LANDSAT DATA CONTINUITY MISSION

MOE Requirements

Effective Date: December 6, 2012

Expiration Date: December 6, 2017

National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

CM Foreword

This document is a Landsat Data Continuity Mission (LDCM) Project Configuration Management (CM)-controlled document. Changes to this document require prior approval of the applicable Configuration Control Board (CCB) Chairperson or designee. Proposed changes shall be submitted to the LDCM CM Office (CMO), along with supportive material justifying the proposed change. Changes to this document will be made by complete revision.

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1 Introduction

1.1 Scope

The Mission Operations Element Requirements Document (MOERD) establishes the procurement requirements for the LDCM Mission Operations Element. It is a Level 4 document that contains the functional and performance requirements for the software and hardware systems comprising the Mission Operations Element.

Design, implementation, and operation are not defined in this document. It is expected that the MOE will include all detailed functions needed to successfully operate the LDCM observatory for the life of the mission.

The grouping of functions within the sections of this document is strictly for organizational purposes. Grouping or categorizing requirements is not in any way intended to imply MOE system or sub-system architecture or design.

1.2 Mission Operations Element (MOE) Overview

The LDCM Mission Operations Element (MOE) is that part of the LDCM Flight Operations Segment (FOS) that provides the primary means to communicate with the observatory and conduct the LDCM mission as described in the LDCM Operations Concept (Ref Doc. 427-02-02).

The MOE software and hardware systems will reside at the LDCM Mission Operations Center (MOC), a government facility. For operations contingency purposes, a backup MOE (bMOE) will reside at a backup MOC (bMOC) facility, located at a geographically separate location from the MOC. The primary MOE and the bMOE interface for data transfer routinely and operational transfer of observatory command and control as needed.

A defined subset of MOE functionality, referred to as the mini-MOE, will support the Observatory Integration & Test (I&T) facility and the Instrument Development & Test (D&T) facility during the pre-launch phase of the mission. The two mini-MOEs will provide rudimentary interface, command, telemetry and mission monitor & analysis capabilities.

This document sets the MOE requirements for a single MOC and a supporting bMOC. Reference the MOE Statement of Work (SOW) for MOE support requirements for the MOC and bMOC.

The MOE consists of six primary services:

- Planning and Scheduling
- Telemetry, Command and Control
- Mission Monitor & Analysis
- Flight Dynamics
- Memory Management
- Product / Event / Report Handling

These MOE services are not intended to imply a particular MOE architecture or system design.

The Planning and Scheduling (P&S) function builds and manages an activity schedule for the LDCM observatory and ground system. The P&S is primarily a rule-based event-driven system, producing a schedule of time-ordered planned activities. It contains all the planned observatory commands (real-time and absolute-time stored) and GSE directives. The schedule incorporates requests for image data collections that are generated by the Collection Activity Planning Element (CAPE) of the LDCM Flight Operations Segment. Refer to section 1.3 for further details. The MOE schedules the CAPE requested scenes, organizes them into intervals, and returns interval to scene identifier mappings to the CAPE. The MOE performs planning and scheduling of the CAPE-requested and other observatory activities such as communications system management, data recorder management, maneuvers, instrument calibration requests and other events that occur on board the observatory.

The Link Control function of the MOE establishes, configures and maintains the data communications paths between the MOE components and the Networks (LGN, NEN and SN) or LDCM Simulators. The Telemetry function processes Housekeeping (S-band) real-time telemetry to assess spacecraft state of health and support command functions. This function may also be utilized to evaluate any housekeeping data, real-time or playback, recorded by the MOE. The Command function generates, manages transmission of and verifies observatory commands. This function supports command encryption, authority management, and constraint checking prior to transmission of the commands. Command verification is performed following issuance of commands. Command loads are built to implement observatory activity schedules and flight software updates.

The Mission Monitor & Analysis (MM&A) functions process near- and long-term observatory telemetry data. This function is used to trend and analyze the performance of the observatory for state of health monitoring using all collected housekeeping data (e.g.,

potential problems with the observatory attitude, power, temperature, or other subsystems). MM&A provides the capability to report data in various formats to meet engineering needs.

The Flight Dynamics functions provide attitude estimation and sensor calibration, orbit prediction, maneuver planning, definitive attitude and orbit ephemeris generation, mission planning products and ground station acquisition data.

Management of observatory memory falls into three categories. In order of increasing frequency of activity, these areas are: observatory flight software, flight operations-owned data elements and recorded housekeeping and mission data. Updates to the LDCM observatory flight software will be provided to the MOE by the LDCM Space Segment Contractor(s). The MOE will build and send the command loads to update the flight software on the observatory. Periodic table and stored command sequence maintenance may be performed by the Flight Operations Team (FOT). The MOE will provide the capabilities necessary to build the command loads and verify their uplink. Current copies of the on-board memory images will be maintained by the MOE. Recorded housekeeping & mission data storage and recovery is performed on a routine basis. The MOE will support these operations in manual and autonomous modes of operation.

The MOE acts as the keystone system for support of observatory operations, accepting data from various sources, performing value added processing, reporting results of that processing, and delivering the resultant products. The MOE provides services to other MOE applications, MOC-resident elements, other MOC facilities, LDCM segments and authorized users through the sharing of information. This information, and access to it, will be controlled through the controlled repository function of the MOE.

The ground system will be operated at various levels of automation supported by MOE services and their interfaces.

1.3 Mission Operations Center (MOC) Overview

Each of the MOC (bMOC) facilities provides a system of applications and interfaces to external support elements sufficient to meet mission objectives. Major elements integrated into the MOC environment include the MOE and Collection Activity Planning Element (CAPE). This system interfaces to the User Portal Element (UPE), Ground Network Element (GNE), Infrastructure Element (IE), LDCM Project Reference Database (PRD) system and institutional services provided under the Project Service Level Agreement (PSLA). Institutional services include voice and data network support, the Near Earth Network (NEN), Space Network (SN) and the NASA Flight Dynamics Facility (FDF). Figure 1-1 provides a context for the MOC and its interfaces.

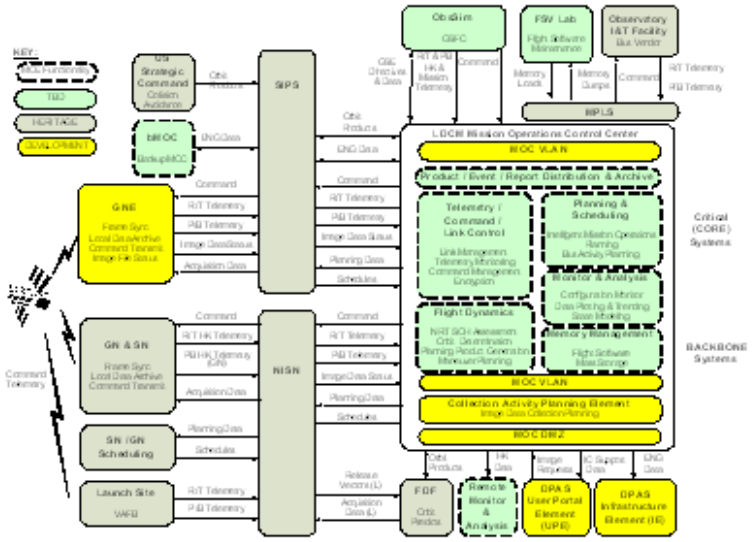

Figure 1 - 1 LDCM MOC Context

The MOC internal network is government supplied and designed to provide secure access to support elements hosted on a variety of networks. Figure 1-1 above provides a high level notional view of the network services available.

The following subsections are not intended to describe the MOE functionality. They illustrate MOE's role in the overall collection planning process, mission data accounting & management, controlled distribution & access to products and elaborates on the related interfaces.

1.3.1 Planning & Scheduling Using the CAPE and MOE

This section is not intended to describe the MOE functionality. It illustrates the MOE role in the overall collection planning process and elaborates on the related interfaces.

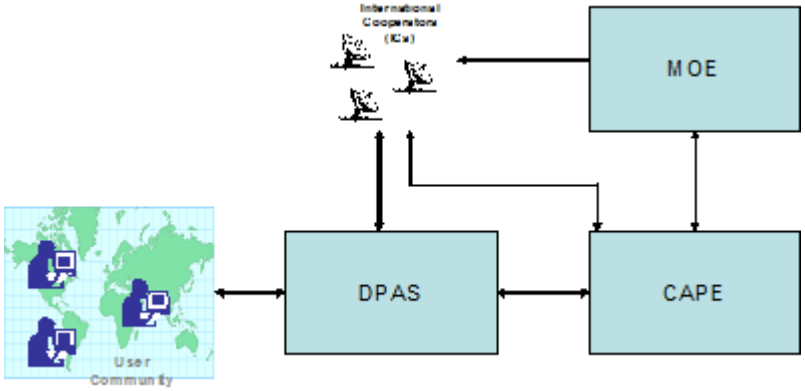

Figure 1 - 2 LDCM Data Collection Planning Context

The Collection Activity Planning Element (CAPE) is the LDCM component which determines the data (at a scene level) that will be acquired by the observatory's imaging sensor(s). The scenes to be collected are largely determined by a set of algorithms running with a set of global imaging requirements expressed as the Long Term Acquisition Plan (LTAP). In addition to these, individual requests from agencies and users in the LDCM User Community are submitted through the Data Processing and Archiving Segment (DPAS). The DPAS forwards these requests to the CAPE for consideration via the User Portal Element (UPE). The CAPE receives activity schedules from the MOE as in input to image data planning.

International Cooperators submit requests for specific acquisitions through the same DPAS functionality, UPE, as the rest of the User Community. IC requests for image data may also be submitted using a mask or table that provides the relative priority of scenes in their region.

The CAPE processes all these inputs (and others) to produce a final Image Data Collection Schedule, which is a scene-based list of image data to be acquired by the observatory. The MOE ingests this list and uses it to generate the detailed spacecraft activity schedules, including determining imaging intervals. After doing the detailed observatory schedule the MOE informs the CAPE of the status of all the scenes in the Image Data Collection Schedule.

The MOE processing of the Image Data Collection Schedule is an automatable process. The MOE initiates contact with the CAPE interface, retrieves any new CAPE schedules, notifies operations staff if a new schedule is found, and executes the schedule process. The operations staff is notified of the results of the process, including any identified constraint violations. Note that the MOE Planning & Scheduling system is not required to autonomously resolve all conflicts but does support constraint checking and activity de-confliction through priority value processing. Planning & Scheduling capabilities are require to detect and report conflicts that are resident in the operator-defined databases.

1.3.2 MOE Memory Management and Data Accounting

This section is not intended to describe the MOE functionality. It illustrates the MOE role in the overall mission data accounting & management process and elaborates on the related interfaces.

The key to successful end to end data accounting is the tracking of data from request to delivery of the finished product. The MOE plays an active role in the process through interaction with the space system; commanding the collection, storage, recovery and release of the requested data. Through the process, the MOE generates and distributes several products, obtains status from the observatory and the Ground Network Element (GNE), schedules observatory activities, predicts constrained resource utilization, manages SSR memory and maintains the 'as run' history of activities and data recovery.

The CAPE translates user requests into scenes, de-conflicts scene requests and packages the plan into a Image Data Collection Schedule for the MOE. The Planning & Scheduling function of the MOE integrates the Image Data Collection Schedule, bundling scene sequences into intervals and de-conflicting the schedule. A Scene to Interval Mapping Table is generated, providing interval identifiers, the scenes included in each interval and the expected files to be created on board to record the data. The table is deposited in a controlled repository with product availability notification distributed to the CAPE and GNE.

A stored command load is generated by the MOE Command function and uplinked for execution by the observatory. The load contains the instrument commands for data collection and SSR commands for data recording. The interval identifiers generated by the MOE are passed along in the SSR record commands and becomes an integral part of the recorded data file name. The load also incorporates commands to initiate and terminate flight software managed downlink of the recorded data.

The observatory (space system) flight software will, on-command, downlink recorded data files not previously transmitted, oldest first. Once transmitted, a file will only be re-transmitted by command request. Any file with the protect flag set will be retained by the SSR, others are over-written, oldest first, as storage is needed. The observatory maintains a catalog of SSR files with transmit and protect status. The catalog is available on request in the S-band telemetry. This data will be utilized by the MOE to update the 'as run' history of activities (including the Scene to Interval Mapping Table) and derive re-transmit and unprotect commands. The table is deposited in a controlled repository with product availability notification distributed to the CAPE and GNE.

In response to files received by the ground, the GNE will generate the GNE catalog of file status. The catalog is used to generate argument values for re-transmit and unprotect commands in near-real-time or are collected for controlled or scheduled command uplink. The GNE catalog is available on request from the GNE. This data will be utilized by the MOE to update the 'as run' history of data recovery (including the Scene to Interval Mapping Table) and derive re-transmit and unprotect commands.

The MOE will be capable of comparing the observatory and GNE catalogues upon request and deriving re-transmit / unprotect commands based on the comparison.

1.3.3 Utilization of the Controlled Repository

This section is intended to illustrate the MOE role in the overall product distribution and controlled access process and elaborates on the related interfaces.

The MOE will generate, distribute, archive and provide access to engineering data. This engineering data satisfies the needs of a diverse LDCM community ranging from MOE applications to remote engineering data users such as the ICs, Cal/Val Team, NASA/USGS/vendor support engineering and off-site FOT. Access to this data is needed from several networks but is always controlled. The Controlled Repository function simplifies this function, maintains the integrity of the available data, distributes the data, synchronizes the distributed data files, and provides data access where needed. The repositories are redundant in the MOC, a single repository in the bMOC with a repository maintained on the unrestricted network. This latter repository facilitates access by remote authorized users, applications on the unrestricted networks and to initialize a bMOC cold-start. At a minimum, the repositories contain a copy of the Project Reference Database and products generated by the MOE.

1.3.4 The Project Reference Database (PRD) system

This section is intended to illustrate the MOE role in the overall PRD process and elaborates on the related interfaces.

The PRD is maintained by a standalone system which supports configuration management of all ground system data administered by the Flight Operations Configuration Control Board. The system is a government provided set of utilities used to collect, control and distribute configuration managed data across ground system applications. The system will generally be co-located with the MOE Controlled Repositories and mini-MOE sites.

The PRD is a file containing all the configured data used to develop, test, and operate the Observatory, as well as some of the metadata needed to manage the PRD. The master PRD zip file is distributed across the Controlled Repositories of the MOE. The term "configured data" is understood to include all MOE databases and MOE-related FOT Products under control at the Flight Operations CCB. Dynamic data such as actual telemetry, as well as any static data used in LDCM flight or ground software without configuration control through the Flight Operations CCB, are not considered configured data.

Input and output to the PRD is in the format native to the application. The PRD system will perform any necessary translations from the native application format to the CCSDS compliant XML Telemetric & Command Exchange PRD format.

The PRD content is distributed across a wide, geographically dispersed network of LDCM development sites.

Some of the key user sites are shown in Figure 1-3 below.

- Spacecraft Integration & Test (I&T) facility (a mini-MOE site)
- Instrument Development & Test (D&T)lab (a mini-MOE site)
- MOC (Primary and Redundant Controlled Repository)
- bMOC (backup Controlled Repository)
- Remote Mission Monitor and Analysis System (Open Controlled Repository)
- Flight Software Vendor (a stand-alone PRD system)

PRD Notional Deployment

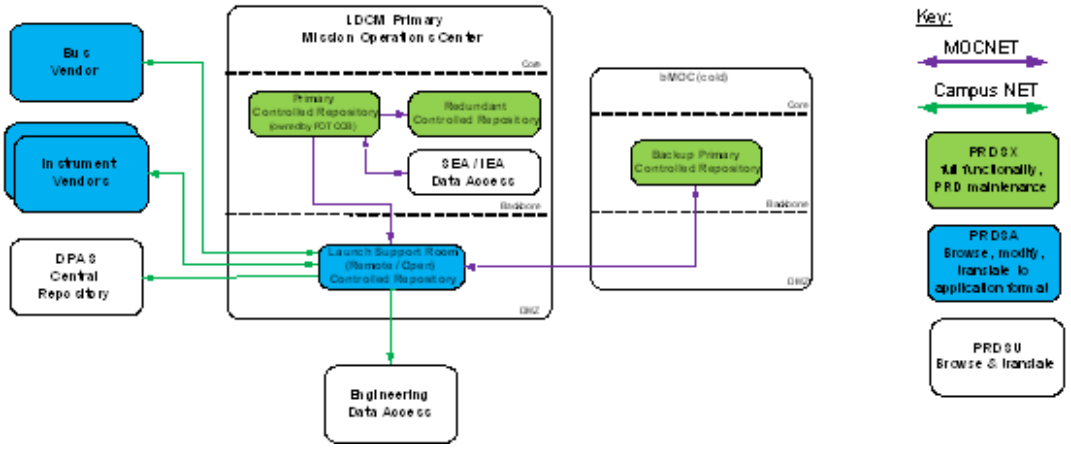

Figure 1 - 3 LDCM Project Reference Database (PRD) System Notional Deployment

1.4 Overview of the LDCM Ground System (GS)

The GS is comprised of an integrated system of elements and interfaces to external support elements. The segments comprising the GS include the Flight Operations Segment (FOS) and the Data Processing and Archive Segment (DPAS). The FOS elements include the MOE, CAPE, and Ground Network Element (GNE). DPAS elements are the User Portal Element (UPE), Storage & Archive Element (SAE) Image Processing Element (IPE) and Infrastructure Element (IE). In addition to the CAPE, the MOE interfaces with the GNE and IE.

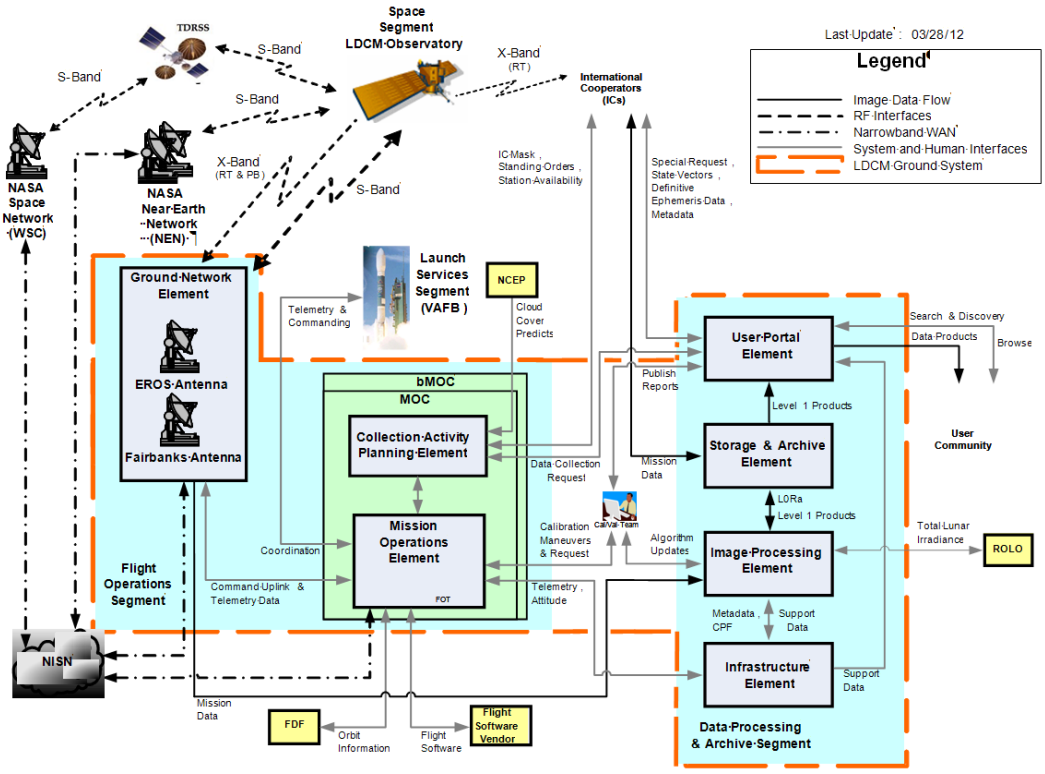

Figure 1 - 4 LDCM Ground System context

1.5 Document Terminology

The following terms may be used internal to requirements in this document:

The term “shall” indicates a requirement - a specification of a function, capability, or constraint with which the system design must be compliant, verifiable and have a demonstrated achievement during the mission.

The term "(TBS)", which means "to be specified", means that the spacecraft, instrument or other ground system element contractor will supply the missing information in the course of the contract. These serve as a placeholder for future requirements. The MOE contractor is not liable for compliance with these "placeholder" requirements, as insufficient information is provided on which to base a design.

The term "(TBR)", which means "to be refined/reviewed", means that the requirement is subject to review for appropriateness by both contractor and the government, and subject to revision. The MOE contractor is liable for compliance with the requirement as if the "TBR" notation did not exist. The "TBR" merely provides an indication that the value is more likely to change in a future modification than requirements not accompanied by a "TBR".

The term “Rationale:” does not define a requirement but adds context to the stated requirement.

Note that Appendix A of this document and the LDCM Acronym List and Lexicon provide definition of additional terms.

1.6 Document Overview

Figure 1-5 provides the context for this document with respect to other LDCM controlled documents.

