As long as the product design and processing steps do not change, no further peer review is necessary.

5.3 LROC Data Transfer

The transfer of data to the PDS Imaging Discipline Node will be accomplished as described in the LROC SOC – PDS Imaging Discipline Node ICD.

Archive volumes will be generated automatically from meta-data, stored in an SQL database, extracted from the data products as they were processed. Volumes will be automatically checked for adherence to PDS formats at the time of generation.

5.4 LROC Data Distribution

Once released by the PDS, the LROC data will be available on-line through a set of PDS search and retrieval tools that will provide access to data from all LRO instruments. The user will be able to search the archive and retrieve data that meet criteria such as a specific time range, instrument, or location on the moon. Map-based searches will also be supported as appropriate. Data will be made available via electronic transfer.

Appendix A. Abbreviations and Acronyms

Abbreviation/ Acronym	DEFINITION
ASU	Arizona State University
CDR_1	Critical Design Review
CDR_2	Calibrated Data Record
EDR	Engineering Data Record
GN&C	Guidance, Navigation, and Control
ICD	Interface Control Document
ISIS	Integrated Software for Imagers and Spectrometers
ITSB	Interdisciplinary Science and Technology Building
LDWG	LRO Data Working Group
LRO	Lunar Reconnaissance Orbiter
LROC	Lunar Reconnaissance Orbiter Camera
MOC	Missions Operations Center
PDR	Preliminary Design Review
NAC	Narrow Angle Camera
PDS	Planetary Data System
RDR	Reduced Data Record
SCR	System Concept review
SESE	School of Earth and Space Exploration
SIS	Software Interface Specification
SOC	Science Operations Center
SRR	System Requirements Review
TBD	To Be Determined
TBR	To Be Resolved
USGS	United States Geological Survey
WAC	Wide Angle Camera

Appendix B: CODMAC/NASA Data Levels

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). Referred to in this document as Experimental Data Records (EDRs).
Level 1B	Resampled - Level 4	Irreversibly transformed (e.g., resampled, remapped, calibrated) values of the instrument measurements (e.g., radiances, magnetic field strength). Referred to in this document as Calibrated Data Records (CDRs).
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). Referred to in this document as either derived data products (RDRs).
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. Referred to in this document as either derived data products (RDRs).
Level 3	Derived - Level 5	Geophysical parameters mapped onto uniform space-time grids. Referred to in this document as either derived data products (RDRs).
	Ancillary Data – Level 6	Non-science data needed to generate calibrated or resampled data sets and consisting of instrument gains, and offsets, spacecraft positions, target information, pointing information for scan platforms, etc.