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U.S. Geological Survey

Ground System Requirements Document (GSRD)

Landsat Data Continuity Mission (LDCM)

Version 2.1

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1 Introduction

1.1 Scope

This document establishes the Ground System Requirements for the Landsat Data Continuity Mission (LDCM). It is a Level 3 requirements document that includes the functional, performance, and design requirements for all LDCM Ground System Elements and an allocation matrix of Ground System level requirements to responsible organizations.

1.2 Document Organization

Section 1 provides an introduction and mission overview for the LDCM. Section 2 provides the applicable documents. Section 3 provides the Ground System Requirements.

Appendix A presents allocations system performance requirements to the Ground System elements. Appendix B contains a requirements traceabilty matrix to the mission-level requirements (SMRD). Appendix C contains the verification cross reference matrix. Appendix D contains the TBx list and close-out plan for each requirement

1.3 Change Control

The approved Ground System Requirements Document (GSRD) will be placed under LDCM Project configuration control. Any proposed changes to the GSRD will require Configuration Control Board approval as per the Project Plan. Requests for changes to the GSRD should be submitted directly to the LDCM Configuration Control Manager, who will coordinate the appropriate review process. Revisions to the GSRD shall be made through a formal change process. The Configuration Control Manager will route change requests to the USGS Chief Engineer, who will obtain the necessary agreement from project management, scientists, and engineers before release as the official version. Changes are approved and signed by those on the signature sheet. USGS EROS is responsible for revisions and will maintain documentation for all change requests.

1.4 Terminology

A **Requirement** is 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.

A **Shall** statement designates a mandatory requirement that must be verified through an accepted process. Any deviations from these requirements require a Configuration Control Board approval.

1.4.1 Standard Products

The standard products are intended to include both Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) data. Under certain operating scenarios, however, it is conceivable that only one of the instruments may be collecting data. Therefore, the standard products could consist of spectral bands from OLI only, TIRS only, or OLI and TIRS.

Level 1 Data Products - Level 1 data products consist of radiometrically calibrated data resampled for registration to a cartographic projection, referenced to the World Geodetic System 1984 (WGS84), G873 or current version. The Level 1 data have had radiometric, geometric, and terrain corrections applied.

Level-0Rp Data Products - Level 0 data products are image data with all data transmission and formatting artifacts removed, time provided, spatial, and band-sequentially ordered multi-spectral digital image data. Level-0Rp are subsetted to WRS-2 framing conventions.

Quality Assessment (QA) band - Quality Assessment band is created using OLI data, or OLI and TIRS data, for all sun-lit Earth acquisitions. The QA band will be constructed by setting the bits according to specified image quality criteria. A 16-bit QA band will accompany the 16-bit Level-1 science products, and an 8-bit version would accompany the full spatial resolution browse.

Full Resolution Browse (FRB) - These are full spatial resolution browse derived from Level-1 products and which have been rescaled from 16- to 8-bits per band. The OLI FRB will be comprised of 3 spectral bands (TBR); the TIRS FRB will be a single band (which band is TBR).

1.4.2 Level of Processing

Level-0 Reformatted Product (L0Rp) Data Products - Level 0 data products are image data with most data transmission and formatting artifacts removed, time provided, spatial, and band-sequentially ordered multi-spectral digital image data. Level-0Rp are subsetted to WRS-2 framing conventions.

Level 1G Data Products - Level 1G data products consist of Level 1R data products resampled for registration to a cartographic projection, referenced to the World Geodetic System 1984 (WGS84), G873 or current version. The geometric corrections incorporate the use of observatory ephemeris data.

Level-0 Reformatted Archive (L0Ra) Data Products - Level-0Ra data products are image data with most data transmission and formatting artifacts removed, time provided, spatial, and band-sequentially ordered multi-spectral digital image data. Level-0Ra data are interval-based.

Level 1R Data Products - Level 1R data products consist of radiometrically corrected image data derived from Level 0 data linearly scaled to at-aperture spectral radiance.