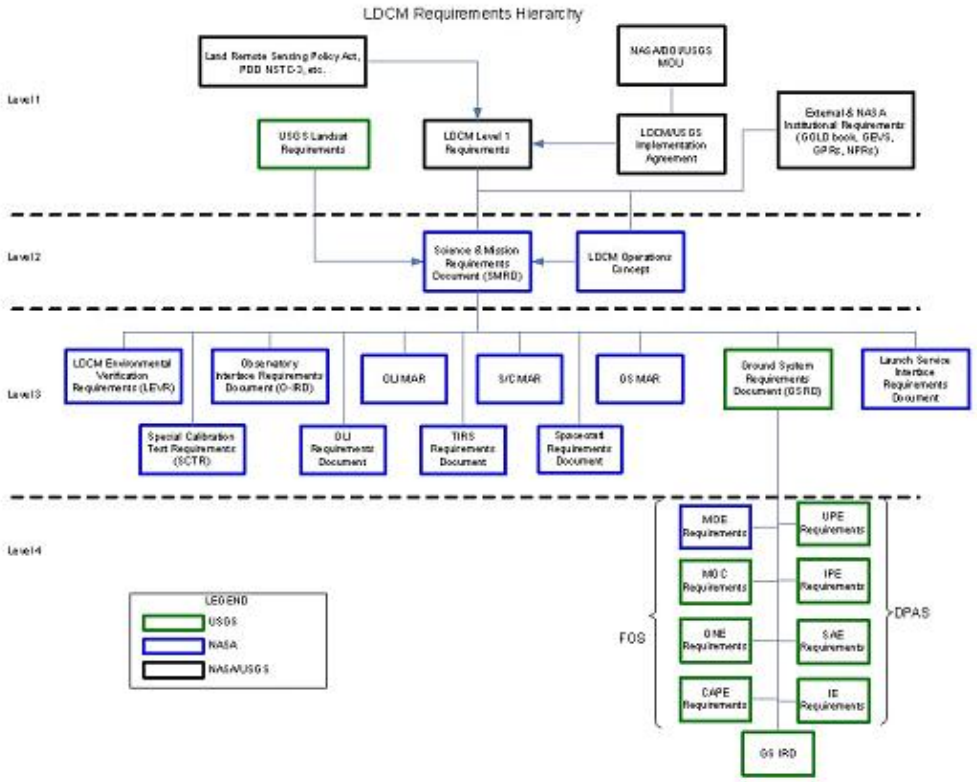

Figure 1 - 5 LDCM Requirements Flow

Sections of this document may be read in any order. However, the following sequence of review is recommended:

Overview:	Sections 1, 2
General Requirements:	Sections 3, 4, 5, 11, 12, 13, 14, 16, 17
Function / Service Requirements:	Sections 6, 7, 8, 9, 10, 15

2 Applicable and Reference Documents

2.1 Applicable Documents

The MOERD is consistent with and responsive to the following applicable documents.

Document Number	Revision/ Release Date	Document Title
427-06-03	Revision A December, 2007	LDCM Spacecraft Requirements Document
427-02-03	Revision B November, 2007	LDCM Observatory Interface Requirements Document
427-06-01	Draft February, 2007	LDCM Launch System Requirements Document
NPD 8010.2E	March 04, 2007	NASA Policy Directive, Use of the SI (Metric) System of Measurement in NASA Programs
NPR 2810.1A	May 16, 2006	NASA Procedural Requirement, Security of Information Technology
		<http://www.hq.nasa.gov/office/procurement/regs/pn04-25.html> - NASA IT Security Clause
SM 600.5	November 14, 2007	U.S. Geological Survey Manual (SM) 600.5 - Automated Information Systems Security
FIPS 201	March, 2006	Personal Identity Verification (PIV) of Federal Employees and Contractors
NIST Special Publication 800-73	March, 2006	Interfaces for Personal Identity Verification
450-SNUG	June 2002	Space Network (SN) Users' Guide, Revision 8
453-GNUG	February 2005	Ground Network (GN) User's Guide, Revision 1
452-ICD-SN/CSM	May 2004	Interface Control Document Between the Space Network and Customers for Service Management
CCSDS 231.0-B-2	September 2003	Recommendation for Space Data Systems Standards. TC Synchronization and Channel Coding. Blue Book. Issue 1.
CCSDS 231.0-B-1 Cor.1	June 2006	Recommended Standard Technical Corrigendum 1 to CCSDS 231.0-B-1, Issued September 2003. Blue Book. Issue 1.

CCSDS 232.0-B-1	September 2003	Recommendation for Space Data Systems TC Space Data Link Protocol. Blue Book. Issue 1.
CCSDS 232.1-B-1	September 2003	Recommendation for Space Data Systems Standards. Communications Operations Procedure-1. Blue Book. Issue 1.
CCSDS 133.0-B-1	September 2003	Recommendation for Space Data Systems Standards TM Space Packet Protocol. Blue Book. Issue 1.
CCSDS 131.0-B-1	September 2003	Recommendation for Space Data Systems Standards TM Synchronization and Channel Coding
CCSDS 732.0-B-1	July 2006	Recommendation for Space Data Systems Standards AOS Space Data Link Protocol
CCSDS 727.0-B-4	January 2007	Recommendation for Space Data Systems Standards CCSDS File Delivery Protocol (CFDP)

2.2 Reference Documents

The following documents provide further context for the MOERD and the LDCM.

Document Number	**Revision/ Release Date**	**Document Title**
427-02-06	Revision B December 6, 2007	LDCM Acronym List and Lexicon
427-02-02	January 4, 2007	LDCM Operations Concept Document
427-09-01	Draft May 2007	MOE Statement of Work
427-PG-1410.2.1	Draft August 2007	Landsat Data Continuity Mission (LDCM) Configuration Management Procedures
NASA-STD-8739.8	Baseline July 28, 2004	Software Assurance Standard
427-02-07	Rev -, January 4, 2007	Landsat World Reference System -2 (WRS-2) Definition
NPR 7150.2	September 27, 2004	NASA Software Engineering Requirements
DM 375 Chapter 19	April 15, 2002	Information Technology Security Program
LDCM-TSSC-REQ-003	January 16, 2008	USGS LDCM Collection Activity Planning Element (CAPE) Requirements Document
CCSDS 301.0-B-3	January, 2002	Recommendation for Space Data Systems Time Code Formats.
CCSDS 660.0-M-0.0	Draft October, 2007	Draft Report Concerning Space Data System Standards XML Telemetric & Command Exchange.

427-09-05	Draft December, 2007	LDCM Project Reference Database System (PRDS) to Users Data Format Control Document (DFCD)
GSFC STD-1000A Revision A 2005-05-30	Rev C.2 December 12, 2006	Rules for the Design, Development, Verification and Operation of Flight Systems

3 General / Administrative

MOE224 The MOE shall conform to NPD 8010.2E, NASA Policy Directive, Use of the SI (Metric) System of Measurement in NASA Programs.

MOE225 The MOE shall comply with the following subparts of Section 508 of the Rehabilitation Act (29 U.S.C. 749d), as amended, 36 CFR Part 1194 <http://www.access-board.gov/sec508/508standards.htm>: Technical Standards Subpart B 1194.21, 1194.22, 1194.26, and Information, Documentation, and Support Subpart D.

Rationale: compliance with accessibility requirements for software and selected hardware; also compliance with requirement from NPR 7150.2

MOE227 The MOE shall utilize an open architecture with standard interfaces.

Rationale: for extensibility, scalability, and simplification of I&T; enables modularity and scalability, plug and play architecture

MOE229 The MOE shall provide standardized message-based communications between MOE sub-systems and applications.

Rationale: supports modularity, situational awareness, and autonomous operations

MOE231 The MOE shall use Universal Time Coordinated (UTC) time as the time base for all operations activities.

MOE232 The MOE shall display time values utilizing time code formats where:

- the calendar subset includes year (YYYY or YY) and day of year (JJJ)

- the time of day subset includes hour (hh), minute (mm), second (ss) and fractional second.

Rationale: Defines common data field characteristics for cross-reference of data products.

MOE234 The MOE shall be automatically synchronized to a GFE-provided external master time signal reference.

Rationale: Allows time across the various MOE systems to be synchronized with a time source that stays accurate without operator intervention. This ensures that ground timestamps on data, event logs, etc. remains accurate.

MOE236 The MOE shall receive and archive all housekeeping data for the life of the mission.

Rationale: record for possible retrieval, all spacecraft / observatory housekeeping data collected during all phases of the mission.

MOE238 The MOE shall maintain version control for all MOE data.

MOE239 The MOE shall interface with the ground communications network for the exchange of mission data and products among the ground system elements.

Rationale: support MOE interface to other LDCM elements (CAPE, GNE, DPAS IE< etc) thru government supplied ground communications networks

MOE241 The MOE shall provide the bi-directional interface between the ground system elements and the space-ground communications links to the Observatory.

Rationale: the MOE will be the system to provide in-flight operational command and control support for the observatory.

MOE243 The MOE shall provide an anomaly reporting and status tracking capability.

Rationale: detect, report and summarize data supporting observatory anomalies. Provide the capability to generate electronic data used to originate and support updates to a problem tracked by typical institutional anomaly reporting systems.

MOE245 The MOE shall maintain documentation electronically and providing access by authorized users.

Rationale: make all controlled documentation useable by the FOT and supporting engineers available via the data network.

MOE247 The MOE shall utilize the Project Reference Database System (PRDS) for configuration management of all MOE databases and MOE-related FOT Products under control of the Flight Operations Configuration Control Board (CCB).

Rationale: support utilization of a common database among applications to maintain consistency and quality of parameter values, XML format is preferred for most reference data items.

4 Information Technology Security (ITS)

The MOE will reside in environments hosted by NASA. The element is required to meet the security requirements of NASA. This section defines those requirements.

MOE251 The Mission Operations Element (MOE) shall utilize IT security requirements outlined in NASA Procedural Requirement (NPR) 2810.1A, Security of Information Technology as the baseline requirements document for the IT security. In addition compliance is required with technology requirements outlined as follows:

MOE252 In addition to the existing Incident Handling and Reporting requirements in NPR 281 0.1 A, all incidents involving personally identifiable information shall be reported within one hour of detection.

MOE253 Following the approval of each Center's Migration Plan by the NASA CIO, implement Active Directory trusts and network interconnections based on the approved NASA Architecture Design. All new implementations shall meet the approved NASA Architecture Design for Active Directory.

MOE254 Administrative rights and privileged accounts shall be limited to only those employees requiring them and maintained through periodic review of those with administrative privileges to ensure that administrative rights are still required.

MOE255 The MOE shall meet the IT security requirements outlined in the NIST publications. NPR 2810.1A requires that National Institute of Standards and Technology (NIST) publications (<http://csrc.nist.gov/publications/fips/index.html>) including the Federal Information Processing Standards (FIPS) and Special Publication (SP) 800 series documents be implemented to meet the Federal Information Security Management Act (FISMA) requirement.

MOE256 The MOE is one element of the Mission Operations Center (MOC). The MOC has been categorized a MODERATE system. The MOE controls that are selected shall be implemented at a MODERATE level at a minimum.

Note: These documents addresses a broad set of information systems security control techniques including those of:

- System, physical, software, and data protection;
- Personnel and administrative procedures;
- Risk management and contingency planning; and
- Computer security plans and reviews.

4.1 Access Control

All systems and applications classified according to Federal Information Processing Standards 199 and National Institutes of Standards and Technology Special Publication 800-60 as being Moderate or High are required to utilize two-factor authentication. All NASA systems and applications are required to only allow two factor authentication used in conjunction with the Internet Protocol Security to administer servers and network devices.

MOE261 The MOE shall comply with Homeland Security Presidential Directive [HSPD]-12, two-factor authentication based on Public Key Infrastructure [PKI] and Smartcards.

MOE1452 When federal Personal Identity Verification (PIV) credentials are used as an identification token where token-based access control is employed, the MOE access control system shall conform to the requirements of FIPS 201, Personal Identity Verification (PIV) of Federal Employees and Contractors and NIST Special Publication 800-73, Interfaces for Personal Identity Verification.

MOE262 Where appropriate, the MOE shall utilize centralized logging of operating system and application logs to identify unauthorized and anomalous activity with capability to maintain the integrity of the logs for a minimum of one year.

5 Reliability and Availability

MOE264 The MOE shall have a system up time availability for core critical command and control operations of at least 99.9% averaged over 30 consecutive days, not including planned maintenance and non-contact time periods.

Rationale: MOE must be available to support real-time command operations; excludes non-scheduled contact time and planned down time per month for performance of system maintenance

MOE266 The MOE, excluding command and control operations, shall have a system up time availability of 98.5% averaged over 30 consecutive days, not including planned maintenance conducted during non-contact periods.

Rationale: MOE systems, non-critical to command and control, can have a less stringent up-time availability, and be scheduled for maintenance on a non-interference basis to mission operations. These systems require redundancy and provide the capability to failover but hot failover capability is not required.

MOE268 The MOE shall add and remove MOE non-core critical systems with no loss in data or interruption to operations.

Rationale: The real-time system is expected to be fault-tolerant of the loss of backup or off-line systems, enables modularity and scalability, plug and play architecture.

MOE270 The MOE shall ensure that no single point of failure exists for critical command and control functions.

MOE271 The MOE shall have a mean time to restore core critical command and control operations of 1 minute or less.

Rationale: This provides for the transfer of command authority from one workstation to another in the event of failure, ensures no loss of ability to command, control, and ingest of telemetry

MOE273 A controlled ‘power-down’ and ‘power-on initialization’ sequence for the MOE operational crititcal core and backbone shall be complete in less than 30 minutes.

Rationale: The operational ITOS, Flexplan, Archiva, and FDS MOE subsystems (12 servers) may be power cycled or re-booted between contacts.

MOE275 The MOE shall support training, testing, or system maintenance with no interruption to MOE functionality.

Rationale: to support training, testing, and system maintenance and use of the observatory simulator on a non-interference basis.

MOE277 The MOE shall operate with the observatory simulator simultaneously with mission operations, with no impact to mission operations.

Rationale: specifically creates ability to use simulator while performing mission ops

MOE279 All MOE applications shall generate and publish event messages providing alarm / warning / event information to indicate application state.

Rationale: Event messages can be evaluated and responded to as defined by operator.

MOE281 The MOE shall provide system monitoring tools to track MOE system performance.

Rationale: supports health assessment of the MOE and analysis in the event of failure

MOE283 The MOE shall log, track, and report system faults and failures.

Rationale: applications report significant events to the centralized logging system and may maintain additional internal logging, etc to support fault management

MOE285 The MOE shall report system faults and failures remotely to a communications/pager service

Rationale: the intent is to notify operations personnel of faults or failures using a centralized and/or distributed system, as necessary.

6 Telemetry, Command and Control

This section defines the MOE requirements for command and telemetry processing.

MOE289 The MOE shall provide the sole interface between the ground system elements and the ground to space forward communications links to the Observatory.

Rationale: Provides the sole and controlled gateway for access to the forward link.

MOE291 The MOE shall provide the bi-directional interface between the ground system elements and the observatory simulator.

Rationale: the MOE will provide command and control interface to the observatory simulator for FOT training, etc.

MOE293 The MOE shall simultaneously perform real-time commanding, real-time housekeeping telemetry receipt and ingest, stored housekeeping telemetry receipt and ingest, playback of internally recorded housekeeping telemetry and support for observatory simulator command and telemetry operations.

Rationale: allows MOE, as a system, to perform command and telemetry operations. Segments of the system are configured to support operations

MOE295 Each MOE workstation shall be individually configurable to define its control, command and telemetry processing attributes, including data stream access.

Rationale: allow the operator to select command destination and data source selection. This allows operators to connect to the simulator or view playback telemetry while other operators are actively supporting a contact.

MOE297 Each MOE workstation shall have the capability to display dynamic system control, command and telemetry processing attributes.

Rationale: allow the operator to select command destination and data source selection. This allows operators to connect to the simulator or view playback telemetry while other operators are actively supporting a contact.

MOE1656 The MOE shall provide access to event messages in real-time from the command controller workstation to all other C&T workstations.

Rationale: Allows users to see event messages and logs without having to log in each time.

MOE1668 The MOE shall allow individual users to select from which command controller workstation to access events.

Rationale: Allows users to specify the event source, i.e., observatory or simulator

6.1 Link Control

MOE300 The MOE shall establish, manage and terminate the forward and return links with the GNE, GN and SN networks.

Rationale: The MOE is configurable to support forward and return link services with the networks via GSE directives.

MOE302 The MOE shall assess and report the configuration and status of the forward and return links with any ground station.

Rationale: Data related to the status of the links is needed to support verification of directive activities and link status. Data sources may include GNE ground station status messages.

MOE304 The MOE shall have the ability to configure the forward, return and status data streams between any ground station automatically based on the schedule or manually from the command console via directive.

Rationale: ability to establish links for commanding and telemetry; ensure only one station sends command to the observatory at a time

MOE306 The MOE shall configure forward, return, and status data streams from one ground station to another in less than 10 seconds.

Rationale: quick configuration to set up link to observatory for a hot handover between networks or stations.

MOE308 The MOE shall write the network (GNE, NEN, or SN) resource routing codes for which it is configured to support derived telemetry parameters.

Rationale: To provide the MOE operators positive identification of the expected resource

MOE310 The MOE shall generate LDCM Ground Network Element (GNE) forward and return link service requests.

Rationale: MOE must acquire link through GNE before commanding

MOE1519 The MOE shall identify telemetry and appropriately store telemetry into off-line storage (I&T/on-orbit spacecraft/simulator) as per LEO-T Header data class field.

Rationale: Need to distinguish amongst various types of data: spacecraft I&T/On-Orbit/Simulation to prevent corruption/mixing data types and to store in proper locations, databases, etc.

6.2 Commanding

This section defines the MOE requirements for commanding to manage the forward link to the observatory, issue commands generated within the MOC, perform hazardous/critical command checking, and perform command verification.

MOE314 The MOE shall communicate with the observatory in accordance with the following Consultative Committee for Space Data Systems (CCSDS) Recommendations for Space Data Systems Standards:

231.0-B-1 Telecommand Synchronization and Channel Coding,

232.0-B-1 Telecommand Space Data Link Protocol,

232.1-B-1 Communications Operations Procedure-1, and

133.0-B-1 TM Space Packet Protocol

Rationale: CCSDS compliance

MOE316 The MOE shall generate commands to perform the observatory functions and requirements as defined in the LDCM Command Handbook and supporting documents defining command definition and processing requirements.

Rationale: overarching requirement for MOE to be able to command the observatory to perform any of its operational capabilities. The handbook is provided as a deliverable item by the spacecraft bus vendor.

MOE318 The MOE shall generate commands to support the retransmission of X-band telemetry data units.

MOE319 The MOE shall time tag all stored commands (absolute and relative) with a resolution of one (1) milli-second.

Rationale: Allows the operator to sequence and correlate ground system events. This is a format requirement and not an accuracy requirement.

6.2.1 Command Encryption and Authentication

MOE322 The MOE shall perform NSA-approved Caribou command encryption and authentication implemented using the MYK-15 device.

MOE323 The MOE shall include a command encryption and authentication bypass (clear mode).

6.2.2 Authorization for Commanding

MOE1495 The MOE shall control access to TT&C workstations using login attributes.

Rationale: this requirement is supported by login attributes and a definition of the commands available by authority

MOE333 The MOE shall allow only a single authorized operator to control and transmit commands to the observatory.

Rationale: This provides for a designated single command controller or command gateway (i.e. can allow or block transmission of commands submitted by another operator)

6.2.3 Commanding Requirements

Requirements providing the capability to construct real-time commands and uplink loads for the observatory are delineated in the following subsections.

MOE341 The MOE shall perform real time commanding to the observatory.

Rationale: allows operator to generate and send discrete and/or command sequences during a contact, manually from a command line input and/or as automated execution of pre-staged commands

MOE343 The MOE shall validate, generate, and uplink discrete observatory commands.

Rationale: allows operators to generate and send individual or syntax-based commands

MOE345 The MOE shall uplink observatory command loads.

Rationale: allows operators to uplink and verify command load files to the observatory. Reference the "Load Generation" section for requirements governing load creation.

MOE347 The MOE shall construct real-time commands from operator specified bit patterns expressed in hexadecimal.

Rationale: Provides the capability to construct commands not defined in the Project Reference Database. This class of commands, by definition, cannot be validated.

MOE349 The MOE shall provide notification to the operator of any invalid commands.

MOE350 The MOE invalid command notifications shall include the specific reason for command validation failure.

Rationale: operator feedback as to the nature of the command invalidity (e.g. "cmd not found", "sub-mnemonic out of range", etc)

MOE352 The MOE shall generate command procedures via a scripting language.

Rationale: automates the execution of command sequences on the ground that varies based upon observatory state or operator argument value input. See the definition of "procedure" in the glossary.

MOE354 The MOE shall support commanding in an autonomous (unattended) state.

Rationale: Provide the capability to run autonomous operations.

6.2.4 Load Generation

MOE357 The MOE shall uplink observatory loads that are stored as named files in the system.

Rationale: Provides the capability to create and store a load for use at anytime. These loads may be memory or command loads.

MOE359 The MOE shall generate and store loads using a file naming convention for time-tagged stored sequences using absolute time tags.

Rationale: Provide the capability to build and store ATS Loads.