Level 1Gt Data Products - Level 1Gt data products consist of Level 1R data products resampled for registration to a cartographic projection, referenced to the World Geodetic System 1984 (WGS84), G873 or current version. The geometric corrections incorporate the use of observatory ephemeris data; digital elevation model (DEM) data are used to correct for terrain relief.

Level 1T Data Products - Level 1T data products consist of Level 1R data products resampled for registration to a cartographic projection, referenced to the WGS84, G873 or current version, orthorectified, and corrected for terrain relief. The geometric corrections use observatory ephemeris data and ground control points; DEM data are used to correct for terrain relief.

1.5 Mission Overview

1.5.1 Mission Statement

The LDCM will acquire multispectral digital image data affording global coverage of the Earth's landmass on a seasonal basis, which are sufficiently consistent with Landsat 7 in terms of acquisition geometry, coverage characteristics, spectral characteristics, output product quality, data product availability and data integrity to allow detection and quantitative characterization of changes in/on the land surface.

1.5.2 Mission Background

The Landsat Data Continuity Mission (LDCM) is a component of the Landsat Program being conducted jointly by the National Aeronautics and Space Administration (NASA) and the United States Geological Survey (USGS) of the Department of the Interior (DOI). The LDCM goals are in keeping with the Landsat programmatic goals stated in the Land Remote Sensing Policy Act of 1992 (Public Law 102-555) and the Commercial Space Act of 1998 (Public Law 105-303). This policy requires that the Landsat Program provide data into the future that is sufficiently consistent with previous Landsat data to allow the detection and quantitative characterization of changes in or on the land surface of the globe. The LDCM was conceived as a follow-on mission to the highly successful Landsat series of missions, which have been providing satellite coverage of the Earth's continental surfaces since 1972. The data from these missions constitute the longest continuous record of the Earth's surface as seen from space.

The LDCM will transition the archive to the USGS National Satellite Land Remote Sensing Data Archive (NSLRSDA) at the end of the operational mission. The LDCM Observatory will carry the image sensor.

1.5.3 Mission Objectives

The goal of the LDCM, consistent with U.S. law and government policy, is to continue the acquisition, archival, and distribution of multispectral imagery affording global, synoptic, and repetitive coverage of the Earth's land surfaces at a scale where natural and human-induced changes can be detected, differentiated, characterized, and monitored over time.

The following are the major mission objectives:

- Acquire and archive moderate-resolution (circa 30 m ground sample distance) multispectral image data affording seasonal coverage of the global land mass for a period of no less than 5 years with no credible single point failures.
- Acquire and archive medium-low resolution (circa 120 m ground sample distance) thermal image data affording seasonal coverage of the global land mass for a continuous period of not less than 5 years with no credible single point of failures.
- Ensure that LDCM data are sufficiently consistent with data from the earlier Landsat missions, in terms of acquisition geometry, spatial resolution, calibration, coverage characteristics to permit studies of land cover and land use change over multi-decadal periods.
- Distribute LDCM data products to all users on a nondiscriminatory basis and at a price no greater than the incremental cost of fulfilling a user request.

A segment diagram of the LDCM is shown in Figure 1-1.