MOE361 The MOE shall provide a capability to generate and store loads using a file naming convention for time-tagged stored sequences using relative time tags.

Rationale: Provide the capability to build and store RTS Loads.

MOE363 The MOE shall provide a capability to generate and store table loads using a file naming convention from operator specified information.

Rationale: Provide the capability to build and store Table Loads.

MOE365 The MOE shall generate and store loads using a file naming convention from de-conflicted observatory activity schedules.

Rationale: This Master Schedule forms the basis of command input for ATS load creation.

MOE367 The MOE shall allow the operator to specify the ATS load start and stop times.

Rationale: The start and end times are specified for every ATS load.

MOE369 The MOE shall generate and store memory loads using a file naming convention to upload/implement Flight Software (FSW) memory modifications and updates.

Rationale: ability to load and/or modify FSW on the observatory

MOE371 The MOE shall generate and store loads using a file naming convention to execute and control observatory attitude and orbit maneuvers.

Rationale: supports maneuver capability

MOE373 The MOE shall produce a load generation report for all loads, containing accounting information, description of load contents, any warning and/or error messages and a summary of creation results.

Rationale: For successful creation attempts, a description of each load file on the system will be available. For failed attempts, the report will indicate the problems.

MOE375 The MOE shall allow authorized operators to edit loads.

Rationale: The MOE provides the capability to deny unauthorized operators access to system capabilities.

MOE377 The MOE shall allow operators to display loads in hex and interpreted formats.

MOE378 The MOE shall report the status of command load generation.

Rationale: allows operators to know the state of command loads that may each be in different stages of development and to know the completion status of automated processing steps. Operators are notified of any problems detected by the system during creation of the load.

MOE380 The MOE shall allow only authorized operators to transfer and/or delete load files.

Rationale: The MOE provides the capability to deny unauthorized operators access to system capabilities.

MOE382 The MOE shall configuration manage load files within the system to preclude the uplink of unapproved load files.

Rationale: provide mechanisms to segregate test or in-work load files from those authorized for uplink.

6.2.5 Critical / Hazardous Command Management

MOE385 The MOE shall identify and designate critical commands in the command database.

Rationale: flagging of commands that could jeopardize the health and safety of the observatory or its subsystems.

MOE389 The MOE shall employ at least one additional operator confirmation prior to the use of a critical command in a command load or in real-time commanding.

Rationale: creates operator intervention for critical commands; Ensures that operator has to provide additional approval before command is used in a command load or in real-time.

MOE391 The MOE shall enable or disable the use of additional operator confirmation(s) prior to critical commanding via system parameter and/or command.

Rationale: Provides support for autonomous commanding, operator and/or procedure may manage this system parameter. The parameter is to be accessible for display and evaluation by procedure. Value is set to enable by default at system startup.

MOE1487 The MOE shall identify and designate hazardous commands in the command database.

Rationale: flagging of commands that could endanger the safey of personnel working on the observatory during I&T, launch prep & launch or cause significant damage to the observatory or facilities

MOE1488 The MOE shall prevent use of a hazardous command in a command load or in real-time commanding.

Rationale: Ensures that the command cannot be used in a command load or in real-time.

6.2.6 Constraint Checking

MOE394 The MOE shall identify and designate command constraints and rules.

Rationale: flagging command sequences or context that could jeopardize the health and safety of the observatory or its subsystems, under certain conditions.

MOE396 The MOE shall temporarily modify or edit command rules and constraints by authorized operators.

Rationale: restrict the modification of this database entry type to only specific operators

MOE398 The MOE shall perform automatic constraint and rule checking of discrete commands and command loads.

Rationale: perform routine check of commands before transmission

MOE400 The MOE shall enable / disable automatic constraint and rule checking of discrete commands and command loads by operator specification.

Rationale: The capability to allow transmission of commands or command sequences that have not been constraint or rule checked by setting a system parameter and/or directive.

MOE402 The MOE shall perform manual constraint and rule checking of discrete commands and command loads.

Rationale: operator can invoke an evaluation of a candidate script or schedule

MOE404 The MOE shall identify the item failing constraint check and the constraint or rule that was violated via event messages.

Rationale: notify the operator of the problem and where it is

MOE406 The MOE shall require at least one additional operator confirmation prior to the transmission of commands or command sequences that have failed constraint check.

Rationale: creates operator intervention for commands that fail constraint checks; Ensures that operator has to provide additional approval before command is used in a command load or in real-time.

6.2.7 Command Verification

This section applies to the verification of real-time commands. Assessment of stored command activity is addressed under Mission Monitor & Analysis.

MOE410 The MOE shall notify the operator that the commands sent to the observatory were correctly received utilizing COP-1 verification.

Rationale: Assess and report ‘command verification (CV)’ status

MOE412 The MOE shall provide for operator enable / disable of the command verification function.

Rationale: be able to turn COP-1 verification on and off via ground system directive.

MOE414 The MOE shall manually retransmit commands or command loads that were not command verified (CV) by the observatory.

MOE415 The MOE shall autonomously retransmit commands or command loads that were not command verified by the observatory.

MOE416 The MOE shall perform an operator specified number of autonomous command retransmission attempts.

Rationale: allow for N number of automatic retransmission attempts before stopping

MOE418 The MOE shall enable and disable the autonomous command retransmission capability.

Rationale: ability to turn on/off automated retransmission function

MOE420 The MOE shall identify and designate telemetry verification (TV) parameters and expected values in the command database.

Rationale: defining applicable telemetry responses to command.

MOE422 The MOE shall notify the operator that the commands sent to the observatory were correctly received and executed utilizing telemetry verification (TV).

Rationale: Assess and report 'telemetry verification (TV)' status of an issued command by evaluation command database defined TV parameter expected value against current value in telemetry.

MOE424 The MOE shall provide for operator enable / disable of the telemetry verification (TV) function.

Rationale: be able to turn telemetry verification on and off via ground system directive.

6.2.8 Command Project Reference Database

MOE427 The MOE shall define observatory commands and their characteristics in a command database.

MOE428 The MOE shall have the capability to search and sort observatory commands defined in the command database.

Rationale: allows for ease in building command sequences

MOE430 The MOE command database shall allow the referencing of commands and command sequences based on mnemonic specification.

Rationale: provides logical IDs for commands

MOE1493 The MOE command database shall have unique mnemonic specification for each command and command sequence in the database.

Rationale: provides logical IDs for commands

MOE432 The MOE shall manage the authority to modify the command database by login attributes.

Rationale: restricts write access to the MOE command database

MOE434 The MOE shall employ at least one additional operator approval or rejection step prior to modification of observatory commands and their characteristics in the command database.

Rationale: requires approval from Flight Operations CCB-approved personnel

MOE436 The MOE command databases shall receive modifications derived from the Project Reference Database (PRD).

Rationale: common database providing Flight Operations CCB controlled databases, etc.

MOE438 The MOE shall provide command database modifications for submission to the Project Reference Database (PRD).

Rationale: mechanism for submissions to the Flight Operations CCB for approval & distribution.

6.2.9 Logging & Reporting

MOE441 The MOE shall archive all command operations and command history for the life of the mission in raw (hex) and interpreted formats.

Rationale: This archive includes all command messages issued to the observatory and provides a time-tagged history of all commands sent to observatory

6.3 Telemetry Processing and Reporting

This section defines the requirements for telemetry processing by the MOE software. Processing the data includes extracting data from the source packets, assessing quality, calibrating, converting, and limit sensing individual telemetry parameters as defined in the project telemetry database. Output, including display, of state conversions, conversion to engineering units and raw value options are required.

6.3.1 Telemetry Processing

MOE446 The MOE shall accept telemetry from the observatory in accordance with the following Consultative Committee for Space Data Systems (CCSDS) Recommendations for Space Data Systems Standards:

131.0-B-1 TM Synchronization and Channel Coding,

133.0-B-1 TM Space Packet Protocol and

732.0-B-1 AOS Space Data Link Protocol.

Rationale: CCSDS compliance

MOE448 The MOE shall time tag all observatory and ground system data with a UTC time.

Rationale: Allows operator to correlate ground system and spacecraft data output displays & reports.

MOE450 The MOE shall time tag all MOE generated data with a resolution of one (1) milli-second.

Rationale: Allows the operator to sequence and correlate ground system events. This is a format requirement and not an accuracy requirement.

MOE452 The MOE shall process all spacecraft telemetry data with a resolution of one (1) micro-second.

Rationale: Allows the operator to sequence and correlate spacecraft events with a time resolution consistent with spacecraft time tagging of telemetry. This is a format requirement and not an accuracy requirement Note: some attitude data has a period of 50 micro-seconds.

MOE454 The MOE shall process and report all housekeeping telemetry.

Rationale: The MOE may need to process real-time, playback and re-transmitted housekeeping telemetry from various S-band and/or X-band downlink virtual channels. The same packet may be received multiple times.

MOE1497 The MOE shall process stored state of health (SSOH) telemetry in the format documented in the space to ground ICD. The SSOH packets are contained in M_PDUs, and each SSOH M_PDU is transmitted using the encapsulation service with encapsulation (version 8) packets.

MOE456 The MOE shall decommutate all housekeeping telemetry, Flight Software Event messages and Flight Software Table dumps based on the telemetry database.

Rationale: establishes that decomutation is driven by a database

MOE458 The MOE shall have the capability to replay telemetry up to a 20X record-time rate processing all packets received.

Rationale: To be able to replay telemetry in a timely manner to prevent telemetry backlogs and interference with real-time telemetry downlink;

MOE459 The MOE shall replay housekeeping telemetry based on an operator specified start and stop time and replay rate.

MOE460 The MOE shall specify the replay of housekeeping telemetry by ground receipt time or spacecraft time.

MOE461 The MOE shall record and distribute CCSDS formatted housekeeping packets received from up to two network (ground station) sources simultaneously.

Rationale: supports ground station handover. Real time data is distributed to operators as per workstation configuration, playback data is recorded and distributed for ingest.

MOE463 The MOE shall conduct handoffs between GNE, Near Earth Network (NEN), and Space Network with overlapping observatory view periods with loss of less than 10 seconds of data.

Rationale: allows handoff from one ground station to another without significant loss of real-time telemetry (S-band link).

MOE465 The MOE shall select a new telemetry source and reinitialize related parameters within 1 second.

Rationale: provides the capability to cleanly perform handovers between contacts or quickly transition between processing of real/time and playback telemetry.

MOE467 The MOE shall perform rudimentary processing of telemetry data to generate datasets of continuous time-ordered packet data.

Rationale: generate datasets of packet data (telemetry and ground system) in time order with duplicate packets removed for use by FD and other ground system applications.

MOE469 Time-ordered packet data processing by the MOE shall be controlled by directive, generating datasets over operator specified time intervals.

MOE470 The MOE shall create subsets of time-ordered packet data by operator specified packet ID list.

Rationale: provide datasets containing just the data needed by the application

MOE1521 The MOE shall receive and process ascent telemetry as defined in the Launch Site Support Plan.

Rationale: Used to verify observatory health.

MOE1655 The MOE shall inject telemetry for long-term storage at a rate of at least 8.5 times the real-time rate. Note: The requirement assumes the real-time rate is 22,000 samples per second, with the following APID's enabled: 0, 1, and 18-28. For testing purposes, this rate can be estimated by injecting a fixed quantity of data and measuring the time required to complete the operation. The injection is considered complete when the data is stored within the long-term storage database.

Rationale: In order to support anomaly recovery, analysis of back orbit data must be completed promptly.

6.3.2 Data Quality

MOE473 The MOE shall prevent ingest of invalid telemetry messages.

Rationale: rejection of telemetry that is not in a recognizable format and can not be de-commutated or is de-commutated but contains incorrect/invalid values in the packet header, etc. Data is not recorded as part of the telemetry archive but may be recorded to a temporary file.

MOE475 The MOE shall notify the operator via event message when invalid telemetry is detected.

Rationale: signals ops team when bad telemetry is detected

MOE477 The MOE shall assess the quality of received spacecraft telemetry packets and report the results of that analysis.

Rationale: supports link quality assessment and S-band data retransmission

MOE479 The MOE shall detect corrupted packets and correct single bit errors.

MOE480 The MOE shall process corrected packets.

MOE481 The MOE shall process or pass uncorrectable frames as per operator selected configuration under directive control.

MOE482 The MOE shall notify the operator via event message when uncorrectable frames are detected.

Rationale: signals ops team when bad telemetry is detected

MOE484 The MOE shall mark all parameters in a processed uncorrectable frame as bad quality data.

MOE485 The MOE shall perform session monitoring and sequence error checking on active links between ground stations and the MOE.

Rationale: quality checking on link and data transfer during communications

MOE487 The MOE shall assess packet continuity of S-band real-time and playback telemetry.

Rationale: This process would notify the MOC of data drop-outs and provide the information to support re-transmit requests. Continuity of engineering data supports assessment of the real-time downlink and the attitude estimation process.

MOE489 The MOE shall notify the operator of non-continuous packet receipt via event message.

Rationale: warn operator of a degraded telemetry link

MOE491 The MOE shall assess the time since last update of displayed data and mark all parameters exceeding defined thresholds as stale in data quality.

Rationale: viewer of data should know if data displayed has not updated in the expected time interval

MOE493 The MOE shall annotate displayed data with the assessed quality of the data displayed.

Rationale: to support proper interpretation of data by the operator.

6.3.3 Calibration & Conversion

MOE496 The MOE shall convert telemetry counts into Engineering Units (EUs) using predefined database conversion operators such as but not limited to: polynomials, equations, lookup, super-commutation, logarithmic, splines, derived parameters, bit ordering.

MOE497 The MOE shall convert discrete telemetry counts into operator-configurable text or numeric values in real time using predefined database conversion operators.

MOE498 The MOE shall output telemetry counts in raw or converted format.

MOE499 The MOE shall provide temporary overrides for polynomial definitions via user-specified values.

Rationale: Modify polynomial conversion coefficients for test or until database update. These updates are temporary and only applied to specified workstations and only for the currently active session.

MOE501 The MOE shall provide temporary overrides for polynomial definitions using directives.

Rationale: Modify polynomial conversion coefficients via script to support unattended operations.

MOE503 The MOE shall display operator-selected telemetry data in real time.

Rationale: this provides the operator to look at telemetry in displays or events in response to a write request (i.e. - output an event message with the parameter value in response to a directive).

6.3.4 Limit Processing

MOE506 The MOE shall provide a capability to verify in real-time that telemetry parameters are within prescribed operating limits.

MOE507 The MOE shall display telemetry limit flags (states).

MOE508 The MOE shall provide a capability for operators to temporarily define and/or modify telemetry parameter limit conditions.

Rationale: temporary changes are intended to be applied only to the local workstation and handle situations where definition or modification is needed without modifying the operational database. These updates are temporary and only applied to specified workstations and only for the currently active session.

MOE510 The MOE shall define or modify telemetry parameter limit conditions using directives.

Rationale: Modify / add via script to support unattended operations.

MOE512 The MOE analog limit checking function shall support Red-High (RH), Yellow-High (YH), Green, Yellow-Low (YL), and Red-Low (RL) limit ranges.

MOE513 The MOE shall provide an operator-configurable color coding scheme to display telemetry relative to limit ranges.

Rationale: without specifying a particular approach, this requires an easily interpretable limit display to determine spacecraft health and safety, e.g. Red-High (RH), Yellow-High (YH), Green, Yellow-Low (YL), and Red-Low (RL). This is configurable to accommodate various forms of color-blindness.

MOE515 The MOE shall provide an operator-selectable non-color-coded scheme to display telemetry relative to limit ranges.

Rationale: identification of limit display using fonts, symbols, flashing text etc.

MOE517 The MOE shall perform delta limit sensing.

Rationale: this capability notifies the operator of unexpected changes in the magnitude of parameters.

MOE519 The MOE shall perform conditional limit sensing utilizing two or more sets of database defined limits based on a database defined switch parameter value.

Rationale: Provides reliable limit sensing ranges based on defining parameter (telemetry, etc) values.

MOE521 The MOE shall provide the capability for notification of limit violations only after an operator-specified number of consecutive limit failures.

Rationale: Addresses limit persistence - the ability to set how many consecutive points which exceed the limit values must be received before a limit failure is reported (and the telemetry point's state changed).

MOE523 The MOE shall generate event messages when limit state transitions occur.

Rationale: Used to notify personnel of any limit violation.

MOE525 The MOE shall provide a capability to enable / disable all limit checks, groups of limit checks or individual limit checks.

Rationale: Groups would be identified in the telemetry data base (e.g., associating a group of parameters to a particular subsystem).

MOE527 The MOE shall create observatory reports of telemetry related events, including missing telemetry summaries.

Rationale: These reports summarize the contact activities and results, including data collection statistics, limit violations and summaries.

6.3.5 GSE Data Processing Requirements

MOE530 The MOE shall ingest and process real-time status/control messages from the LGS and GLC stations.

Rationale: Allows telemetry and command functions to process key status information about the

GSE status & configuration and the quality of data received. Will not perform real-time monitoring with KSat station.

MOE1470 The MOE shall ingest and process real-time status / control messages from the LDCM Observatory Simulator.

6.3.6 Derived Telemetry requirements

MOE533 The MOE shall generate data parameters using database defined algorithms.

Rationale: This allows the operator to derive parameter values based on spacecraft and/or GSE telemetry. The algorithms to be applied are defined in the Project Reference Database.

MOE1490 The MOE shall assess the data quality of derived telemetry parameters.

Rationale: Determine current quality for staleness and quality of any telemetry parameter used.

MOE535 The MOE shall provide full limit processing capabilities for derived telemetry.

Rationale: operator can define limits, have them sensed and reported.

MOE1491 The MOE shall display derived telemetry parameters.

Rationale: Use to support operator activities

6.3.7 Telemetry Project Reference Database

MOE538 The MOE shall define observatory telemetry and their characteristics in a telemetry database.

MOE539 The MOE shall have the capability to search and sort observatory telemetry defined in the telemetry database.

Rationale: allows for ease in defining displays, etc

MOE541 The MOE telemetry database shall allow the referencing of telemetry based on mnemonic specification.

Rationale: provides logical IDs for referencing telemetry

MOE543 The MOE shall manage the authority to modify the telemetry database by login attributes.

Rationale: restricts write access to the MOE telemetry database

MOE547 The MOE telemetry databases shall receive updates derived from the Project Reference Database (PRD).

Rationale: common database providing Flight Operations CCB controlled databases, etc.

MOE549 The MOE shall provide telemetry database modifications for submission to the Project Reference Database (PRD).

Rationale: mechanism for submissions to the Flight Operations CCB for approval & distribution.

6.3.8 Logging & Reporting

MOE552 The MOE shall maintain a record of the quality and completeness of the telemetry for the duration of the mission.

MOE553 The MOE shall generate and display time-tagged event messages indicating all command activity, telemetry processing status, limit violations, configuration changes, and all error and warning conditions.

7 Planning and Scheduling

This section defines the requirements for the MOE responsibilities in planning and scheduling the mission. The responsibilities under this function include the creation and maintenance of a master schedule of all ground and space activities. The historical portion of the schedule is updated to form an "as run" timeline.

Processing requirements include incorporation of observatory and ground segment events, ingest and de-confliction of data collection requirements, creation of detailed ground and observatory activity sequences. This master schedule of activities is subsequently utilized to support ground system management, spacecraft real-time and stored commanding.

MOE557 The MOE shall plan and schedule all observatory housekeeping and maintenance activities for the life of the mission.

Rationale: The MOE planning and scheduling system will satisfy the MOE requirements for the life of the mission. The system will be capable of accessing previous schedule and planning into the future.

MOE559 The MOE shall time tag all events and activities in the Master Schedule of Activities with a resolution of one (1) milli-second.

Rationale: Time resolution consistent with spacecraft processing of stored commands.

7.1 Schedule of Activities

MOE562 The MOE shall build and maintain the Master Schedule of Activities containing all activities for the life of the mission.

Rationale: There's one authoritative source for past and planned activities. While this schedule is maintained for the life of the mission, the historical portion may be segmented and archived, as necessary. Planning and scheduling products are derived from this schedule.

MOE564 The MOE shall produce time-ordered activity plans listing all planned activities for the observatory planning window.

Rationale: Provides a timeline of all relevant events, observatory stored commands, observatory real-time commands and ground system directives. This plan is structured to be used by the MOC (i.e. stored command load generation, etc).

7.2 Planning System Inputs

This subsection defines the inputs to the Schedule of Activities.

MOE568 The MOE shall process planning system inputs optionally bounded by user-specified start and stop times.

Rationale: allows the user to control which portions of input data to incorporate (i.e. filtering out past events, etc)

MOE570 The MOE shall ingest operator selectable events derived from the Flight Dynamics mission planning products.

Rationale: Incorporate orbit related events (day/nite, ground station visibilities, CONUS transits, cal/val opportunities, etc) into the master schedule for scheduling of activities and reference.

MOE572 The MOE shall ingest schedules issued by the GNE, NEN and SN.

Rationale: Provide an electronic interface for incorporation of scheduled network events in the master schedule.

MOE574 The MOE shall incorporate all resource down times or reserved times into schedule generation events.

Rationale: The system will incorporate knowledge of resource limitations in the schedule as the information becomes available. These events are considered throughout the scheduling process.

MOE576 The MOE shall ingest the Image Data Collection Schedule from the CAPE into the Master Working Schedule.