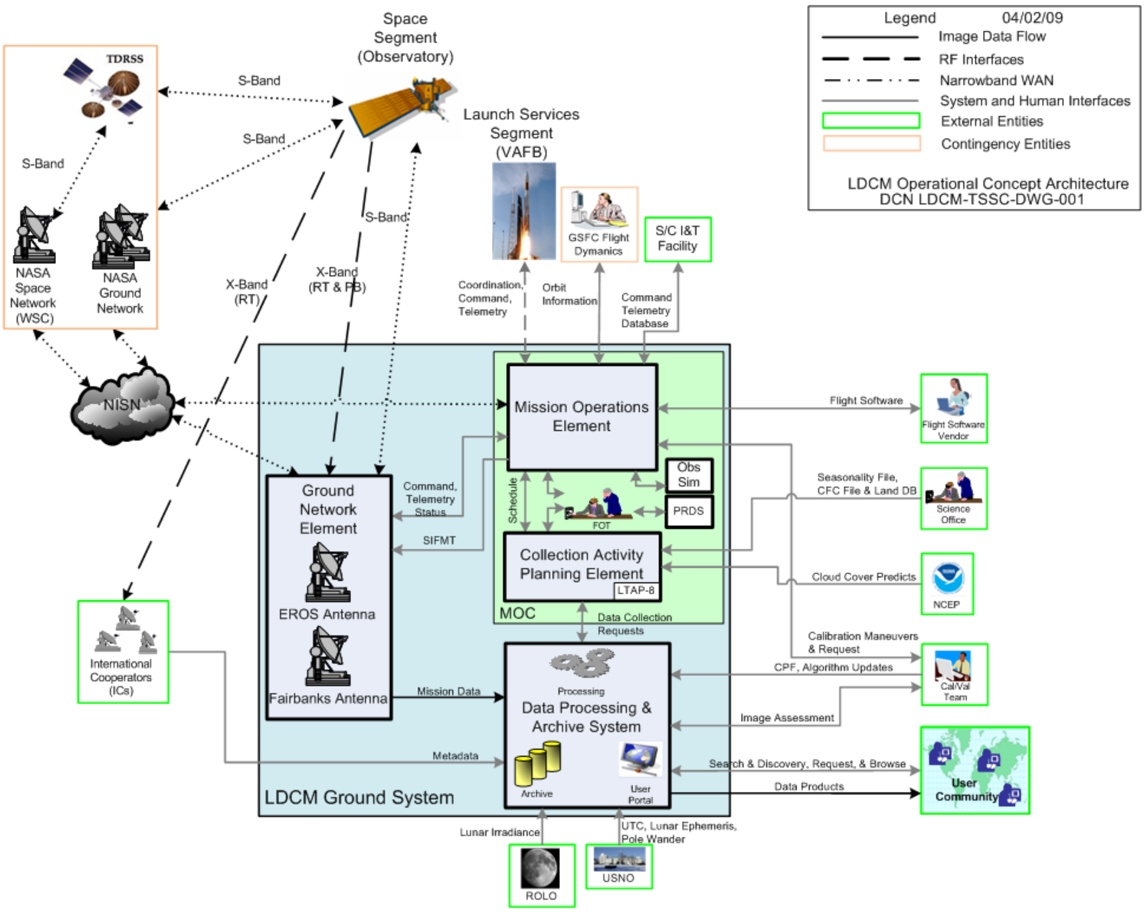

Figure 1-1 LDCM Segment Diagram

1.5.4 Mission Implementation

The LDCM is a partnership between NASA and the USGS. Each agency has been assigned specific responsibilities and will deliver the following major elements to the overall mission. NASA will provide the Space and Launch Segments of the LDCM, while, the USGS will provide the Ground System. NASA/GSFC will provide the overall LDCM project management, mission system engineering and mission assurance for development of the LDCM.

The LDCM Mission consists of three major segments, namely: the Space Segment (SS), the Launch Services Segment (LSS), and the Ground System (GS). The LDCM Requirements Hierarchy in Figure 1-2 depicts the flow down of mission requirements to the major elements of the LDCM. Since LDCM is a cooperative effort between NASA and the USGS; each agency in addition to specific responsibilities, will deliver the following major segments to the overall mission. The segment requirement documents contain detailed requirements for each segment.