Rationale: Integrate the CAPE provided version of the schedule for long term and scene scheduling - provides for database synchronization between the MOE and CAPE.

MOE578 The MOE shall convert CAPE-provided activity requests into schedule events.

Rationale: converts the CAPE-generated scene and any other requests to imaging intervals and/or recorder on/off times, off-nadir, IC downlinks, LTAP8 requests, etc.

MOE580 The MOE shall report the correlation between image data collection requests and interval events.

Rationale: reports the interval to scene mapping for reference by the CAPE, etc; supports MOE mass storage management responsibilities

MOE582 The MOE shall manually incorporate event and activity requests into an activity plan.

Rationale: requires the inclusion of image collection requests from Cal/Val requests, maneuvers, and other observatory activities into an activity plan as well as a backup emergency capability to include routine & priority imaging requests.

MOE584 The MOE shall assign a priority value to all MOE incorporated activity requests.

Rationale: to support schedule de-confliction based on a priority scheme.

7.3 Operations

MOE587 The MOE shall automatically update activity plans as revised Flight Dynamics planning products are received.

Rationale: allows automatic update to a plan, if a revised planning product is received during the planning process (prior to scheduling)

MOE589 The MOE shall support network scheduling of the GNE, NEN and SN.

Rationale: Provide an interface to network scheduling offices for receipt of network schedule and incorporation of scheduled network events in the master schedule.

MOE591 The MOE shall automatically update activity plans as revised network schedules are received.

Rationale: allows automatic update to a plan, if a new request is received during the planning process (prior to scheduling)

MOE593 The MOE shall automatically update activity plans as Image Data Collection Schedules are received.

Rationale: allows automatic update to a plan, if a new schedule is received

MOE595 The MOE shall automatically update activity plans as activity requests are received.

Rationale: allows automatic update to a plan, if a new request is received during the planning process (prior to scheduling)

MOE597 The MOE shall automatically process all activity requests that fall into the current scheduling window, when generating a schedule.

Rationale: requires that when a schedule is being generated, all activity requests for the current scheduling period are used as input. i.e. for a 72-hour window, any activity that falls into that 72 hour period will be automatically read

MOE599 The MOE shall automatically check for activity constraint and rule violations during schedule generation.

Rationale: the candidate schedule is always checked against an operator-defined set of rules concerning command sequencing / constraints

MOE601 The MOE shall automatically check for resource constraint and rule violations during schedule generation.

Rationale: the candidate schedule is always checked against an operator-defined set of rules concerning resource utilization / constraints

MOE603 The MOE shall provide a capability to notify operators via display, report and log messages of conflicts, activity and resource constraint violations, and activity rule violations during planning and scheduling.

Rationale: Displays and reports are used to support the resolution of conflicts and violations. Log messages alert support personnel to the problem.

MOE605 The MOE shall automatically de-conflict unavailable observatory resources.

Rationale: The system will not schedule utilization of un-available resources.

MOE607 The MOE shall de-conflict activity requests based on a priority value.

Rationale: The system will use a priority scheme to assist in de-conflicting the schedule.

MOE609 The MOE shall automatically schedule all observatory and ground station activities within operational resource constraints.

MOE610 The MOE shall automatically schedule sequences based on activity requests or trigger events entered into the schedule.

Rationale: The system will schedule activities, as per a defined rule set, with respect to operator-specified events, such as interval start, ground station AOS, etc.

MOE612 The MOE shall plan and schedule observatory imaging intervals.

Rationale: MOE-planned imaging intervals would likely be a default imaging mode or a reserved collection allocation, as driven by chosen ops procedure.

MOE1496 The MOE shall determine Root File IDs assigned to each imaging interval.

Rationale: Root File IDs are required for command uplink.

MOE1498 The MOE shall manage Root File IDs assigned to each imaging interval.

MOE614 The MOE shall produce a Coordinated Universal Time (UTC) time-based activity schedule.

Rationale: Provides the ability to generate a schedule using UTC.

MOE616 The MOE shall convert to and from UTC reference time and the observatory reference time.

Rationale: Allows MOE products and processes to be time-tagged in either format, if necessary.

MOE618 The MOE shall produce an activity schedule over specific start/stop times.

Rationale: Provides the ability to generate a schedule by user-specified start and stop times

MOE620 The MOE shall generate a conflict-free activity schedule spanning 72-hours of activity.

Rationale: Supports higher level requirements for Autonomous Operations requirement.

MOE622 The MOE shall generate a conflict-free activity schedule at least once every 12 hours.

Rationale: Supports higher level requirements for Data Latency requirements for nominal ops.

MOE624 The MOE shall generate a conflict-free activity schedule in 2 hours or less, including operator interaction time.

Rationale: Allows FOT to generate, review and approve new schedules within 2 hours supporting higher level requirements for Data Latency requirements for priority collections

MOE626 The MOE shall report activity schedule generation status via display and event messages.

Rationale: Visual indicators and log messages report process completion status, error messages and responses to GSE directives.

MOE628 The MOE shall manually modify an activity schedule.

Rationale: Allows authorized personnel to add / delete / modify activities through manual edit of the schedule of activities.

MOE630 The MOE shall insert a contact into the activity schedule within 15 minutes of an in-view observatory contact.

Rationale: This capability allows insertion of an added event into the master schedule as late as 15 minutes before the event start for subsequent use in scheduling real-time commands, stored commands (for uplink) and GSE directives.

MOE632 The MOE shall indicate segments of the activity schedule as committed (active) using operator specified parameters.

Rationale: This capability is used by operations to designate which segments of the schedule have been committed for execution (i.e. loaded to the spacecraft for execution via ATS and enabled for execution, etc).

MOE634 The MOE shall correlate scene requests to file status on-board the observatory and at the GNE.

Rationale: correlates observatory recorder files generated in response to scheduled interval events, assess the status of scene collection activity requests, supports the MOEs requirements for mass storage management

7.4 Product Generation and Distribution

7.4.1 Product & Report Generation

MOE638 The MOE shall script the generation of user-specified planning and scheduling products.

Rationale: A mechanism for the routine generation and distribution of planning and schedule products.

MOE640 The MOE shall generate products over user-specified time intervals.

MOE641 The MOE shall generate a graphical timeline of activity plans and schedules.

MOE642 The MOE shall generate operator-specified planning and scheduling reports.

Rationale: generate reports based on the current Master Schedule of Activities supporting a wide variety of functions including internal analysis and export to external operators - this provides a generic report capability.

MOE646 The MOE shall provide a display of planned, currently active and past observatory and ground activities.

Rationale: notification of what has happened, will happen or what is happening in the observatory or ground

7.4.2 Product Delivery

MOE649 The MOE shall script the delivery of planning and scheduling products and reports.

Rationale: A mechanism for the routine distribution of planning and schedule products to the controlled repository and other users.

MOE651 The MOE shall maintain a copy of the Master Schedule of Activities as a product in the controlled repository.

Rationale: provide a copy of schedule information for contingency long term and short term scheduling and archiving.

MOE653 The MOE shall produce and deliver operator-specified subsets of the Master Working Schedule as products in the controlled repository.

Rationale: provide visibility and schedule request information for long term and short term scheduling.

MOE655 The MOE shall produce and deliver operator-specified subsets of the Master Active Schedule as products in the controlled repository.

Rationale: provide the schedule of committed activities.

MOE657 The MOE shall notify authorized operators and applications of available products by event message distribution.

Rationale: notify GNE, CAPE, DPAS and other operators of product deliveries.

MOE659 The MOE shall report the completion status of scene requests.

Rationale: to assess the status of scene collection activity requests using observatory housekeeping telemetry

MOE661 The MOE shall collect and report image data collection statistics.

Rationale: derived from scheduled data collection request information and GNE X-band data processing reports; post-pass and long-term report;

7.4.3 Product Archive

MOE664 The MOE shall archive and recover all mission planning and scheduling data for the life of the mission.

Rationale: Supports the higher level requirements for Archive requirements by providing operator functions for planning and scheduling data management.

MOE666 The MOE shall display and print all mission planning and scheduling data for the life of the mission.

Rationale: Provides for operator access to stored plans and schedules

7.5 Planning & Scheduling Project Reference Database

MOE669 The MOE shall create, edit, print and delete sets of command / directive sequences in a database for re-use.

Rationale: This database supports generation of detailed schedule commands/activities based on activity requests.

MOE671 The MOE shall provide the following for each operator-configurable scheduling sequence:

a) ID or name

b) relative start time of sequence

c) one or more commands/directives

d) relative time delays between command/directive executions

e) zero or more passed parameters

Rationale: This database supports generation of detailed schedule commands/activities based on activity requests.

MOE673 The MOE shall provide the capability for an operator-defined database of activity priorities, constraints, and rules.

Rationale: This database is used by the system to de-conflict the activity selection during the observatory schedule generation.

MOE675 The MOE Planning & Scheduling function shall receive updates derived from the Project Reference Database (PRD).

Rationale: common database providing Flight Operations CCB controlled databases, etc.

MOE677 The MOE Planning & Scheduling function shall provide database modifications for submission to the Project Reference Database (PRD).

Rationale: mechanism for submissions to the Flight Operations CCB for approval & distribution.

8 Mission Monitor & Analysis

This subsection defines the MOE requirements for trending and analysis. The MOE will provide the capabilities for operations and engineering support personnel to investigate spacecraft anomalies and evaluate performance in the short & long term. These tasks require the operator-controlled extraction of data supporting plot generation, statistical analysis, mathematical manipulation and export for external use.

MOE681 The MOE shall ingest and store all housekeeping telemetry for trending and analysis.

Rationale: The MOE may need to process real-time, playback and re-transmitted housekeeping telemetry from various sources. The same packet may be received multiple times.

MOE683 The MOE shall ingest and store all GSE telemetry for the life of the mission.

Rationale: supports ability to perform MOE trending and analysis of all telemetry data

MOE685 The MOE shall provide access for remote authorized users to the results of mission monitor and analysis event logs, trend and other analysis capabilities.

Rationale: supports ability to support remote analysis performed by FOT, Cal/Val, DPAS Infrastructure Element and other authorized users.

8.1 Configuration Monitoring

MOE688 The MOE shall perform limit sensing utilizing an operator defined set of parameters and limits during the ingest process.

Rationale: Perform “back-orbit” limit sensing of telemetry.

8.2 Timeline Monitoring

MOE692 The MOE shall produce an as-flown timeline that reflects the activities that were actually executed on the observatory.

8.3 Analytical Modeling

Analytical modeling provides a generic interface between the MOE systems and user-derived models. The user can develop models conforming to the capabilities provided by the MOE Analytical Modeling functionality. This capability provides support for complex operations planning and state of health assessments, including SSR memory management.

MOE695 The MOE analytical modeling capability shall execute user-defined models.

Rationale: Model execution can be invoked from the MOE, model is expected to adhere to MOE defined conventions.

MOE697 The MOE analytical modeling capability shall accept directives.

Rationale: Model execution can be managed (started, stopped, etc) by the user, a script or plan.

MOE699 The MOE analytical modeling capability shall ingest data inputs derived from observatory housekeeping telemetry.

Rationale: can provide overrides to a priori state vectors for the modeled items

MOE701 The MOE analytical modeling capability shall ingest planning and scheduling inputs.

Rationale: planned activities are modeled in order to have an accurate representation for predicting future modeled states. The modeling system would generically be capable of parsing a subset of the master schedule of activities.

MOE703 The MOE analytical modeling capability shall ingest observatory housekeeping telemetry inputs.

Rationale: to accurately model the state of mass storage, the model should update an apriori state based on telemetered values

MOE705 The MOE analytical modeling capability shall provide a textual and graphical display.

Rationale: operators must be able to view and interpret mass storage model data

MOE707 The MOE analytical modeling capability shall notify operators of results via event messages.

Rationale: operators must be able to view and interpret mass storage model data

MOE709 The MOE analytical modeling capability shall notify operators of results via a report delivered to the controlled repository.

Rationale: CAPE and other operators must be able to view and interpret mass storage model results

8.4 Trend Analysis

This section describes the capability to generate and store graphical trends and statistical representations of data.

MOE713 The MOE shall generate and store operator configurable trend and statistical product formats.

Rationale: operators have the capability to define trend output formats

MOE715 The MOE shall generate trending and statistical products using stored product formats.

Rationale: operators have the capability to specify stored formats for output

MOE1454 The MOE shall trend up to ten different range parameters per trend output.

Rationale: Display multiple parameters on one or more grids, but a single display, to support analysis of related parameters.

MOE1456 The MOE shall generate trend products using operator-selected time or parameter domain.

Rationale: Allows for time vs data and data vs data plots

MOE717 The MOE shall generate trending and statistical products for any operator-specified time interval.

Rationale: the function can be invoked over any time interval specified in the directive

MOE719 The MOE shall generate trending products and statistical products for operator-selected time period.

Rationale: provide the capability to generate products over standard durations (i.e. the Operational Day, Operational Week) automatically or by schedule.

MOE721 The MOE shall trend telemetry parameters in either raw or engineering unit (EU)-converted format.

MOE722 The MOE shall trend discrete telemetry parameters as numeric values.

Rationale: To be able to represent discrete states on a graph, often plotted with real values to show discrete state correlations to parameters

MOE724 The MOE shall define derived-telemetry via operator-defined equations.

Rationale: Provide the ability to perform mathematical operations on telemetry points to create pseudo-telemetry values.

MOE1492 The MOE shall provide full limit processing capabilities for derived telemetry.

Rationale: operator can define limits, have them sensed and reported

MOE726 The MOE shall have the ability to set a sample filter rate for trended telemetry.

Rationale: Provide some operator control of output generation times.

MOE728 The MOE shall generate trending products from real-time telemetry.

Rationale: used during contacts to analyze the real-time engineering data

MOE729 The MOE shall generate trending products from stored telemetry.

Rationale: used off-line to analyze all recovered and/or archived engineering data

MOE730 The MOE shall generate statistical products from real-time telemetry.

MOE731 The MOE shall generate statistical products from stored telemetry.

MOE732 The MOE shall indicate limit values on trending and statistical displays and reports.

MOE733 The MOE shall provide a capability to trend basic statistical products including minimum, maximum, mean, and standard deviation values at a minimum.

Rationale: allows feeding of standard statistical products through trending function; support long term trending

MOE735 The MOE shall both manually and automatically generate trending products and statistical products.

Rationale: Product generation can be under direct operator control, activity schedule or application triggers internally defined (i.e. Time of day or percent data collected, etc)

MOE737 The MOE shall generate trend and statistical products simultaneously for 2 or more operators during nominal operations.

Rationale: allows at least 2 operators to view telemetry at the same time

MOE739 The MOE shall generate a trending and statistical product for up to 5 telemetry parameters in 5 minutes or less, from the full set of telemetry data.

Rationale: product performance requirement for the full mission life

MOE741 The MOE shall trend a single requested telemetry value from the full telemetry data set in 2 minutes or less.

Rationale: data retrieval performance requirement for the full mission life

8.5 Data Mining & Analysis

This section defines the requirements for output of raw or converted historical data in a tabular format in a time-ordered sequence.

MOE745 The MOE shall generate and store operator configurable engineering data report formats.

Rationale: operators have the capability to define content of an engineering data report

MOE747 The MOE shall generate engineering data reports using stored report formats.

Rationale: operators have the capability to specify stored formats for output

MOE749 The MOE shall generate and distribute engineering data reports in a tabular and textual form

Rationale: generates and saves reports in product form

MOE751 The MOE shall display operator-selected ingested data for any operator-specified time interval.

MOE752 The MOE shall display ingested data in either raw or engineering unit (EU)-converted format.

Rationale: generate a time-sequenced tabular listing of data

MOE754 The MOE shall display discrete ingested data with operator-defined text or numeric values.

8.5.1 Data Export

MOE756 The MOE shall export operator-specified ingested data to current PC-based media, standard desktop software applications, and via the internet.

Rationale: This capability provides a general interface to the operator community; in particular, this capability is required by the Cal/Val group.

MOE758 The MOE shall export ingested data in either raw or engineering unit (EU)-converted format.

8.5.2 Dynamic Remote Overview Display

MOE760 The MOE shall display periodically-updating user-defined subsets of converted engineering data to authorized external users.

Rationale: Remote display page showing observatory state of health, ground system status and filtered system alarms, warnings and events. Display to be used by operations and engineering for remote ground system state and contact monitor support.

8.5.3 Post-Pass Summary

MOE763 The MOE shall create pass summaries that describe the results of each observatory contact.

Rationale: A quick-look summary for operations and management - includes selected mnemonics, procedures executed, observatory events, system events, commands sent, and limit and configuration monitor violations. The report should also include S and X-band recovery information. Reports are generated for operational and remote access.

8.6 Mission Monitor & Analysis Project Reference Database

MOE766 The MOE shall define trend product templates and their characteristics in a Mission Monitor & Analysis database.

Rationale: provide plots and reports for use by schedules, operators, and scripts

MOE768 The MOE shall define statistical product templates and their characteristics in a Mission Monitor & Analysis database.

Rationale: provide statistical reports for use by schedules, operators, and scripts

MOE770 The MOE shall define engineering data reports and their characteristics in a Mission Monitor & Analysis database.

Rationale: provide database managed reports for use by schedules, operators, and scripts

MOE772 The MOE shall manage the authority to modify the Mission Monitor & Analysis system databases by login attributes.

Rationale: restricts write access to the MOE configured databases

MOE774 The MOE Mission Monitor & Analysis system databases shall receive modifications derived from the Project Reference Database (PRD).

Rationale: common database providing Flight Operations CCB controlled databases, etc.

MOE776 The MOE shall provide Mission Monitor & Analysis system database modifications for submission to the Project Reference Database (PRD).

Rationale: mechanism for submissions to the Flight Operations CCB for approval & distribution.

9 Flight Dynamics

The flight dynamics requirements are intended to meet all ground system requirements for orbit and attitude maintenance within the MOC. Real-time capabilities include state of health assessment of on-board orbit estimation and attitude estimation. Off-line capabilities supported include orbit determination, definitive orbit determination, control (maneuver planning and calibration) and prediction, definitive attitude determination and prediction, and attitude sensor calibration.

9.1 Health and Safety Assessment

MOE781 The MOE shall perform evaluation of on-board derived ephemeris and attitude estimates available in the housekeeping telemetry.

Rationale: assess state of health of the on-board generated flight dynamics data

MOE783 The MOE shall have the capability to perform real-time evaluation of orbit data using predicted ephemeris and GPS data in the observatory housekeeping telemetry.

Rationale: to alert operations and image processing of potential poor GPS data

MOE785 The MOE shall automatically detect when the observatory orbital parameters deviate beyond operator defined thresholds.

Rationale: limit (threshold) sense differences between predicted and GPS provided orbit data

MOE787 The MOE shall report threshold violations detected by the orbital parameter evaluation process via event messages.

Rationale: to alert operations and image processing of potential poor orbit data

MOE789 The MOE shall have the capability to perform real-time evaluation of attitude data using predicted attitude and on-board attitude estimation parameters available in the observatory housekeeping telemetry.

Rationale: to alert operations and image processing of potential poor attitude

MOE791 The MOE shall test results from the real-time attitude evaluation process against operator defined thresholds.

Rationale: test the resultant values to identify attitude deviations and estimates of low confidence.

MOE793 The MOE shall report threshold violations detected by the real-time attitude evaluation process via event messages.

Rationale: to alert operations and image processing of potential poor attitude

9.2 Orbit Determination (OD)

MOE796 The MOE shall generate the definitive ephemeris of the observatory based on the GPS orbit data available in housekeeping telemetry at an accuracy of better than 30m in each axis, 3 sigma.

Rationale: value-added processing of GPS orbit data in telemetry to ensure accuracy required to support image processing, accuracies needed internally to meet the predicted ephemeris requirements may be higher. Refer to the LDCM Spacecraft Requirements Document for input data requirements.

MOE798 The MOE shall generate a definitive ephemeris for the previous Operations Day, every Operational Day or upon request by GSE directive.

Rationale: Ground processing of observatory-generated ephemeris within ancillary data is required to ensure sufficient accuracy to support planning / acquisition data generation and DPAS image processing. Processing is also used to verify integrity of on-board estimates.

MOE800 The MOE shall perform gap filling in the definitive ephemeris for missing GPS orbit data consistent with the requirements for predicted ephemeris.

MOE801 The MOE shall notify product users of definitive ephemeris processing completion status, providing the definitive ephemeris file name.

Rationale: explicitly notify users concerning a new product for use

MOE803 The MOE shall produce, store and deliver definitive ephemeris processing quality reports.

Rationale: This definitive ephem is used as the seed for the predicted ephemeris used for planning product generation and comparison of the OBC OD.

MOE805 The MOE shall evaluate the definitive ephemeris against the requirements for the Operational Orbit defined in the NASA/GSFC LDCM Spacecraft to Ground Interface Control Document (ICD), 70-P58230P.

MOE806 The MOE shall evaluate the definitive ephemeris and quality report against operator-defined criteria and report any violations via log and event messages.

MOE1634 The MOE shall have the capability to perform orbit determination using a batch least-squares method.

Rationale: Adds the capability to assess the initial GPS filter tuning and assist with post maneuver OD recovery during orbit raising if needed, as well as contingencies and/or anomalies throughout the mission life.

9.3 Orbit Control

MOE808 The MOE shall perform observatory maneuver planning for the life of the mission.

Rationale: Capability is required to support higher level requirements for Science Accommodation and Calibration Requirements.

MOE810 The MOE shall generate maneuver plans to transfer the observatory from the injection orbit to the operational orbit.

Rationale: Key functionality.

MOE812 The MOE shall generate maneuver plans in support of all observatory ground track maintenance, inclination maintenance, instrument and thruster calibration, imaging, and decommissioning activities.

Rationale: Key function and higher level requirements for traceability.

MOE814 The MOE shall automatically identify and report maneuver constraint violations during maneuver planning using the Operational Orbit defined in the NASA/GSFC LDCM Spacecraft Requirements Document (S-RD), GSFC 427-06-03.

MOE815 The MOE shall maintain an observatory ground track to WRS-2 grid within +/- 5 km cross-track at the descending node.

Rationale: key function

MOE817 The MOE shall determine, and maintain calibration coefficients for each of the observatory thrusters

Rationale: to perform thruster cal using maneuver reconstruction after each burn.

MOE819 The MOE shall monitor and predict observatory propellant usage throughout the life of the mission.

Rationale: propellant (maneuver planning), etc.

MOE821 The MOE shall predict a near-term (45-day) sequence of orbit maneuver maintenance events.

Rationale: provide rudimentary planning information to the FOT, data to be ingested into the long-term mission planning schedule and support Conjunction Assessment activities.

MOE823 The MOE shall support End of Life Decommissioning activities.

9.4 Orbit Prediction

MOE826 The MOE shall propagate the observatory orbit, assuming a solar flux (F10.7) value of less than 215 (10-22 W/m2/Hz) and no maneuver activity during the propagation interval, with an accuracy of predicted orbit state vectors for the first forty (40) hours of the following or better:

30 meters (3s) radial

330 meters (3s) along-track

50 meters (3s) cross-track

Rationale: supports orbit control, Conjunction Assessment requirements

MOE828 The MOE shall propagate the observatory orbit, assuming a solar flux (F10.7) value of less than 215 (10-22 W/m2/Hz) and no maneuver activity during the propagation interval, with an accuracy of predicted orbit state vectors for the first seventy-two (72) hours of the following or better:

420 meters (3s) radial

4200 meters (3s) along-track

480 meters (3s) cross-track

Rationale: support station acquisition for S & X-band acquisition and maintenance of the WRS-2 path/row transit times reported to the CAPE for scene scheduling

MOE830 The MOE shall propagate the observatory orbit for operator-defined durations.

Rationale: need for orbit prediction / maneuver planning; parent requirement to predicted ephemeris generation

MOE832 The MOE shall construct and maintain the initial WRS-2 model defined by LDCM document 427-02-07.

Rationale: provide WRS-2 grid and adjust the definition as necessary.

MOE834 The MOE shall generate and maintain a WRS-2 path/row to time translation table.

Rationale: accurate timing data that must be provided to the CAPE for image collection planning

9.5 Conjunction Assessment (CA)

MOE837 The MOE shall produce 7-day LDCM ephemeris data in required format necessary to support Conjunction Assessment (CA) and avoidance maneuver activities.

Rationale: deliver observatory orbit data for subsequent analysis by the Joint Space Operations Center (JSpOC) via Flight Dynamics Analysis Branch (FDAB) CA service

MOE839 The MOE shall receive Conjunction Assessment data from the FDAB.

Rationale: Perform risk analysis and mitigation for close approaches with other orbiting objects

MOE841 The MOE shall propagate object vector and compare results to predicted observatory ephemeris.

Rationale: perform conjunction analysis and support avoidance maneuvers

MOE843 The MOE shall plan and execute collision avoidance maneuvers as required.

Rationale: Mitigate risk of close approach as indicated by FDAB analysis and recommendation and as dictated by project management direction.

9.6 Attitude Determination (AD)

MOE846 The MOE shall produce data of sufficient quality, continuity, and pre-processing to meet ingest requirements of the MOE attitude determination system.

Rationale: Data input files are Level-0 equivalent.

MOE848 The MOE shall have the capability to generate attitude estimates from raw sensor data contained in observatory housekeeping telemetry and meeting mission accuracy requirements as defined in the NASA/GSFC LDCM Observatory Interface Requirements Document (O-IRD), GSFC 427-02-03..

Rationale: off-line process utilizing Level-0 housekeeping data - general capability

MOE850 The MOE shall validate that the on-board attitude estimates meet mission accuracy requirements as defined in the NASA/GSFC LDCM Observatory Interface Requirements Document (O-IRD), GSFC 427-02-03.

Rationale: off-line process to verify integrity of the on-board attitude estimation process

MOE852 The MOE shall have the capability to validate the on-board attitude within 30 minutes of receipt of data. This process may be initiated via GSE directive.

Rationale: to alert operations and image processing of potential poor on-board attitude estimates

MOE854 The MOE shall generate a definitive attitude history file for the previous Operations Day, every Operational Day or upon request by GSE directive.

Rationale: Ground processing is used to verify integrity of on-board attitude estimates and provide a corrected attitude for possible use by data processing, etc.

9.7 Attitude Prediction

MOE857 The MOE shall predict attitude and generate an attitude predict file for up to four weeks in duration.

Rationale: this capability is needed to support sensor calibrations and other attitude related functions

MOE1485 The MOE shall invoke attitude prediction and file creation by directive.

Rationale: Operators or schedule can initiate a predict.

MOE859 The MOE shall predict star sensor target fields and compare these predicts to star acquisition data available in observatory housekeeping telemetry on an as-needed basis.

Rationale: assess state of health of the star sensor and star catalog.

MOE861 The MOE shall generate star sensor target predicts over the duration of the attitude predict file.

Rationale: produce a list of stars for the full duration of the input attitude estimation file to support operations and analysis.

MOE863 The MOE shall generate star availability and interference events at the guide star and sensor level over the duration of the attitude predict file.

Rationale: report any interference events.

9.8 Attitude Control

MOE870 The MOE shall perform observatory attitude maneuver planning for the life of the mission.

Rationale: Capability is required to support higher level requirements for Science Accommodation and Calibration Requirements.

MOE872 The MOE shall generate maneuver plans in support of all observatory attitude maintenance, calibration, imaging, and orbit maneuver activities.

Rationale: Key function and higher level requirements for traceability.

MOE874 The MOE shall automatically generate off-nadir imaging maneuver plans.

Rationale: Off-nadir requests received from the CAPE

9.9 Attitude Sensor Alignment & Calibration

MOE877 The MOE shall monitor on-board sensor calibrations and re-calibrate, as necessary to meet absolute attitude accuracy requirements.

Rationale: to assure meeting mission attitude requirements

MOE879 The MOE shall specify and generate attitude maneuver sequences.

Rationale: generate maneuver sequences supporting attitude and instrument calibration maneuvers

MOE881 The MOE shall specify and generate attitude sensor calibration maneuver sequences to provide sufficient sensor data to derive sensor alignment & calibration coefficients meeting mission attitude determination requirements.

Rationale: may be coincident with instrument maneuvers

MOE883 The MOE shall generate maneuver plans in a format that is acceptable for input to the uplink generation process.

Rationale: minimize the requirement for human translation of maneuver sequences

9.10 Product Generation and Distribution

MOE886 The MOE shall both manually and automatically generate flight dynamics products and subsequently distribute these products.

Rationale: Product generation can be under direct operator control, activity schedule or application triggers internally defined (i.e. Time of day or percent data collected, etc)

MOE888 The MOE shall distribute mission planning products to a controlled repository on the operational network.

Rationale: Controlled repository supports management of operational engineering data products.

MOE890 The MOE shall generate attitude and orbit maneuver tables in a format that is acceptable for uplink.

Rationale: review and approval for uplink of modified maneuver tables is an off-line process. The data will be provided in an electronic format requiring minimal interpretation for uplink

MOE892 The MOE shall generate attitude sensor calibration tables in a format that is acceptable for uplink.

Rationale: review and approval for uplink of modified calibration tables is an off-line process. The data will be provided in an electronic format requiring minimal interpretation for uplink

MOE894 The MOE shall accept and upload externally-generating attitude sensor calibration data.

Rationale: receipt and implementation of bus-provider's sensor cal updates

MOE900 The MOE shall ingest and upload externally-generated observatory ephemeris data.

Rationale: prior to GPS initialization, in the event of a GPS failure or for Conjunction Assessment support, allows MOE to use ephemeris from external source

MOE902 The MOE shall export ephemeris and attitude data for an operator-selectable time interval to current PC-based media, standard desktop software applications, and via internet.

MOE903 The MOE shall display the observatory orbit and ground tracks based on operator-defined durations.

MOE904 The MOE shall generate attitude-dependent predicted ground station contact/view periods for the observatory.

Rationale: accuracy for in-view is derived from orbit propagation accuracy

MOE906 The MOE shall incorporate ground station antenna masks in computing predicted station contact/view periods.

MOE907 The MOE shall provide a capability to generate predicted SN contact/view periods for the observatory.

MOE908 The MOE shall generate observatory acquisition data for ground stations.

Rationale: provides capability to generate two line elements (TLE), Brouwer mean element (BME) and improved inter range vectors (IIRV) for ground stations.

MOE910 The MOE shall generate observatory acquisition data for the SN.

Rationale: provides capability to generate two line elements (TLE), Brouwer mean element (BME) and improved inter range vectors (IIRV) for TDRSS.

MOE912 The MOE shall model sun-line RF interference between the observatory and ground stations, and between the observatory and the SN.

MOE913 The MOE shall generate and distribute Solar and Lunar Cal/Val Opportunity planning products.

Rationale: provide OLI calibration opportunities for mission planning purposes.

MOE915 The MOE shall generate and distribute Attitude Validation Reports in response to GSE directive.

Rationale: notify operators of potential errors and/or to distribute and control the routine reporting of the attitude validation processes

MOE917 The MOE shall generate operator-specified flight dynamics and maneuver planning reports.

Rationale: ability to produce products such as view periods, eclipse entrance/exit, ascending/descending node, solar beta angle

MOE919 The MOE shall report and plot attitude with respect to operator selected reference frames.

Rationale: such as LVLH, J2000 inertial, orbital reference, and earth-fixed

9.11 Flight Dynamics Project Reference Database

MOE922 The Flight Dynamics system shall receive updates derived from the Project Reference Database (PRD).

Rationale: common database providing configuration control, etc.

MOE924 The Flight Dynamics system shall deliver updates to the Project Reference Database (PRD).

Rationale: common database providing configuration control, etc.

10 Memory Management

This section defines additional requirements supporting observatory memory management. Mechanisms to generate, store and uplink memory modifications was discussed in Section 6 of this document.

10.1 Flight Software

This subsection defines additional memory management mechanisms provided by the MOE.

Note: For the purposes of delimiting the scope of the Ground Reference Image (GRI) maintenance by the MOE, the GRI will be limited to the flight computer and dumpable areas of the Thermal Infrared Sensor (TIRS).

MOE932 The MOE shall modify any re-programmable/writeable memory locations on the observatory.

Rationale: SW updates for actuators, sensors, processors, etc.

MOE934 The MOE shall export observatory memory dump data to current PC-based media, standard desktop software applications, and via internet.

Rationale: Standard requirement to allow effective data management of memory dump data.

MOE936 The MOE shall compare multiple memory dumps and report the specific differences.

Rationale: Required for OBC memory management.

MOE938 The MOE shall compare memory dumps with the GRI and report the specific differences.

MOE939 The MOE shall provide the ability to view the Ground Reference Image.

MOE940 The MOE shall provide the ability to view observatory memory dumps.

MOE941 The MOE shall display memory tables in human-readable format.

10.1.1 Flight Software Project Reference Database

MOE943 The Flight Software Memory Management system shall receive updates derived from the Project Reference Database (PRD).

Rationale: common database providing configuration control, etc.

MOE945 The Flight Software Memory Management system shall deliver updates to the Project Reference Database (PRD).

Rationale: common database providing configuration control, etc.

10.2 Mass Storage (Solid State Recorder)

This section defines additional functionality required of the MOE to support housekeeping and mission data collection fron the spacecraft Solid State Recorder (SSR).

10.2.1 Data Organization

MOE950 The MOE shall collect the data necessary to support the recovery and management operations for observatory stored housekeeping data..

Rationale: allows ground to generate commands for re-transmission and release of housekeeping data stored on-board the observatory.

MOE952 The MOE shall collect the data necessary to support the recovery and management operations for observatory stored mission telemetry..

Rationale: allows ground to generate commands for re-transmission and release of mission telemetry stored on-board the observatory.

MOE954 The MOE shall generate and assign a unique interval identifier, based on an identifier scheme defined in conjunction with the Government.

Rationale: allows ground to generate the interval ID. Allows data to be tracked through entire LDCM operations and science data processing systems per Level II requirement. Unique interval identifiers will be the same as root file IDs in observatory mass storage for ease in recorder management.

MOE956 The MOE shall generate and maintain the scene to interval identifier mapping table.

Rationale: since CAPE selects scenes and MOE assigns intervals and root file ID, the MOE must keep track of the linkage between the two. Observatory will assign specific file names based on a scheme defined in conjunction with the Government.

MOE958 The MOE shall designate imaging intervals as Priority.

Rationale: The MOE must flag priority intervals so that the ground system can expedite the downlink of the scene/interval. Prioritization of playback data is strictly done on ground. If one scene within a long interval is priority, FOT can schedule that scene as its own interval.

MOE960 The MOE shall designate imaging intervals as Protected.

Rationale: The MOE must flag protected scenes or the interval and file it resides in, so that the observatory does not overwrite them. Expect that standard ops will be to protect all data on board until it is downlinked.

MOE962 The MOE shall remove the Priority and Protected designations from imaging intervals.

Rationale: Ability to remove flags within the MOE

10.2.2 Management Commands

MOE965 The MOE shall generate mass storage commands using interval/root file identifier designations.

Rationale: file -based recorder management capability; root file IDs are the same as interval IDs

MOE969 The MOE shall have the capability to command data in mass storage to be unprotected.

Rationale: If observatory mass storage contains protected data, the MOE will be able to command files or locations to be unprotected in mass storage and available for overwriting. Expected standard ops are to command data to be unprotected when it has been receipt-acknowledged by ground.

MOE971 The MOE shall have the capability to set the priority status of mass storage by command.

MOE972 The MOE shall provide a capability for operators to select data in mass storage for downlink.

Rationale: Allows the ground to determine what files or locations to downlink and re-downlink when.

MOE974 The MOE shall accept spacecraft SSR state vector telemetry.

Rationale: to support analysis of scene / interval / file data collection and recovery information

MOE976 The MOE shall accept GNE file status data.

Rationale: to support analysis of scene data collection and recovery information

MOE978 The MOE shall display file directory listings, tables, and dump data in human readable formats.

Rationale: ability for operators to view and interpret tables and dumps

MOE980 The MOE shall provide a configurable capability to automatically command the observatory to downlink Priority files first, then the oldest files in mass storage.

Rationale: For unattended operations, the MOE can direct the downlink priority first, then oldest to most recently recorded

MOE982 The MOE shall automatically maintain a state vector of data file status based on the schedule, observatory real-time telemetry, and GNE data receipt messages.

Rationale: This capability provides a current assessment of data status used for autonomous ground management of data retransmission or unprotect.

MOE984 The MOE shall provide a configurable capability to automatically command the retransmission of data files based on the status received from the GNE.

Rationale: This capability allows autonomous commanding of data retransmission.

MOE986 The MOE shall provide a reconfigurable capability to automatically command the observatory to unprotect files in mass storage based on the status received from the GNE.

Rationale: once MOE receives acknowledgements from GNE, MOE can automatically allow these files to be overwritten on the observatory

MOE988 The MOE shall generate a playback data accounting summary for each observatory downlink session supported, to include the following information:

a) File name of each file received

b) data type/source (want this to be part of file name)

c) byte-size for each file

d) File Acknowledgement Flag

e) number of pending File Retransmission Requests buffered for this pass.

Rationale: Generation of playback accounting summaries is required to ensure data completeness and integrity for the stored science and engineering data replayed during ground station contacts.

10.2.3 Mass Storage Modeling

This section defines the requirements for a SSR model. The model utilizes the generic analytical modeling capabilities of the Mission Monitor & Analysis function.

MOE992 The MOE shall model current and predicted observatory mass storage utilization.

Rationale: Allows MOE to monitor and plan on-board recorder usage

MOE994 The MOE mass storage modeling capability shall accept observatory data collection and downlink planning and scheduling inputs.

Rationale: future collection and downlink activities must feed model in order to have an accurate representation for planning purposes

MOE996 The MOE mass storage modeling capability shall accept observatory housekeeping telemetry inputs.

Rationale: to accurately model the state of mass storage, the model should update an apriori state based on telemetered values

MOE998 The MOE mass storage modeling capability shall provide a textual and graphical display.

Rationale: operators must be able to view and interpret mass storage model data

MOE1000 The MOE mass storage modeling capability shall notify operators of results via event messages.

Rationale: operators must be able to view and interpret mass storage model data

MOE1002 The MOE mass storage modeling capability shall notify operators of results via a report delivered to the controlled repository.

Rationale: CAPE and other operators must be able to view and interpret mass storage model results

MOE1004 The MOE mass storage modeling capability shall be available to remote authorized users.

Rationale: CAPE access to the model

11 Product Generation, Distribution and Archive

This section discusses the general requirements for MOE product handling.

MOE1008 The MOE shall process engineering data into deliverable products within 72 hours of receipt 95% of the time.

MOE1009 The MOE shall script the generation of operator-specified engineering data products.

MOE1010 The MOE shall script the generation of time sensitive engineering data products.

MOE1011 The MOE shall notify product users of processing completion status.

Rationale: inform users and applications on process success or failure, supports autonomous operations

MOE1013 The MOE shall notify users of product availability via event messages.

Rationale: provide notification of product availability to authorized users, including applications. The notification specifies the explicit file name of the product, where applicable

MOE1015 The MOE shall provide a controlled repository on the operational network for user-specified engineering data products.

Rationale: provides a controlled repository to support file sharing of operational engineering data products by ground system applications (i.e. other MOE applications, bMOC, CAPE, GNE, IE, etc).

MOE1017 The MOE shall provide a controlled repository on an unrestricted network for use by authorized remote users.

Rationale: provides a controlled repository to support file sharing of operational engineering data products by external authorized users (i.e. FOT, remote trend system, bMOC, etc)

MOE1019 The MOE shall distribute products to one or more repositories via directive and scripts.

Rationale: provide a means for product distribution to one or more applications and/or repositories in manual and autonomous modes of operation.

MOE1021 The MOE shall archive and retrieve engineering data products for the life of the mission.

Rationale: This is a MOE requirement to perform routine archival of dynamic engineering data products, including housekeeping telemetry, on a routine basis without impact to the operational system.

12 Event Generation, Logging and Report Operations

This section defined the general requirements for event message generation, distribution and handling.

MOE1025 The MOE shall publish copies of operator selected log messages to a centralized log.

Rationale: a comprehensive time ordered sequence of events will be available showing events from all applications

MOE1027 The MOE shall have the capability to display and archive the centralized log.

Rationale: support operator access of the log

MOE1029 The MOE shall provide the capability for operators to create and modify the conditions when event messages are generated.

Rationale: ability to modify event conditions in the database

MOE1031 The MOE shall provide the capability for operators to create and modify the content of event messages.

Rationale: ability to modify event message text in the database

MOE1033 The MOE shall time tag all ground system event messages with a GSE time.

Rationale: tag ground events with ground time.

MOE1035 The MOE shall interpret space segment event messages using the observatory time.

Rationale: tag spacecraft events with spacecraft time in the event message and not the ground time tag

MOE1037 The MOE shall distinguish between events tagged with GSE and observatory times..

Rationale: Allows operator to distinguish ground system events from spacecraft events.

MOE1039 The MOE shall provide an operator-configurable color coding scheme to display event messages.

Rationale: without specifying a particular approach, this requires an easily interpretable means of identifying alarms, warnings and routine messages, e.g. Red for alarms, yellow for warnings, blue for routine messages, etc. This is configurable to accommodate various forms of color-blindness.

MOE1041 The MOE shall provide an operator-configurable non-color-coded scheme to display event messages.

Rationale: This is identification of event message displays using fonts, symbols, flashing text etc.

MOE1043 The MOE shall generate operator-defined event message reports.

MOE1044 The MOE shall allow the operator to enable, disable, filter, and display event messages.

MOE1045 The MOE shall provide an operator-configurable control to filter repeated event messages.

Rationale: Allows operator to prevent the same event message from occurring over and over in the event log. You may not want the same limit violation repeated over and over again, but rather on every nth occurrence

MOE1047 The MOE shall log all event messages for the life of the mission.

MOE1048 The MOE shall display any event messages and logs.

12.1 Remote Notification System

MOE1050 The MOE shall monitor the event log and notify appropriate on-call personnel when the MOC is not staffed.

MOE1051 The MOE shall generate alert notifications remotely to a communications/pager service.

Rationale: Notifying personnel in response to operator selected ground system events.

MOE1053 The MOE shall incorporate operator definable call lists and schedules to perform the notifications.

Rationale: Allows the authorized operator to maintain the call list database throughout the life of the mission.