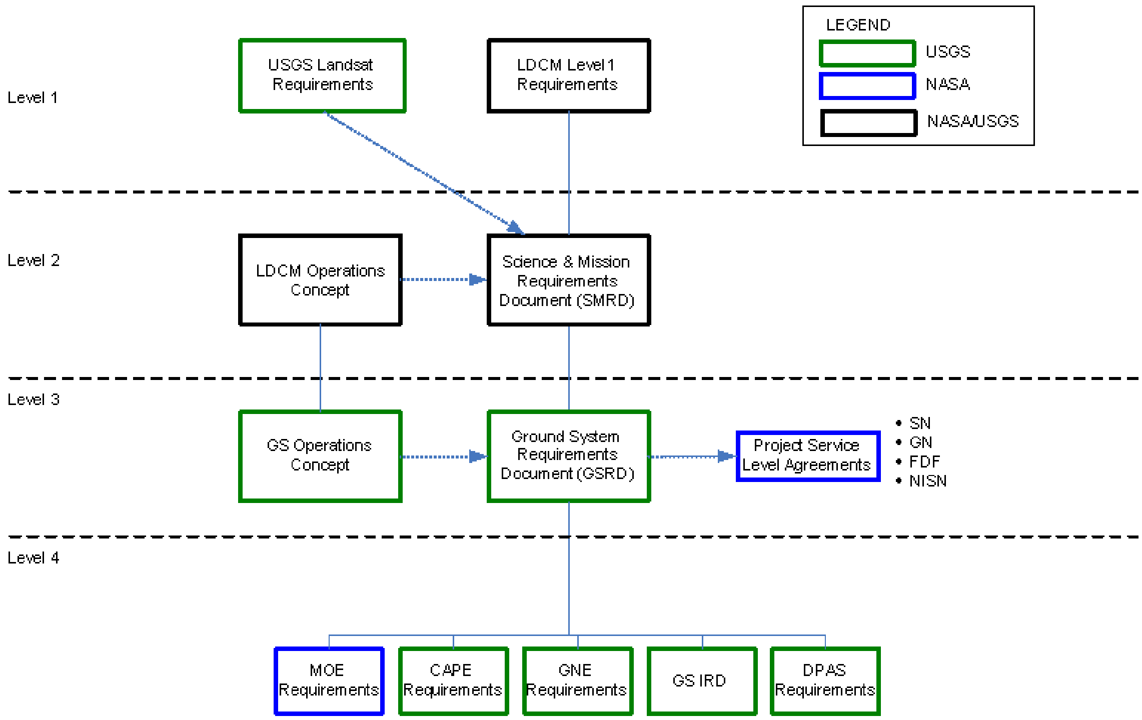

Figure 1-2 LDCM Requirements Hierarchy

1.5.4.1 Space Segment

The Space Segment (SS) consists of the observatory and pre-launch Ground Support Equipment (GSE). The observatory is comprised of the imaging sensor(s) and the spacecraft platform. The observatory will operate in a 705 Km orbit with a 16-day repeat cycle and a 10:00 a.m. (+/- 15 minutes) mean local time for the descending node. Imaging sensor and ancillary data (combined as mission data) will be collected, stored onboard and subsequently down linked to ground stations within the LDCM Ground Network Element (GNE) via an X-band communications link. This link will include stored housekeeping telemetry. Additionally, a real-time X-band downlink capability will transmit mission (imaging sensor and ancillary) data to the GNE and International Cooperators (ICs) equipped to receive this data. The observatory will also receive and execute commands and transmit real-time housekeeping telemetry via the GNE S-band link. The GSE provides the functionality to perform observatory ground based integration and testing prior to launch.

1.5.4.2 Ground System

The LDCM Ground System encompasses the LDCM observatory management, command transmission to the observatory, LDCM Ground System reception of observatory telemetry and image data; and data processing, archive, and distribution data for the Landsat data user community. The Ground System consists of the Ground Network Element (GNE), the Collection Activity Planning Element (CAPE), the Mission Operations Element (MOE) and the Data Processing and Archive System (DPAS). The Ground System is supported by the Flight Operations Team (FOT) within the MOC and the Cal/Val Team within the Ground System.

1.5.4.3 Launch Services Segment

The Launch Services Segment (LSS) provides the assets and services associated with the launch vehicle (LV) and payload integration. Included with the launch vehicle are all launch vehicle ground support equipment (including hardware and software), property, facilities to integrate the spacecraft to the LV, integration verification, and pre-launch testing with ground-based functions.