MOE1055 The MOE shall provide for notification trigger message filtering, rudimentary wildcard trigger selection, and Nth occurrence filtering.

Rationale: to provide basic mechanisms to minimize invalid and excessive notifications.

MOE1057 The notification system shall receive updates derived from the Project Reference Database (PRD).

Rationale: common database providing configuration control, etc.

MOE1059 The notification system shall deliver updates to the Project Reference Database (PRD).

Rationale: common database providing configuration control, etc.

13 Operator Interface

This section defines the characteristics of the MOE - Human interface for MOC and remote support.

13.1 Data Display

MOE1064 The MOE shall generate and store operator configurable textual and graphical data displays.

Rationale: operators have the capability to define data displays

MOE1066 The MOE shall display stored textual and graphical data displays.

Rationale: operators have the capability to call-up data displays

MOE1068 The MOE shall display time tags of GSE data with a time of format unique to ground system generated data.

Rationale: Allows operator to distinguish ground system time reference from spacecraft time reference in output displays, reports & events. Uniqueness is imparted in the delimiter or font selection as opposed to data field definition.

MOE1070 The MOE shall display time tags of observatory data with an observatory time of format unique to observatory generated data.

Rationale: Allows operator to distinguish ground system time from spacecraft time output displays, reports & events. Uniqueness is imparted in the delimiter or font selection as opposed to data field definition.

MOE1072 The MOE shall have the capability to provide video output of NASA selected workstations to 3 or more display and/or video projection devices.

Rationale: provide the capability to project, for the general audience, operator-selected displays

MOE1074 The MOE shall capture a printable image of all data displayed on a workstation.

Rationale: the operator may capture a screen snap or copy of data displayed on a workstation for reference and distribution.

MOE1076 The MOE shall route hardcopy output to an operator selected output device.

Rationale: MOC to support at least two or more printers of which the operator can select from.

13.1.1 Display Project Reference Database

MOE1079 The MOE shall define data displays and their characteristics in a display database.

MOE1080 The MOE shall manage the authority to modify the display database by login attributes.

Rationale: restricts write access to the MOE configured display database

MOE1082 The MOE display databases shall receive modifications derived from the Project Reference Database (PRD).

Rationale: common database providing Flight Operations CCB controlled databases, etc.

MOE1084 The MOE shall provide display database modifications for submission to the Project Reference Database (PRD).

Rationale: mechanism for submissions to the Flight Operations CCB for approval & distribution.

13.2 Operator Input

MOE1087 The MOE shall utilize a Graphical User Interface (GUI) for system operation.

MOE1088 The MOE shall utilize a command line interface for system operation.

MOE1089 The MOE shall support a minimum of multiple operators (seats) per environment as defined in the Facility Requirements section of this document.

13.3 Operator Capacities

MOE1091 The MOE shall provide the capability for a remote interface to housekeeping telemetry, trending and analysis, events and engineering data products for at least 10 concurrent operators.

Rationale: a remote (open net) mission monitor & analysis system to support ops and engineering personnel who are remotely-located from the MOC (i.e. on-call FOT, Cal/Val, bus vendor, etc)

MOE1093 The MOE shall provide internal access to Mission Monitor and Analysis functionality for at least 20 concurrent operators from the MOE provided workstations.

Rationale: FOT, sub-system and instrument support engineers/experts accessing the operational Trend and analysis system from command & telemetry, planning & scheduling and Flight Dynamics workstations.

MOE1095 The MOE shall provide a capability to generate and save operator logs.

Rationale: keep a record of operator interaction with the system

14 Automation

This subsection defines the requirements levied on the MOE for support of autonomous operations during normal mission operations. The MOE will provide tools to perform routine and periodic operations autonomously.

MOE1099 The MOE shall support a single 8-hour by 5-day shift (M-F) approach and operate autonomously whenever not staffed.

MOE1100 All functional applications in the MOE shall have the ability to run unattended while performing all routine and periodic operations for 72 hours.

Rationale: supports autonomous operations during 3-day weekend; assume schedules have already been made and command loads generated prior to going into autonomous mode.

MOE1102 All the applications in the MOE shall have the ability to be managed via directives.

Rationale: running from directives generated via command line, application, activity schedule, etc.

MOE1104 The MOE shall have the ability to execute the ground elements of the Master Active Schedule.

Rationale: Autonomously manage the ground system as per the plan derived from the Master Schedule of Activities.

MOE1106 The MOE shall autonomously distribute all products on a time or activity schedule basis.

Rationale: Minimizes operation intervention in the data distribution process.

MOE1108 The MOE shall autonomously establish a command and telemetry link with a GNE station for every observatory-GNE contact.

Rationale: autonomy needed for unattended operations

MOE1110 The MOE shall schedule and generate command loads automatically, when planned to do so.

Rationale: This is intended to support revision of data collection based on updated cloud cover predictions at CAPE in an autonomous mode, etc.

MOE1112 The MOE sub-systems and applications shall automatically respond to start, stop, pause, heartbeat, and directive requests.

Rationale: basic level of support for all applications in the autonomous environment

MOE1114 The MOE shall monitor and report message traffic, system health status, and system configuration among and between MOE sub-systems.

Rationale: monitor communications between MOE functions in service oriented architecture (SOA) environment and provide status of MOE equipment and software (situational awareness)

15 Backup MOE (bMOE)

This subsection defines requirements in support of the backup MOE. The bMOE will be housed in the backup MOC (bMOC). This facility will serve a variety of functions throughout the mission. As such, the size and physical location of the bMOE deployment may vary. The bMOE delivery requirements are listed in Section 16. Transfer of FOT products sufficient and necessary to continue operations from any supported facility will be via a controlled repository physically located outside of the MOC.

Due to bMOC storage constraints, only statistically compressed data will be stored long-term in the bMOE. However, during bMOC operations, all data will be stored until MOC failback operations are complete. Also, reduced storage capacity limits the size of the bMOC controlled repository. For this reason, the bMOC controlled repository cannot hold all products for the life of the mission. For these reasons, MOE236, MOE441, MOE557, MOE562, MOE664, MOE666, MOE683, and MOE1047 are waived for the bMOE.

MOE1118 The bMOE shall provide all the capabilities of the MOE as described in sections 3 through 14 of this document, except for the limitations noted above.

Rationale: the backup MOE provides all the functionality of the MOE. Note that section 16.13 specifies bMOE interface requirements.

MOE1120 The bMOE shall support mission operations for a full planning cycle.

MOE1121 The bMOE shall download all data and databases necessary to support 'power-on initialization' for all MOE applications from an operator-specified controlled repository within four (4) hours of the request.

Rationale: Load current versions of the operational databases and MOE products to fully configure the MOE for normal operations.

MOE1123 The primary MOE shall communicate bi-directionally with the bMOE or controlled repository, for data transfer, synchronization, and check-pointing whenever the bMOE is active.

Rationale: During checkout, maintenance and parallel operations, the system will assess synchronization of the MOE and bMOE, reporting any deviations in configuration and database, and providing mechanisms to support automated or manual re-synchronization.

MOE1125 The MOE shall transfer critical command and control data and information to the bMOE or controlled repository, a minimum of once per 8 hour period.

Rationale: ensures current copies of the Project Reference Databases and other critical ops information is available to the bMOC and consistent between MOE and bMOE.

MOE1127 The MOE shall transfer critical command and control data and information to the bMOE or controlled repository, via ground system directive.

Rationale: provides the capability to initiate the transfers by manually invoked directive or schedule.

MOE1129 The MOE shall transfer critical command and control data and information to the bMOE or controlled repository within 1 hour from the start of the transfer.

Rationale: establishes time for updating bMOE databases and information

MOE1131 The bMOE shall transfer critical command and control data and information to the MOE or controlled repository, a minimum of once per 8 hour period.

Rationale: when bMOE is serving as primary, ensures current copies of the Project Reference Databases and other critical ops information is available to the MOC and consistent between MOE and bMOE.

MOE1133 The bMOE shall transfer critical command and control data and information to the MOE or controlled repository within one hour from the start of the transfer.

Rationale: establishes time for updating MOE databases and information, when bMOE is serving as primary

16 Interfaces

This section of the MOE RD identifies the external elements the MOE will interface to, the general types of communication required, and the specific requirements including but not limited to link control, transport protocol, and software interfaces. See Appendix B for additional information. Figure 16-1 illustrates the MOE interfaces in the context of the overall LDMC mission.

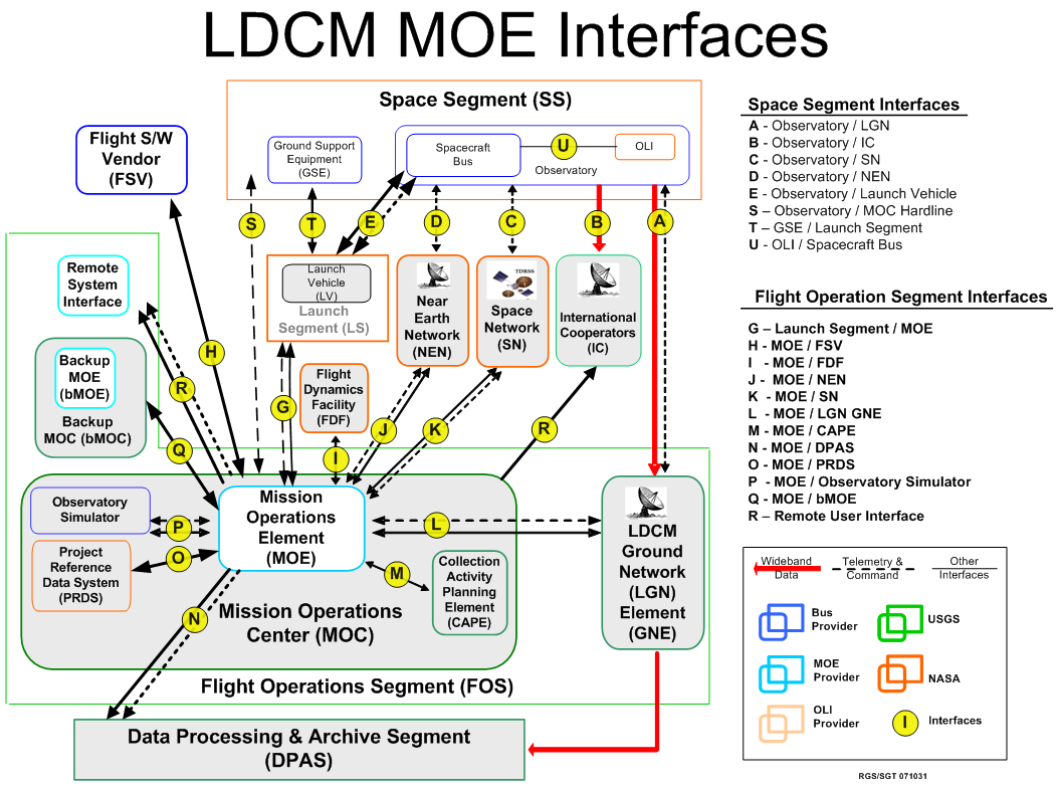

Figure 16 - 1 Mission Operations Element Interfaces

16.1 LDCM Observatory

MOE1142 The MOE shall interface with the LDCM Observatory as defined in the NASA/GSFC LDCM Spacecraft to Ground Interface Control Document (ICD), 70-P58230P.

MOE1144 The MOE shall generate commands for transmission to the observatory.

MOE1145 The MOE shall accept housekeeping telemetry from the observatory.

16.2 LDCM Observatory Simulator (ObsSim)

MOE1147 The MOE shall interface with the LDCM Observatory Simulator as defined in the NASA/GSFC LDCM Spacecraft to Ground ICD, GSFC TBS.

MOE1148 The MOE shall generate commands for transmission to the observatory simulator.

Rationale: command structure is the same as that of the observatory, however, the simulator may not support encryption

MOE1150 The MOE shall accept housekeeping telemetry from the observatory simulator.

MOE1151 The MOE shall generate GSE directives for the observatory simulator.

Rationale: allows the operator to run the simulator and change its configuration

MOE1153 The MOE shall receive and process simulator status & configuration data (GSE data).

Rationale: allows the operator to monitor the simulator status, verify overall configuration and responses to GSE directives.

MOE1480 The MOE shall interface with LDCM Ground Station Simulator (PTP).

Rationale: The Observatory Simulator will be integrated with the project provided ground station simulator.

16.3 LDCM Ground Network Element (GNE)

The GNE consists of ground stations at Sioux Falls, SD (LGS), Gilmore Creek, AK (GLC), and Svalbard, Norway (KSat).

MOE1156 The MOE shall support operations with the LDCM Observatory via the GNE as defined in the NASA/GSFC LDCM Spacecraft to Ground Interface Control Document (ICD), 70-P58230P.

MOE1157 The MOE shall support S-band and X-band RF link operations with the GNE

MOE1158 The MOE shall receive real-time S-band housekeeping telemetry from the GNE.

MOE1159 The MOE shall receive S-band stored housekeeping telemetry from the GNE.

MOE1160 The MOE shall receive S-band housekeeping telemetry recorded and played back by the GNE.

Rationale: provide the capability to receive housekeeping recorded by the GNE but not received by the MOE

MOE1162 The MOE shall receive data from the GNE to support X-band data recovery.

Rationale: this data will be available in near-real time and upon request by the MOE for use in constructing the recorder memory management commands

MOE1164 The MOE shall receive return link quality information from the GNE.

Rationale: allows the operator to monitor the GNE link status via GSE data and for comparison to MOE generated information.

MOE1166 The MOE shall receive and process GNE status & configuration data (GSE data) for the LGS and GLC stations.

Rationale: allows the operator to monitor the GNE status, verify overall configuration and responses to GSE directives. Will not perform real-time monitoring with SvalSat station.

MOE1168 The MOE shall receive scheduling data/information from the GNE.

Rationale: confirmation of proposed GNE schedule requests from the Planning & Scheduling function.

MOE1170 The MOE shall send scheduling requests to the GNE.

Rationale: supports the MOE Planning & Scheduling process

MOE1172 The MOE shall send the GNE Network Schedule to the LGS and GLC stations.

Rationale: Sent to the GNE following committal of a new schedule; Does not apply to KSAT.

MOE1174 The MOE shall send observatory commands to the GNE for S-band uplink.

MOE1175 The MOE shall provide acquisition data to the GNE.

MOE1176 The MOE shall generate GSE directives for execution by LGS and GLC.

Rationale: Allows the operator to run the simulator and change its configuration.

MOE1178 The MOE shall send notification messages to the LGS and GLC stations.

Rationale: To notify LGS and GLC of product availability, alarms generated thru evaluation of GSE data, and other applicable events generated by the MOE.

MOE1516 The MOE shall receive scheduling data/information from the KSAT as per the MOE-GNE ICD.

Rationale: Confirmation of proposed KSAT schedule requests from the Planning & Scheduling function.

MOE1517 The MOE shall send scheduling requests to the KSAT as per the MOE-GNE ICD.

Rationale: Supports the MOE Planning & Scheduling process.

16.4 Near Earth Network (NEN)

MOE1181 The MOE shall support operations with the LDCM Observatory via the NEN as defined in the NASA/GSFC LDCM Spacecraft to Ground Interface Control Document (ICD), 70-P58230P.

MOE1182 The MOE shall receive real-time S-band housekeeping telemetry from the NEN.

MOE1183 The MOE shall receive stored S-band housekeeping telemetry from the NEN.

MOE1184 The MOE shall receive S-band housekeeping telemetry recorded and played back by the NEN.

Rationale: provide the capability to receive housekeeping recorded by the NEN but not received by the MOE

MOE1186 The MOE shall receive pass reports from the NEN as defined in the Ground Network User's Guide.

MOE1187 The MOE shall receive scheduling data/information from the NEN as defined in the Ground Network User's Guide.

MOE1188 The MOE shall send scheduling information and acquisition data to the NEN as defined in the Ground Network User's Guide.

MOE1189 The MOE shall send observatory commands to the NEN.

MOE1190 The MOE shall provide acquisition data to the NEN.

16.5 NASA Space Network (SN)

The LDCM MOC interfaces to the SN using a Government-provided, MOC-hosted SN-compatible system. The SN-compatible system will be separate from the MOE and provide the following services consistent with the Interface Control Document between the Space Network and Customers for Service Management:

SN Scheduling

Forward and return link service requests (GCMRs)

Real/time SN status / control messages

MOE1193 The MOE shall support operations with the LDCM Observatory via the SN as defined in the NASA/GSFC LDCM Spacecraft to Ground Interface Control Document (ICD), 70-P58230P.

MOE1194 The MOE shall receive real-time S-band housekeeping telemetry from the SN.

MOE1195 The MOE shall receive S-band housekeeping telemetry recorded and played back by the SN.

Rationale: provide the capability to receive housekeeping recorded by the SN but not received by the MOE

MOE1197 The MOE shall send observatory commands to the SN.

MOE1198 The MOE shall provide acquisition data to the SN.

16.6 International Cooperators (IC)

MOE1200 The MOE shall send IC downlink schedules to a DPAS repository.

Rationale: IC station schedule report. The MOE will distribute these schedules through the open side controlled repository for access by the ICs, CAPE, DPAS, etc.

MOE1202 The MOE shall send IC acquisition data to a DPAS repository.

Rationale: The MOE will also distribute the acquisition data through the open side controlled repository for access by the ICs, CAPE, DPAS, etc.

MOE1204 The MOE shall provide the capability for authorized users controlled access to IC downlink schedules and acquisition data.

16.7 Observatory at Integration & Test Facilities (I&T) and Launch Segment (LS)

MOE1208 The MOE shall interface with the LDCM Observatory at the I&T Facilities and Launch Site as defined in the NASA/GSFC LDCM Spacecraft to Ground Interface Control Document (ICD), 70-P58230P.

MOE1210 The MOE shall support S-band and X-band RF link operations with the I&T Facilities and Launch Site

Rationale: connectivity of the mini-MOE, MOE and bMOE, as appropriate, to support pre-launch testing

MOE1212 The MOE shall send observatory commands to the observatory.

Rationale: commands to the observatory while it is at the observatory I&T facility and at the launch site.

MOE1214 The MOE shall receive housekeeping telemetry from the observatory.

Rationale: The MOE must be able to receive telemetry from the observatory while it is at the observatory I&T facility and at the launch site.

MOE1481 The MOE shall interface with LDCM Ground Station Simulator (PTP) supporting the Observatory pre-launch.

Rationale: Communications with Observatory will be supported by the project provided ground station simulator.

16.8 Mission Operations Center (MOC) Facility

MOE1221 The MOE shall receive a master time signal reference from the MOC facility.

MOE1222 The MOE shall receive access to the MOC VLAN supporting the MOC facility.

Rationale: This LAN will host the protected elements of the MOC and provide access to the NISN networks.

MOE1224 The MOE shall receive access to the MOC DMZ provided by the MOC facility.

Rationale: This provides access to the networks supporting DPAS elements, Remote MM&A and other external support elements.

MOE1226 The MOE shall exchange data as necessary with the configuration controlled LDCM Project Reference Database (PRD).

Rationale: the MOE will derive it's databases from the application common LDCM Project Reference Database. In addition, the MOE will transmit changes to its databases to the LDCM PRD for incorporation.

MOE1513 The MOE shall forward real-time telemetry frames with LEO-T header to the LSR AstroRT frame relay system.

Rationale: Real-time telemetry frames are sent to the LSR AstroRT frame relay workstation such that telemetry can be simulcast to the other AstroRT workstation present in the LSR.

MOE1514 The MOC shall make available to the controlled repository command history logs containing STOL and ASCII hex command statements showing at least the command packet and VCCs associated with each command.

Rationale: To make such files available to internal systems such as Orbital GSE and to provide debugging information including a way of comparing the log of uplinked commands with the log containing command history from the spacecraft.

16.9 NASA Flight Dynamics Facility (FDF) / Flight Dynamics Analysis Branch (FDAB)

MOE1229 The MOE shall send predicted ephemeris to the FDF / FDAB.

Rationale: supports Earth Science Mission Operation (ESMO) a.m. constellation coordination activities, and conjunction assessments.

MOE1231 The MOE shall deliver the 7-day LDCM ephemeris data in CA format to the FDAB no later than 1 pm ET daily.

Rationale: JSpOC computations begin promptly at 1 pm ET daily.

MOE1233 The MOE shall provide the predicted near-term (45-day) sequence of orbit maneuver maintenance to the FDAB routinely in a machine-readable fixed format file. Notification shall contain pertinent maneuver data (delta-V time, size, etc)

Rationale: FDAB will evaluate the effect of planned maneuvers on predicted conjunctions

MOE1235 The MOE shall receive LDCM definitive ephemeris data from the FDF / FDAB.

Rationale: for anomaly resolution

MOE1237 The MOE shall receive predicted observatory ephemeris from the FDF/ FDAB.

Rationale: during launch and early orbit; FDF provides based on state vectors at LV separation; allows MOE to make contact with observatory; supports conjunction assessments

16.10 Flight Software Vendor (FSV)

MOE1240 The MOE shall send stored memory loads to the FSV.

Rationale: send proposed or executed memory load files created under the command function to the FSV

MOE1242 The MOE shall send memory dump data to the FSV.

Rationale: FSV has a copy of what is actually on-board.

MOE1244 The MOE shall send a copy of the Ground Reference Image data to the FSV.