1.6 Requirements Priority

The LDCM Ground System will be designed to meet all requirements in this GSRD. However, in order to facilitate the prioritization of the requirements implementation and testing, the criticality of the associated functions will be defined.

- Priority 1 -- basic capability to support launch and early orbit and assess performance of the spacecraft, instruments, and the MOE
- Priority 2 -- these capabilities are needed for the mission to be considered “operational”, i.e. every functional aspect of the mission is working from external user request through data delivery
- Priority 3 -- capabilities pertaining to automation, enhancements, or other functionality required for implementation prior to USGS LDCM project close-out and transition to O&M

Both Priority 1 and 2 functional requirements will be implemented for GRTs, and performance requirements by MRTs, i.e. for scheduling purposes both will be implemented and tested by LRD. Element release schedules will align with requirements categorization. Releases for GRTs will have Priority 1 and Priority 2 capabilities and element releases following GRTs will have Priority 3 capabilities.

This delineation helps to ensure that while the entire ground system is being designed, implemented and tested before launch, there is a mechanism to focus priorities if necessary (e.g., prioritizing discrepancies).

1.6.1 Priority 1

Priority 1 requirements encompass requirements for ground system functions required for launch support. These are the functions necessary for conducting on-orbit checkout and safely operating the observatory. If these functions are not available, then launch would be postponed until such time that they are available. These functions include the basic capability to assess performance of the instrument and allow the sign off of critical spacecraft, instrument(s), and MOE pre-launch performance requirements which will then allow payment due to the Government's acceptance of these items.

The following encompass the Priority 1 functions:

- Provide LGN X and S-band communications with the observatory
- Provide SN, and NEN S-band communications with the observatory
- Acquire and store observatory science and housekeeping data
- Process and display observatory housekeeping data
- Generate and uplink real-time and stored observatory commands
- Perform observatory engineering analysis
- Perform Level 0 processing on observatory science and housekeeping data to assess instrument performance
- Generate Level 1 data products to assess instrument performance

1.6.2 Priority 2

Priority 2 requirements are characterized as needed for the mission to be considered “operational”, i.e. every functional aspect of the mission is working from external user request through data delivery. However, it doesn't make sense financially or technically to delay launch for these capabilities. These capabilities allow sign-off of non-MOE ground system vendor requirements. The full automation desired in the long run may not be operational at this point, but an interim solution may satisfy the functional requirement.

The following encompasses the Priority 2 functions, in addition to the Priority 1 functions:

- Perform Level 0 and Level 1 processing at full capacity
- Generate Level 1T data products
- Permanently archive mission data
- Provide public access to LDCM data
- Generate LTAP-8 driven collection schedule
- Provide a backup MOC

1.6.3 Priority 3

Finally, there is Priority 3 which will have capabilities pertaining to automation, enhancements, or other functionality required for implementation prior to USGS LDCM project close-out and transition to O&M.
Like the Priority 2 functions, launch would not be delayed due to these capabilities not being implemented.

All capabilities not included in Priority 1 or Priority 2 are denoted as Priority 3.

2 Applicable Documents

2.1 LDCM Project Documents

The GSRD is consistent with, and responsive to, the following documents of the exact issue and revision shown. Unless otherwise stated in this document, all inconsistencies in this GSRD will be resolved in the following order:

1. LDCM Level 1 Requirements
2. LDCM Science and Mission Requirements Document (SMRD, Level 2)
3. USGS Landsat Requirements (as amended 01/11/2007)
4. Ground System Mission Assurance Requirements Document (MAR)
5. Ground System Requirements Document (GSRD)

Document Number	Revision/ Release Date	Document Title
	Draft/September 2007	Level 1 Requirements for the Landsat Data Continuity Mission
GSFC 427-02-01	Draft/July 2007	Science and Mission Requirements Document
LS-PD-XX	Version 1/August 2007	USGS Landsat Requirements LDCM Addendum
GSFC 427-02-02	Draft/December 2006	Landsat Data Continuity Mission Operations Concept Document
GSFC 427-03-07	Draft/August 2007	Ground System Mission Assurance Requirements
LDCM-OCD-002	Rev 1/September 2007	Ground System Operations Concept
GSFC 427-02-06	Rev A/August 2007	LDCM Lexicon
GSFC 427-02-07	Rev -, code 427/January 2006	Landsat Worldwide Reference System-2 Definition

2.2 Government Documents

The LDCM shall comply with the following U.S. Government documents:

Document Number	Revision/ Release Date	Document Title
NPR 8715.6	August 17, 2007	NASA Procedural Requirements for Limiting Orbital Debris
NPR 2810.1A	Rev. A, May 2006	NASA Policy Guideline,

		Security of Information Technology
NASA GPD 7120.1	May 23, 2003	Goddard Space Flight Center (GSFC) Space Asset Protection Policy
450-SNUG	June 2002	Space Network Users' Guide (SNUG) Revision 8
453-GNUG	May 2007	Ground Network Users' Guide (GNUG) Revision 2
NISN-001-001	May 2007	NASA Integrated Services Network (NISN) Services Document
U.S. Code Title 15, Chapter 82	January 7, 2003	Land Remote Sensing Policy
PDD NSTC-3	October 6, 2000	Landsat Remote Sensing Strategy
Public Law 102-555	October 28, 1992	Land Remote Sensing Policy Act of 1992
CCSDS 131.0-B-1	September 2003	Recommendation for Space Data Systems Standards. TM Synchronization and Channel Coding. Blue Book Issue 1
CCSDS 132.0-B-1	September 2003	Recommendation for Space Data Systems Standards. TM Space Data Link Protocol. Blue Book. Issue 1.
CCSDS 133.0-B-1	September 2003	Recommendation for Space Data Systems Standards. Space Packet Protocol. Blue Book. Issue 1.
CCSDS 231.0-B-1	September 2003	Recommendation for Space Data Systems Standards. TC Synchronization and Channel Coding. Blue Book. Issue 1
CCSDS 232.0-B-1	September 2003	Recommendation for Space Data Systems Standards. TC Synchronization and Channel Coding. 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 401.0-B	July 2006	Recommendation for Space Data Systems Standards. Radio Frequency and Modulation Systems. Blue Book Issue 17
CCSDS 727.0-B-4	January 2007	Recommendation for Space Data Systems Standards. CCSDS File Delivery Protocol (CFDP). Blue Book Issue 4
Public Law 105-303	October 28, 1998	Commercial Space Act of 1998
Code of Federal Regulations, (22 CFR 120-130)	April 1, 2007	International Traffic in Arms Regulations (ITAR)
Presidential Decision Directive (PDD) NSTC-3	October 6, 2000	Landsat Remote Sensing Strategy

432-1-H	October 1990	Handbook for Managing USGS Records
Public Law 93-112	September 26, 1973	United States Workforce Rehabilitation Act of 1973
5 U.S.C. § 552a Public Law 93-579	December 31, 1974	Privacy Act of 1974
440-2-H	August 2005	USGS Physical Security Handbook (USGS PUB)
440-3-H	February 1991	USGS Security Controls Policy (USGS PUB)
		DOI Cyber Security Handbook (USGS PUB)
NIST SP 800-53	February 2005	Recommended Security Controls for Federal Information Systems
GSFC-STD-9100	May 1, 2006	Low Density Parity Check Code for Rate 7/8
FGDC-STD-009-1999	August 1999	Content Standard for Remote Sensing Swath Data

3 Requirements

3.1 System

3.1.1 Institutional Requirements

GS22: The GS shall comply with the International Traffic in Arms Regulations (ITAR) as defined in the Code of Federal Regulations, Parts 120 through 130 (22 CFR 120-130) Subchapter M, Title 22.
Rationale: NASA and USGS institutional requirement.