Rationale: FSV has a copy of the operations configuration controlled image.

MOE1246 The MOE shall receive flight software updates from the FSV.

Rationale: method for receiving memory modifications from the FSV

MOE1248 The MOE shall receive Ground Reference Image data from the FSV.

Rationale: provide capability for FSV to deliver a reference.

16.11 Collection Activity Planning Element (CAPE)

MOE1251 The MOE shall provide the capability for CAPE operators and applications controlled access to copies of the Master Schedule of Activities and its derivatives via the controlled repository.

Rationale: observatory and ground system information needed for image collection planning - forecast & master working schedules

MOE1253 The MOE shall produce and deliver operator-specified subsets of the Forecast Schedule to the CAPE.

Rationale: provide the CAPE a current version of the schedule for long term and scene scheduling - provides for database synchronization between the MOE and CAPE.

MOE1257 The MOE shall produce and deliver operator-specified subsets of the Master Active Schedule to the CAPE.

Rationale: provide the CAPE a current version of the schedule committed for execution - provides for database synchronization between the MOE and CAPE.

MOE1259 The MOE shall produce and deliver operator-specified subsets of the Resource Availability Report to the CAPE.

Rationale: observatory and ground system availability information needed for image collection planning - a report derived from the Master Schedule

MOE1261 The MOE shall send the WRS path/row to time translation table to the CAPE.

Rationale: timing needed for image collection planning via the controlled repository.

MOE1265 The MOE shall provide notification messages to CAPE.

Rationale: provide notification of applicable processing status and products delivered to the controlled repository

MOE1267 The MOE shall receive collection requests from the CAPE via the controlled repository.

Rationale: the MOE will obtain the Image Data Collection Schedule information from the CAPE

MOE1269 The MOE shall receive notification messages from CAPE.

Rationale: notification of data collection requests delivered to the controlled repository

MOE1520 The MOE shall send the Master Integrated Schedule (MIS) to the CAPE as per the CAPE to MOE ICD.

Rationale: Provide the CAPE a current version of the schedule for long term and scene scheduling - provides for database synchronization between the MOE and CAPE.

16.12 Data Processing and Archive Segment (DPAS)

MOE1272 The MOE shall provide Engineering Data Products to the controlled repository for access by DPAS operators and applications as per the MOE-DPAS ICD.

Rationale: Supports cal/val teams access to housekeeping telemetry derivatives.

MOE1522 The MOE shall provide planning and scheduling products to the controlled repository for access by DPAS operators and applications as per the MOE-DPAS ICD.

Rationale: Provide DPAS a current version of the schedule for use and archive.

16.13 Backup MOE (bMOE)

MOE1283 The MOE and bMOE shall exchange data as necessary to support the transfer of operation between MOE and bMOE.

MOE1284 The bMOE shall support all the same interfaces as the MOE, identified in sections 16.1 through 16.12. (Section 16.8 is applied for a bMOE and bMOC interface.)

Rationale: the bMOE must provide the same capabilities, with the exception that it does not contain a hardware version of the LDCM Simulator.

17 Facility Requirements

MOE functionality will be deployed to four facilities including the Observatory Integration & Test Facility, Instrument Development & Test Facility, MOC and backup MOC. This section defines the general facility and other MOE supporting baseline deployment requirements.

The intent of this section is to define the minimum number of individual operable instances of a functionality and to provide insight into the space and power provided at each site.

MOE1289 Deployments of MOE functionality shall have the same form, fit and function in each deployment. The number of copies of each workstation type or application may vary.

Rationale: Components of the MOE shall be common to all deployments, allowing for equipment swapping and minimal reconfiguration requirements. Note: See section 15 for exceptions to this requirement for the bMOE;

MOE1291 The MOE shall be scalable, configured in deployments of functional units (copies) of the capability as follows:

FUNCTIONAL UNIT	MINIMUM UPPER LIMIT
Front End	4
CMD/TLM Workstations**	50
Mission Monitor & Analysis	3
Planning & Scheduling	2
Flight Dynamics	3

** at least 10 with command capability

(reference count by facility)

MOE1292 The MOE shall operate on U.S. standard single-phase or dual-phase electrical power.

MOE1293 The MOE shall operate in a temperature range from 10 degrees C to 29 degrees C.

MOE1294 The MOE shall operate in a humidity range from 40% to 60%.

17.1 Observatory Integration & Test (I&T) Facility

A copy of the MOE will be deployed at the observatory integration and test facility to support MOE testing and product generation by the FOT. This site will support command and telemetry functions of the MOE. This abbreviated system is referred to as a mini-MOE.

MOE1297 The baseline I&T MOE (mini-MOE) shall deploy to this facility sufficient to support the following:

FUNCTIONAL UNIT	QUANTITY
Front End* (Spacecraft Interface)	1
CMD/TLM Workstations**	2
Mission Monitor & Analysis	1

* keyset zero set; includes MYK & Workstation with serial card

** at least 2 of 2 with command capability; one with serial card

MOE1298 The total aggregate space requirement for the baseline I&T MOE shall not exceed 40 square feet (contiguous). Below is a list of equipment by unit type.

UNIT	DESCRIPTION	Height (cm)	Width (cm)	Depth (cm)
Front End	Rack of equipment	200	61	122
CMD/TLM	Standard PC	61	76	76
MM&A	Standard PC	61	76	76

MOE1299 The total aggregate power requirement for the baseline I&T MOE shall require a minimum of 2 20 A standard 110 Vac circuits. Below is a list of service needs by unit type.

UNIT	DESCRIPTION	Amp	Vac	Service
Front End	Rack of equipment	10	110	Single Phase
CMD/TLM	Standard PC	10	110	Single Phase
MM&A	Standard PC	10	110	Single Phase

17.2 Instrument Development & Test (D&T) Facility

A copy of the MOE will be deployed at the instrument development and test facility to support MOE testing and product generation by the FOT. This site will support command and telemetry functions of the MOE. This abbreviated system is referred to as a mini-MOE.

MOE1302 The baseline D&T MOE (mini-MOE) shall deploy to this facility sufficient to support the following:

FUNCTIONAL UNIT	QUANTITY
Front End without MYK	1
CMD/TLM Workstations*	2

Mission Monitor & Analysis	1

* at least 2 of 2 with command capability

MOE1303 The total aggregate space requirement for the baseline D&T MOE shall not exceed 40 square feet (contiguous). Below is a list of equipment by unit type.

UNIT	DESCRIPTION	Height (cm)	Width (cm)	Depth (cm)
Front End	Rack of equipment	200	61	122
CMD/TLM	Standard PC	61	76	76
MM&A	Standard PC	61	76	76

MOE1304 The total aggregate power requirement for the baseline D&T MOE shall require a minimum of 2 20 A standard 110 Vac circuits. Below is a list of service needs by unit type.

UNIT	DESCRIPTION	Amp	Vac	Service
Front End	Rack of equipment	10	110	Single Phase
CMD/TLM	Standard PC	10	110	Single Phase
MM&A	Standard PC	10	110	Single Phase

17.3 GSFC Mission Operations Center (MOC) Facility

A copy of the MOE will be deployed at the GSFC Mission Operations Center capable of supporting pre-launch, launch, commissioning, normal mission operations and decommissioning of the LDCM observatory.

MOE1307 The baseline MOC MOE shall deploy to this facility sufficient to support the following:

FUNCTIONAL UNIT	QUANTITY
Front End *	2
CMD/TLM Workstations**	16
Mission Monitor & Analysis	2
Mission Monitor & Analysis	1 (remote access)
Planning & Scheduling	2

Flight Dynamics 2

*includes MYK & Workstation with serial card

** at least 6 of 12 with command capability

MOE1308 The total aggregate space requirement for the baseline MOC MOE shall not exceed 600 square feet (contiguous). Below is a list of equipment by unit type.

UNIT	DESCRIPTION	Height (cm)	Width (cm)	Depth (cm)
Front End	Rack of equipment	200	61	122
CMD/TLM	Standard PC	61	76	76
MM&A	Standard PC	61	76	76
P&S	Standard PC	61	76	76
FD	Standard PC	61	76	76

MOE1309 The total aggregate power requirement for the baseline MOC MOE shall require a minimum of 10 20 A standard 110 Vac circuits. Below is a list of service needs by unit type.

UNIT	DESCRIPTION	Amp	Vac	Service
Front End	Rack of equipment	10	110	Single Phase
CMD/TLM	Standard PC	10	110	Single Phase
MM&A	Standard PC	10	110	Single Phase
FD	Standard PC	10	110	Single Phase

17.4 Launch Support Room (LSR)

A copy of the MOE will be deployed at the Launch Support Room co-located with and part of the GSFC Mission Operations Center to support pre-launch, launch, and commissioning operations of the LDCM observatory. The facility will host the Spacecraft Engineering Area (SEA) and the Instrument Engineering Area (IEA).

MOE1312 The baseline LSR MOE shall deploy to this facility sufficient hardware to support the following:

FUNCTIONAL UNIT	QUANTITY
Front End rack-mounted	1
TLM rack-mounted workstations, KVMed, with dual-head monitors	6

TLM desktop workstations, non-KVMed, with dual-head monitors 17

Mission Monitor & Analysis workstation,

rack-mounted with, remote-access 1

Flight Dynamics rack-mounted workstations, KVMed, with 1 node-locked licensed and 1 dongle licensed 2

Notes:

- Each of the FDS machines must have the NASA pack

- Some workstations may be attached to a MOC Front End

- MOE team provides all racks

MOE1313 The total aggregate space requirement for the baseline LSR MOE shall not exceed 600 square feet (contiguous). Below is a list of equipment by unit type.

UNIT	DESCRIPTION	Height (cm)	Width (cm)	Depth (cm)
Front End	Equipment Rack	200	61	122
TLM	Standard PC	61	76	76
MMA	Standard PC	61	76	76
FD	Standard PC	61	76	76

MOE1314 The total aggregate power requirement for the baseline LSR MOE shall require a maximum of 16 20 A standard 110 Vac circuits. Below is a list of service needs by unit type.

UNIT	DESCRIPTION	Amp	Vac	Service
Front End	Rack of equipment	10	110	Single Phase
TLM	Standard PC	10	110	Single Phase
MM&A	Standard PC	10	110	Single Phase
FD	Standard PC	10	110	Single Phase

17.5 Backup Mission Operations Center (BMOC) Facility

A copy of the MOE will be deployed at the Goddard Space Flight Center. This MOC will support pre-launch, launch, commissioning and contingency activities of the LDCM observatory as the bMOC.

MOE1317 The baseline bMOC MOE shall deploy to this facility sufficient to support the following:

FUNCTIONAL UNIT	QUANTITY
Front End*	1
CMD/TLM Workstations**	4
Mission Monitor & Analysis	1
Planning & Scheduling	1
Flight Dynamics	1

* includes MYK & Workstation with serial card

** at least 2 of 4 with command capability

NOTE: This delivery will support 5 workspaces supported by dual-headed monitors KVMed to rack mounted processors.

Rationale: Supports operations concept for failover to backup MOC.

MOE1318 The total aggregate space requirement for the baseline bMOC MOE shall not exceed 600 square feet (contiguous). Below is a list of equipment by unit type.

UNIT	DESCRIPTION	Height (cm)	Width (cm)	Depth (cm)
Front End	Rack of equipment	200	61	122
CMD/TLM	Standard PC	61	76	76
MM&A	Standard PC	61	76	76
P&S	Standard PC	61	76	76
FD	Standard PC	61	76	76

MOE1319 The total aggregate power requirement for the baseline bMOC MOE shall require a minimum of 6 20 A standard 110 Vac circuits. Below is a list of service needs by unit type.

UNIT	DESCRIPTION	Amp	Vac	Service
Front End	Rack of equipment	10	110	Single Phase

CMD/TLM	Standard PC	10	110	Single Phase
MM&A	Standard PC	10	110	Single Phase
FD	Standard PC	10	110	Single Phase

18 Appendix A: Glossary

This appendix is intended to supplement the LDCM ACRONYM LIST AND LEXICON (reference listed in Section 2.2). When in conflict, the definition provided here is utilized in the interpretation of this document only.

anomaly -- any unplanned or unexpected event which may result in a loss of operation data or a sharp departure of certain telemetry parameters from their nominal values - a deviation from normal operation that affects the performance of an observatory system or subsystem.

Absolute Time Sequence (ATS) - a Command Sequence or schedule defined using command start at a specific UTC time (or spacecraft time equivalent).

Active Schedule - portion of the Master Schedule used to create the ATS command load uplinked to the observatory.

Activity - an operator-defined combination of ground directives and/or observatory commands which can be planned and scheduled. An action (or set of actions) which can occur on the ground or observatory that requires resources and is associated with a definitive start and stop time.

Activity Plan - a time-based set of activities that have yet to be scheduled

Activity Request - a request for operators to schedule activities.

Activity Schedule - a time-based or time-tagged set of activities and resource allocations for a given time period.

Collision Avoidance (COLA) refers to maneuvers performed to mitigate threats from debris.

Command Loads - a set or packaging of commands related by execution time and/or function, converted to binary streams to be up-linked. (Packaging of both telemetry and commands can be performed in a number of ways, such as the CCSDS Telemetry and Commanding Packaging format.)

Command Sequence - a set of commands related by time. A list of command mnemonics identified by a unique name known to the operators that can be re-used.

Commanding -- the coding and packaging of the command information, command validation and verification, as well as authorization to perform the commands. Telemetry and Commanding are necessarily related to one another because Telemetry and Commanding form a feedback loop; the values of down-linked telemetry may play a role in deciding what command or what command parameters to send next.

Commands - Messages that instruct an action on the observatory to execute.

Command Validation - The process of ensuring that commands have the expected results when they are executed by the observatory. Includes validating the use of command parameters associated with the command mnemonics.

Command Verification - The process of verifying that command mnemonics issued within command procedures and loads, and entered manually by the operator, result in the expected

bit patterns being transmitted from the control center, as defined by the command data base. Includes verifying that the use of command parameters associated with the command mnemonics create the expected results.

Conjunction Assessment (CA)refers to the prediction of potential threat events and the analysis of those events

Constraint Checking - The process of ensuring that constraints associated with the execution of individual commands or groups of commands are enforced, whether they are issued within command loads or procedures, or executed manually by the operator. Examples include: (1) ensuring that a particular command is not executed unless a particular on-board state is in place or a particular command had been issued before it, (2) ensuring that commands are not issued beyond some established command rate, and (3) ensuring that the number of commands allowed for a given structure, such as a command sequence, does not exceed an established limit.

Controlled Repository - one or more depots for MOE and other products. This file service will support general access by operational systems, archive processes, backup systems including the bMOC and the remote-user mission analysis system.

Critical Command (or Critical Operations) - an observatory command which, when executed under certain conditions, could jeopardize the health and safety of the spacecraft or its subsystems. It requires the intervention/authorization of an operator before transmission.

Critical Command and Control Operations (Functions) - the rudimentary capability to issue & verify observatory commands and decommutate, EU convert & limit sense real-time housekeeping telemetry. The system may be operated in a manual mode with a minimum of hardware and software applications. Also referred to as the CORE system.

Database - configured data used to operate the application

Decommutated Telemetry - the extracted telemetry parameters from their assigned positions (such as the Major/Minor Frame Number in TDM telemetry systems or the Byte Position in a Packet within the Transfer Frame in CCSDS telemetry systems) within the telemetry stream.

Directive -- a command to the ground software system. Examples of directives are: bring up a display page, turn limit checking on/off, acquire telemetry, etc.

Discrete command - a single (individual) observatory command, as opposed to a spacecraft stored sequence (RTS or ATS) of commands

Engineering (ENG) Data - consists of databases, housekeeping data and its derivatives, analytical results and planning data.

Engineering Unit (EU) - computed human and machine readable values for telemetry analysis Examples of Engineering Units include values for voltage, temperature (degrees K or C), kilometers, etc.

Event - an occurrence detectable within mission operations systems that is used to monitor and track or otherwise audit ground and space operations.

Event Message - the resulting message from a detected event

Forecast Schedule - A portion of the Master Schedule showing predicted orbital and scheduled events for the upcoming three Operational Weeks. This schedule is formally updated once per week and released for distribution.

Front End - Hardware and software unit supporting command encryption & authentication, network connectivity, and other services, as needed, between the MOE systems and external support elements.

FOT - Flight Operations Team, organization of various operator classes responsible for performing mission operations

FOT Products - databases, procedures, configuration files, documentation, etc produced, maintained and used by the MOE in support of the mission

Government Furnished Equipment (GFE) - a generic term used to describe hardware and software components provided by the government for specified uses.

Ground Network Element (GNE) - The LDCM GNE includes the LGN ground stations, data reconstruction subsystem, and the network/telecom (WAN).

Ground Reference Image (GRI) - the ground-based, controlled flight software version that is currently resident on the observatory representing all reprogrammable memory locations (i.e. the image/memory currently used by the On-Board Computer containing data, commands, subroutines, etc).

Ground Support Equipment (GSE) - a generic term describing ground-based hardware and software components supporting spacecraft operations. Includes FOS, DPAS and external ground interfaces. GSE may include but is not limited to pre-launch electrical GSE (EGSE), GNE station status information, etc.

Ground Support Equipment (GSE) Data - includes status data generated by GSE and the directives (requests for action) received by any GSE

Hazardous Command - a command which when executed may endanger the safety of human beings working on the spacecraft during I&T, launch preparation or launch. The hazardous designation is made via the command database. Hazardous commands cannot be transmitted.

Health & Safety - the discipline of monitoring observatory telemetry to check the well-being of the observatory.

Hot backup - an idle, but equivalent system or subsystem ready to take-over instantly when the primary system or subsystem fails.

Housekeeping (HK) Data - Housekeeping telemetry stripped of CCSDS protocols, with or without value-added processing.

Housekeeping Telemetry - observatory telemetry used in Health and Safety determination. Observatory housekeeping telemetry also includes instrument/payload health and safety telemetry; includes CCSDS protocols, the definition of the nominal S-band downlink. Sometimes referred to as engineering telemetry.

Image Data - Image telemetry stripped of CCSDS protocols, etc; with or without value-added processing.

Image Telemetry - OLI only, TIRS only or both imagery data with auxiliary data; the definition of the X-band downlink telemetry

Image Data Collections - OLI only, TIRS only or both imagery data collections

Invalid telemetry - telemetry that is not in a recognizable format and can not be decommutated or is decommutated but contains incorrect/invalid values, etc.

Joint Space Operations Center (JSpOC) is the facility at Vandenberg at which the Conjunction Assessment screenings are performed. USSTRATCOM is the organization which staffs the JSpOC.

Keyset Zero Set - encryption keyset cleared

Landsat Ground Network (LGN) - the specific complement of ground stations, i.e. LDCM EROS Center, Fairbanks Polar, and a 3rd Contingency Station.

Limit violation - an event when a telemetry parameter exceeds its expected range of values.

Log - A time-tagged list of actions or events

Master Active Schedule - A subset of the Master Schedule of Activities defined by the time span of the active stored command load on-board the observatory.

Master Working Schedule - A subset of the Master Schedule of Activities sent to the CAPE for scene scheduling. This file nominally spans the upcoming three Operational Days.

Master Schedule of Activities - The reference schedule for future and past schedule events for the mission. The Master schedule includes predicted orbital events, ground network schedule events, CAPE schedule, observatory real/time commands, observatory stored commands, and GSE directives.

Memory Load -generally a combination of flight software updates, table loads, and command loads that affect the on-board observatory re-programmable memory locations.

Multi Protocol Label Switching (MPLS) is a data-carrying mechanism that belongs to the family of packet-switched networks. MPLS operates at an OSI Model layer that is generally considered to lie between traditional definitions of Layer 2 (data link layer) and Layer 3 (network layer), and thus is often referred to as a "Layer 2.5" protocol. It was designed to provide a unified data-carrying service for both circuit-based clients and packet-switching clients which provide a datagram service model. It can be used to carry many different kinds of traffic, including IP packets, as well as native ATM, SONET, and Ethernet frames.

Mission Data - Image and ancillary telemetry with or without value-added processing.

Mission Telemetry - X-band image telemetry with CCSDS protocols, etc.

Mission Operations Element (MOE) data - all data that is received externally to the MOE, sent out from the MOE, or created for internal MOE use. Examples include: all forms of

Telemetry (e.g. Raw, Calibrated, etc), all forms of Commands and mnemonics, Pass Summaries, analytical results, event messages, plans/schedules, logs, etc.

Mission Planning & Scheduling data - all activity & event timeline data that is used to plan and schedule the mission. This class of data includes various flight dynamics products, network schedules, CAPE data and various schedule reports, etc.

Mnemonic - an alphanumeric shorthand representation of a telemetry point or a command assigned by convention and operators, and stored in a database to reference.

Network Services - refers collectively to the Ground Network Element (GNE), Near Earth Network (NEN) and the Space Network (SN).

Notification Messages - messages generated for distribution of information such as alarms, warnings, events, product availability, etc.

Observatory - The entire LDCM spacecraft including the bus, instrument(s) and any associated components.

Operational Data Product - consists of files and reports produced to directly support core mission operations on the ground. Operational Data Products include but are not limited to Interval Mapping tables, Acquisition Data, etc

Operator Configurable - item specified or maintained by the operator via configuration management procedures supporting FOT product generation and maintenance (i.e. PRD limit values, displays, etc)

Operator Selectable - operator selects from one or more options for the item which are defined in the application and/or system files (i.e. network ground station routine code, etc.)