GS23: The GS shall use the Système International (SI) units for interfaces; the usage of any other unit(s) other than the SI shall be clearly communicated and documented.
Rationale: The use of consistent units by all project stakeholders is necessary for mission success.

GS150: The GS shall comply with U.S. Code Title 15, Chapter 82 Land Remote Sensing Policy and Presidential Decision Directive (PDD) NSTC-3, Landsat Remote Sensing Strategy, as amended October 6, 2000.
Rationale: USGS institutional requirement.

GS160: The GS shall use the Universal Time Coordinated (UTC) or a UTC-relatable time reference frame for all ground operation commands and data products.
Rationale: Consistent with historical mission ops practice.

GS193: The GS shall comply with all applicable National Archives and Records Administration requirements for archiving data and information per Handbook for Managing USGS Records, 432-1-H.
Rationale: USGS institutional requirement.

GS215: The GS shall comply with National Spatial Data Infrastructure and Federal Geographic Data Committee standards for production of metadata per Content Standard for Remote Sensing Swath Data, FGDC-STD-009-1999.
Rationale: USGS institutional requirement.

3.1.2 Mission Life

GS162: The GS shall support at least 10 years of mission life.
Rationale: 10 years envelopes the 5-year nominal mission lifetime and additional 5 years as risk mitigation against delays in future Landsat systems, and allows the possibility of cross-calibration with future systems.

3.1.3 Latency

GS181: The GS shall assess scene quality and cloud cover assessment for all scenes within 12 days of observation.
Rationale: Consistent with SMRD requirement. Allocation to GS elements is detailed in Appendix A.

3.1.4 General

GS3026: The GS shall have the capability to collect at least 400 individual WRS-2 scenes per 24 hour period; averaged over any WRS-2 observation period.
Rationale: Direct allocation from SMRD. 400 scenes per day is consistent with previous Landsat missions when IC data is included.

GS3027: The GS shall have the capability to collect, archive, process, and distribute priority scenes.
Rationale: Direct allocation from SMRD. This is a heritage Landsat capability, and is included in response to the potential for worldwide emergencies and homeland security concerns. Priority collects are also used for particular science field campaigns.

GS3028: The GS shall have the capability to collect, archive, process, and distribute off-nadir data.
Rationale: Direct allocation from SMRD. This is a new Landsat requirement, and is included in response to the potential for worldwide emergencies and homeland security concerns. The off-nadir capability may also be used to capture scenes off the WRS-2 grid, such as the polar regions, as well as coastal scenes. An interval is defined as a continuous collection of imagery, and will, in many cases, consist of multiple scenes.

3.1.5 Data Loss

GS1338: The GS shall deliver at least 99% of the mission data acquired by the observatory to the science data archive, measured on a quarterly basis.
Rationale: Allocation from the 98.8% capture of mission data in the SMRD. Data loss is defined as unrecoverable data. Data that do not meet latency requirements are not considered part of data loss. Data loss starts when the command load is successfully installed on the observatory. The percentage data lost refers to entire scenes lost, not a bit error rate, i.e. a scene with excess noise is “lost.” Allocation to GS elements is detailed in Appendix A.

3.1.6 Availability

GS165: The GS shall be available 99.9% of the time for command and telemetry functions during commanding and L&EO, measured on a monthly basis.
Rationale: Critical command and telemetry availability required for periodic, contingency, and special events. Functions include the LGN stations and real-time command and control within the MOC.

GS623: The LGN stations shall be available 97% of the time, measured on a monthly basis.
Rationale: This equates to a 24 hour outage over a month. There is sufficient LGN contact time margin to accommodate a 24 hour ground station outage. With multiple apertures available at the polar station,
24 hours allows time to switch to a backup aperture.

GS625: The GS shall be available 95% of the time to search and order data products, measured over a 3 month period.

Rationale: This availability is acceptable to users, approximately the state of the practice in requirements in other USGS and NASA remote sensing ground data distribution systems, and is consistent with the present and future USGS commitment to the Landsat user community. In addition, this accommodates LDCM staffing requirements for 8x5 operations. It allows 4.5 days a quarter which covers a 3 day weekend, ordering any replacement parts, and time for recovery.