Operator Specified - item dynamically entered (i.e. Start time) or temporary override of an operator-configurable item (i.e. temporary limit modification) without application of configuration management procedures (i.e. user report formats, etc)

Pass Summary - MOE data related to an observatory pass

Periodic operations - activities performed on a routine basis that require minimal engineering support

Premium Internet Protocol (PIP) Service -this service provides a premium level of data networking connectivity using the IP suite. PIP service is differentiated from Standard Internet Protocol (SIP) service in that it provides a higher performance level, higher priority for problem resolution, and is not directly connected to the general Internet. PIP service is most appropriate for internal Agency networking requirements where the Agency's operations should be isolated from the general Internet and is used as a project specific resource.

Planning - the discipline of predetermining and coordinating the mission activities for any period of time.

Procedure - A stored sequence of commands or directives written in a high-level language with built-in flow controls (such as if-then-else, do while, case, etc.) to automate observatory operations.

Product - a report in tabular, plot, textual, or graphical form

Project Defined - item specified by the project via ICD or other documentation with application of project-level configuration management procedures (i.e. planning schedule types, etc)

Pseudo Telemetry - telemetry values derived by calculation often involving multiple telemetry points.

Raw Telemetry - telemetry that has not been converted into Engineering Units

Real Time Command (RT Command) - an observatory command built and uplinked to the spacecraft upon operator, script or schedule request.

Relative Time Sequence (RTS) - a Command Sequence or schedule defined using command start times relative to the previous command start in the sequence.

Reports - operator-filtered MOE data output to a file, screen, plotter or printer

Routine operations - operations performed each contact or daily requiring no engineering support

Scheduling - the process of assigning and coordination of resources associated with planned activities, and the assignment of each planned activity to a specific time.

Scripts - a capability involving editable and stored sets of directives (see Directive) whereby mission operations ground systems administration can be accomplished automatically.

Standard Internet Protocol (SIP) Service - this service provides for basic data networking connectivity using the IP suite. SIP service is the commodity Internet service that provides the Agency's link to the Internet in general. It provides basic universal Internet connectivity with lower performance guarantees or restrictions on acceptable use.

Special operations - operations requiring engineering and/or Flight Operations Team support.

Stale telemetry - the staleness test is only applied to real/time housekeeping data parameters received during the contact. If the difference between the ground receipt time of a parameter and the current GSE time exceeds an operator specified threshold, the data available for display is marked as stale. In a CCSDS packet structure, each packet would be assigned a staleness threshold, generally equal to twice the packet period and processing overhead.

State transition - an event when the observatory, one of its subsystems or telemetry parameters enters or exits an operator-defined, detectable condition

Stored Command - a command awaiting execution onboard the observatory.

Stored Command Load - an assembled set of commands related by relative or absolute execution time used to perform a specific function. The command set has been converted to binary streams to be up-linked to form the stored command load.

Table Load -- An uplink of observatory parameters that typically reside in specific on-board memory locations

Telemetry - Includes housekeeping telemetry and pseudo telemetry.

Telemetry Counts - discrete values for raw specific telemetry points

Telemetry parameters - values used in the determination of observatory health and safety.

Trending - the discipline of tracking telemetry values for any number of recent or historical telemetry downlinks.

USSTRATCOM is the organization which staffs the JSpOC.

19 Appendix B: Interface N2 Diagram & Tables

This appendix provides additional insight into the MOE interfaces with a N2 diagram (Figure B-1) and list (Table B-1) of the MOE interfaces. See REFERENCE DOCUMENT, Ground System Interface Requirements Document (IRD)" for additional details.

Table B-1 provides a tabular summary of the MOE related traffic across the nodes as defined in Figure B-1. Several columns found in Table B-1 are described below.

Data Type Field Options

Options are listed below and defined in Appendix A of this document:

- Mission Data
- Housekeeping Data
- GSE Data
- RT Commands
- Mission Planning & Scheduling data
- Operational Data Product
- FOT Products
- Notification Messages
- Database

Frequency, Duration & Schedule Fields

These fields describe the nominal frequency, duration and delivery schedule for the listed general data categories.

Controlled Repository (CR)

Options include the following:

- = not identified for delivery to the CR

A = delivered for product distribution and archive

B = delivered for product distribution and archive; supports MOC cold-start and operation

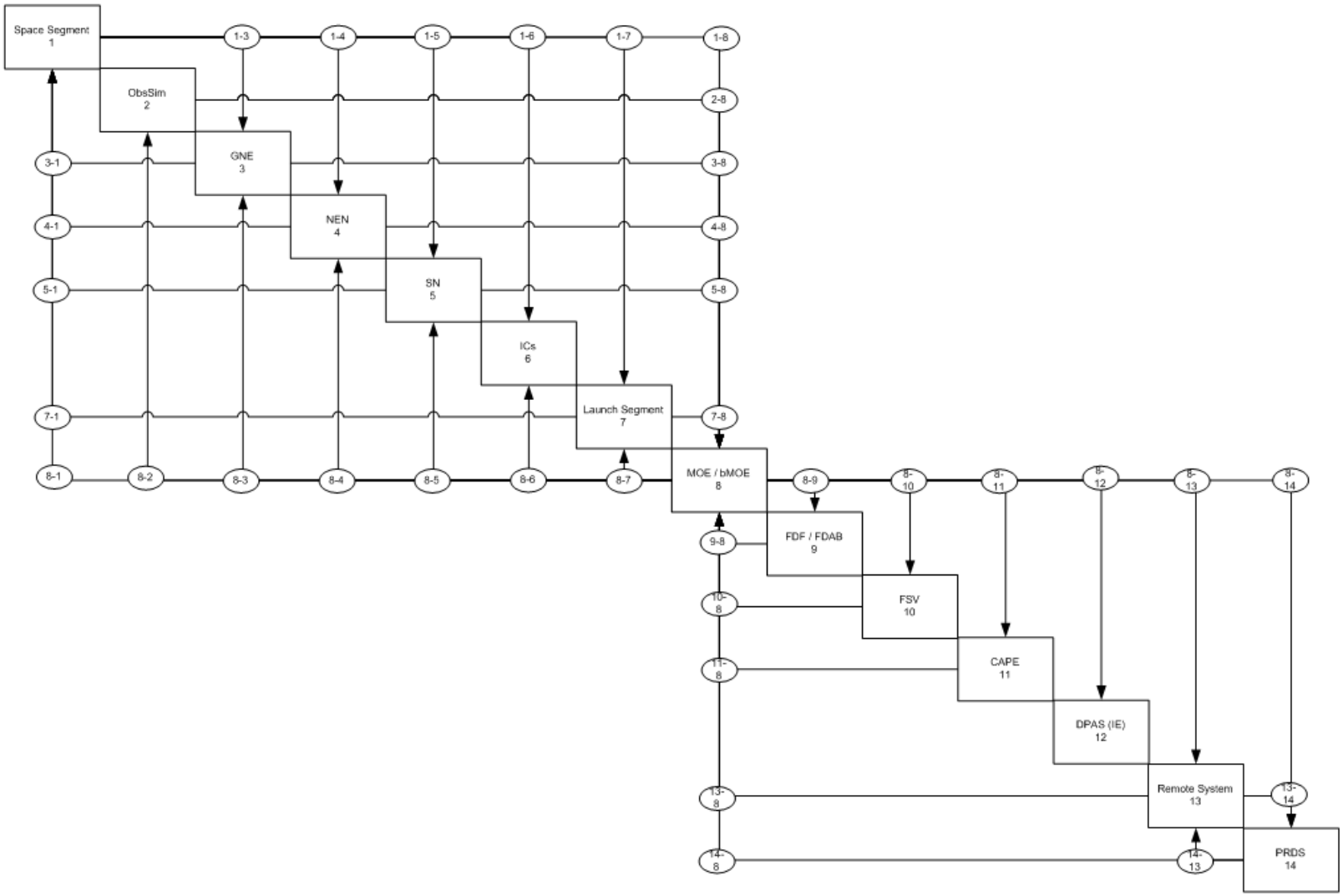

Figure 19 - 1 Figure B-1: Mission Operations Element N2 Diagram

Data Description	From/To	N2	Data Type	Frequency	Duration	Schedule	Transport	CR	Rationale
Observatory Real-time X-band Telemetry	Observatory / GNE	1-3	Mission Data	Each contact	Full contact	As per Master Active			
Observatory Stored X-band Telemetry	Observatory / GNE	1-3	Mission Data	Each contact	Full contact	As per Master Active			
Observatory Real-time S-band Telemetry	Observatory / GNE	1-3	Housekeeping Data	Each contact	Full contact	As per Master Active			
Observatory Stored S-band Telemetry	Observatory / GNE	1-3	Housekeeping Data	Each contact	Full contact	As per Master Active			
Observatory Real-time S-band Telemetry	Observatory / NEN	1-4	Housekeeping Data	Launch & Contingrncy	Full contact	As per Master Active			
Observatory Stored S-band Telemetry	Observatory / NEN	1-4	Housekeeping Data	Launch & Contingrncy	Full contact	As per Master Active			
Observatory Real-time S-band Telemetry	Observatory / SN	1-5	Housekeeping Data	Launch & Contingrncy	As per Master Active	As per Master Active			
Observatory Real-time X-band Telemetry	Observatory / ICs	1-6	Mission Data	As per CAPE Schedule	As per CAPE Schedule	As per Master Active			
Observatory RF S-band Telemetry	Observatory / LS	1-7	Housekeeping Data (TBR)	As required	As required	As per project schedule			
Observatory HardLine S-band Telemetry	Observatory / LS	1-7	Housekeeping Data	As required	As required	As per project schedule			
Observatory HardLine S-band Telemetry	Observatory / MOE	1-8	Housekeeping Data	As required	As required	As per project schedule	via mini-MOE	A	
PRD GSE Database	Observatory GSE / PRDS	1-14	GSE Data	As required	As required	As per project schedule		B	
Observatory Real-time S-band Telemetry	ObsSim / MOE	2-8	Housekeeping Data	As required	As required	Real-time		A	
Observatory Stored S-band Telemetry	ObsSim / MOE	2-8	Housekeeping Data	As required	As required	Real-time		A	
ObsSim GSE Data	ObsSim / MOE	2-8	GSE data	As required	As required	Real-time		A	Simulator configuration & control
ObsSim Network GSE Data	ObsSim / MOE	2-8	GSE data	As required	As required	Real-time		A	Mission data derivatives to MOE
PRD GSE Database	ObsSim / PRDS	2-14	GSE data	As required	As required	As required		B	
Observatory Commands	GNE / Observatory	3-1	RT Commands	As required	As required	Real-time			
Observatory Real-time S-band Telemetry	GNE / MOE	3-8	Housekeeping Data	Each contact	Full contact	Real-time		A	

Table 19 - 1 Table B-1: Mission Operations Element Node Summary (1 of 5)

Data Description	From/To	N2	Data Type	Frequency	Duration	Schedule	Transport	CR	Rationale
Observatory Stored S-band Telemetry	GNE / MOE	3-8	Housekeeping Data	Each contact	Full contact	Near-Real-Time		A	
GNE RT CFDP Sataus Messages	GNE / MOE	3-8	GSE Data	Each contact	Full contact	Real-time			
GNE Mission Data Directory	GNE / MOE	3-8	GSE Data	Each contact	Full contact	Post-pass and on-demand		B	
Network Schedule Notifications	GNE / MOE	3-8	Mission Planning & Scheduling data	Once per week	Three weeks	Noon Wednesday		B	Request confirmations, planned outages, etc
GNE GSE Data	GNE / MOE	3-8	GSE data	Each contact	Pre thru Post-pass	As per Master Active		A	
PRD GSE Database	GNE / PRDS	3-14	GSE data	As required	As required	As required		B	
Observatory Commands	NEN / Observatory	4-1	RT Commands	As required	As required	Real-time			
Observatory Real-time S-band Telemetry	NEN / MOE	4-8	Housekeeping Data	Each contact	Full contact	Real-time		A	
Observatory Stored S-band Telemetry	NEN / MOE	4-8	Housekeeping Data	Each contact	Full contact	Real-time		A	
Network Schedule Notifications	NEN / MOE	4-8	Mission Planning & Scheduling data	Once per week	Three weeks	Noon Wednesday	via email	B	Manual input to MOE from email
GN Pass Reports	NEN / MOE	4-8	GSE data	Each contact	Full contact	Post-contact			
Observatory Commands	SN / Observatory	5-1	RT Commands	As required	As required	Real-time			
Observatory Real-time S-band Telemetry	SN / MOE	5-8	Housekeeping Data	Each contact	Full contact	Real-time		A	
Network Schedule Notifications	SN / MOE	5-8	Mission Planning & Scheduling data	Once per week	Three weeks	Noon Wednesday	via SNAS	B	Manual input to MOE from SNAS display
Observatory Commands	LS / Observatory	7-1	RT Commands	As required	As required	Pad	via mini-MOE	A	
Observatory Commands	I&T / Observatory	7-1	RT Commands	As required	As required	Real-time	via mini-MOE	A	
Observatory Real-time S-band Telemetry	I&T & LS / MOE	7-8	Housekeeping Data	Each contact	Full contact	Real-time		A	
Observatory Stored S-band Telemetry	ITF & LS / MOE	7-8	Housekeeping Data	Each contact	Full contact	Near-Real-Time		A	
PRD GSE Database	ITF & LS / PRDS	7-14	GSE data	As required	As required	As required	via mini-MOE	B	

Table 19 - 2 Table B-1: Mission Operations Element Node Summary (2 of 5)

Data Description	From/To	N2	Data Type	Frequency	Duration	Schedule	Transport	CR	Rationale
Observatory HL Commands	MOE / Observatory	8-1	RT Commands	As required	As required	I&T	via mini-MOE	A	
Observatory Commands	MOE / ObsSim	8-2	RT Commands	As required	As required	Real-time		A	
ObsSim GSE Directives	MOE / ObsSim	8-2	GSE data	As required	As required	Real-time		A	Simulator configuration & control
ObsSim Network GSE Directives	MOE / ObsSim	8-2	GSE data	As required	As required	Real-time		A	Mission data derivatives to MOE
Network Schedule Requests	MOE / GNE	8-3	Mission Planning & Scheduling data	As required	As required	Real-time			
Observatory Commands	MOE / GNE	8-3	RT Commands	As required	As required	Real-time		A	
GNE Network Schedule	MOE / GNE	8-3	Operational Data Product	Once per day	72 hours	Upon uplink to observatory		B	
GNE Acquisition Data	MOE / GNE	8-3	Operational Data Product	Once per day	72 hours	Upon uplink to observatory		B	TBR the operational details
LGN GSE Directives	MOE / GNE	8-3	GSE Data	As required	As required	As required		A	
GNE Notification Messages	MOE / GNE	8-3	GSE Data	As required	As required	As required	via email	A	
Network Schedule Requests	MOE / NEN	8-4	Mission Planning & Scheduling data	As required	As required	Real-time	via email	A	MOE produces network compatible report
Observatory Commands	MOE / NEN	8-4	RT Commands	As required	As required	Real-time		A	
Acquisition Data	MOE / NEN	8-4	Operational Data Product	M-F	7 days	Start of work day		B	
Network Schedule Requests	MOE / SN	8-5	Mission Planning & Scheduling data	As required	As required	Real-time	via SNAS	A	MOE produces report for manual input
Observatory Commands	MOE / SN	8-5	RT Commands	As required	As required	Real-time		A	
Acquisition Data	MOE / SN	8-5	Operational Data Product	M-F	7 days	Start of work day		B	
IC Notification Messages	MOE / IC	8-6	Notification Messages	As required	As required	As required	via email	A	
Observatory Commands	MOE / ITF & LS	8-7	RT Commands	As required	As required	Real-time		A	
Definitive Ephemeris	MOE / FDF	8-9	Operational Data Product	Daily	As required	By 1 PM local	In CA format	B	Supports Conjunction Analysis

Table 19 - 3 Table B-1: Mission Operations Element Node Summary (3 of 5)

Data Description	From/To	N2	Data Type	Frequency	Duration	Schedule	Transport	CR	Rationale
Predicted Ephemeris	MOE / FDF	8-9	Operational Data Product	Daily	7 days	As required		B	Supports contingency operations
Maneuver Planning Data	MOE / FDF	8-9	Operational Data Product	As required	As required	Delta V - TBS hrs		B	Supports Conjunction Analysis
Stored Memory Loads	MOE / FSV	8-10	Operational Data Product	Each modification	As required	Post-modification		B	Memory loads, dumps and reference images
Memory Dump Images	MOE / FSV	8-10	Operational Data Product	Each modification	As required	Post-modification		A	Memory loads, dumps and reference images
Ground Reference Image	MOE / FSV	8-10	Operational Data Product	Each modification	As required	Post-modification		B	Memory loads, dumps and reference images
Forcast Schedule	MOE / CAPE	8-11	Mission Planning & Scheduling data	Once per week	Twenty-one (21) days	Monday morning		B	Events, RT & Stored Cmds, Directives
Master Working Schedule	MOE / CAPE	8-11	Mission Planning & Scheduling data	Once per day	72 hours	Start of work day		B	Events, RT & Stored Cmds, Directives
Master Active Schedule	MOE / CAPE	8-11	Mission Planning & Scheduling data	Once per day	72 hours	Upon uplink to observatory		B	Events, RT & Stored Cmds, Directives
Resource Availability Report	MOE / CAPE	8-11	Mission Planning & Scheduling data	Daily	Twenty-one (21) days	Start of work day		B	TBR duration
WRS-2 Time Translation Table	MOE / CAPE	8-11	Mission Planning & Scheduling data	Daily	72 hours	Start of work day		B	
Scene to Interval Mapping Table	MOE / CAPE	8-11	Mission Planning & Scheduling data	Each committed schedule	duration of schedule	Upon schedule commit		B	Data Schedule Data
Scene to Interval File Mapping Table	MOE / CAPE	8-11	Mission Planning & Scheduling data	Each contact	duration of schedule	Post-contact		B	Data Recovery Data
Notification Messages	MOE / CAPE	8-11	Notification Messages	As required	As required	As required		A	
Engineering Data Products	MOE / DPAS	8-12	Data Processing & Cal/Val data	Each contact	Full contact & playback	Post-pass	Push to Central Repository	A	
Forcast Schedule	MOE / DPAS	8-12	Events, RT & Stored Cmds, Directives	Once per week	Twenty-one (21) days	By COB Wednesday	Push to Central Repository	A	Events, RT & Stored Cmds, Directives
Master Active Schedule	MOE / DPAS	8-12	Events, RT & Stored Cmds, Directives	Once per day	72 hours	Upon uplink to observatory	Push to Central Repository	A	Events, RT & Stored Cmds, Directives
PRD Delivery	MOE / DPAS	8-12	Database	Upon release	Upon update	Release date	Push to Central Repository		
Notification Messages	MOE / DPAS	8-12	Notification Messages	As required	As required	As required	via email	A	Possible interface to USGS via SOAP msg
MOC Boot Data	MOE / Remote System	8-13	Data & Database	As required	As required	Daily		B	

Table 19 - 4 Table B-1: Mission Operations Element Node Summary (4 of 5)

Data Description	From/To	N2	Data Type	Frequency	Duration	Schedule	Transport	CR	Rationale
IC Downlink Schedule	MOE / Remote System	8-13	Operational Data Product	Once per day	72 hours	Upon uplink to observatory		B	
IC Acquisition Data	MOE / Remote System	8-13	Operational Data Product	Once per day	72 hours	Upon uplink to observatory		B	TBR the operational details
FOT Products	MOE / Remote System	8-13	Mission Planning & Scheduling data	Daily	Thirty (30) days	Start of work day		B	
PRD GSE Database	MOE / PRDS	8-14	Database	As required	As required	As required	via mini-MOE	B	
Definitive Ephemeris	FDF / MOE	9-8	Operational Data Product	As required	As required	As required		B	
Predicted Ephemeris	FDF / MOE	9-8	Operational Data Product	As required	As required	As required		B	
FSW Procs / Images	FSV / MOE	10-8	Operational Data Product	As required	As required	As required		B	
FSW Reference Images	FSV / PRDS	10-8	Operational Data Product	As required	As required	As required		B	
CAPE Data Collection Schedule	CAPE / MOE	11-8	Mission Planning & Scheduling data	Once per day	72 hours	End of work day		B	
Notification Messages	CAPE / MOE	11-8	Notification System	As required	As required	As required	via email	A	Possible interface to USGS via SOAP msg
MOC Transfer Data	Remote System / MOC	13-8	Database	As required	As required	I&T		B	All the data needed to cold-start the MOC
PRD Delivery	Remote System / PRDS	13-14	Database	As required	As required	As required		B	
PRD Delivery	PRDS / Obs GSE	14-1	Database	As required	As required	I&T		A	
PRD Delivery	PRDS / MOE	14-8	FOT Products	As required	As required	As required		A	
PRD Delivery	PRDS / FSV	14-10	Database	As required	As required	As required		A	
PRD Delivery	PRDS / Remote System	14-13	Database	As required	As required	As required		B	

Table 19 - 5 Table B-1: Mission Operations Element Node Summary (5 of 5)