3.1.7 Security

GS1803: The GS shall comply with GPD 7120.1 GSFC Space Asset Protection Policy.
Rationale: NASA institutional requirement.

GS26: The GS shall comply with NPR 2810.1A, NASA Procedures and Requirements, Security of Information Technology.
Rationale: NASA institutional requirement.

GS930: The GS shall provide physical and Information Security for GS facilities, equipment, and data compliant with USGS Computer Security Handbook (USGS PUB), USGS Security Controls Policy (USGS PUB), and DOI Cyber Security Handbook (USGS PUB).
Rationale: USGS institutional requirement.

GS942: The GS shall provide physical and Information Security for GS facilities, equipment, and data in accordance with NIST SP 800-53 and all relevant annexes.
Rationale: USGS institutional requirement.

GS3064: The GS shall log all of its major activities.
Rationale: Logging major activities like events, notifications, messages etc., will be essential for later analysis/troubleshooting exercises.

3.1.8 Serviceability

GS156: The GS shall allow servicing of ground-based systems without interruption of MOC command and control and data downlink activities.
Rationale: Allocation from SMRD. Servicing will be conducted on an ongoing as-necessary basis and it must not interfere with nominal mission ops.

GS168: The GS shall be implemented such that data and/or technology migration activities may be performed without interruption to ongoing mission operations
Rationale: Servicing will be conducted on an ongoing as-necessary basis and it must not interfere with nominal mission ops.

3.2 Ground Network Element

3.2.1 General

GS66: The GNE shall provide telemetry and command RF communications interface between the LDCM observatory and the MOCs.
Rationale: This interface is required for telemetry, commanding and science data to flow through GNE.

GS802: The GNE shall provide X-band contact time of at least 98 minutes/day with the observatory.
Rationale: This contact time is required in order to provide sufficient contact time to downlink all science data. This number does not include margin for retransmission. This accounts for 187 minutes of science data from OLI and TIRS which is the maximum amount the observatory can support per day.

GS3057: The GNE shall provide S-band uplink and downlink capability with every X-band pass.
Rationale: All the contact time provided by GS802 is also available for downlinking back orbit telemetry aka stored telemetry, and to ensure that observatory state of health data are updated as frequently as possible.

GS3058: The GNE shall provide two S-band contacts per day with ten minutes or greater duration.
Rationale: This is necessary specifically to allow for uploading of large stored command loads.

GS534: The GNE shall generate timestamps with an accuracy of 100 microseconds.
Rationale: Clock calibration onboard the observatory is supported through the accuracy of GNE time tagging of realtime telemetry data.

GS79: The GNE shall store timestamps with a precision of 100 microseconds.
Rationale: Timestamp formats must support the accuracy requirement in GS534.

GS1745: The GNE shall transfer mission data files to the DPAS in groups constituting complete intervals.
Rationale: DPAS must have all the files comprising an interval before the ingest and processing algorithms can be run. This only means holding individual files until all the files from the same interval are together, and transferring all the files as a group. No data processing is implied. (An interval is a continuous data collection). The intervals will be either reflective only, thermal only, and reflective+thermal based on how the collection is scheduled and executed.

3.2.2 Scheduling

GS540: The GNE shall schedule LGN station contacts based on MOE schedule requests.
Rationale: The MOE uses its FD to determine contact schedule and sends selected set to GNE for confirmation.

GS1682: The GNE shall provide long-range predictions of planned site outages for planning and scheduling purposes.
Rationale: In support of the 28 day forecast schedule on the MOE side.

GS661: The GNE shall be capable of scheduling a station within 15 minutes if the station will be in view of the Spacecraft in the event that the FOT declares a Spacecraft Emergency.
Rationale: In support of rapid response to spacecraft emergencies. Fifteen minutes is consistent with SN and NEN performance.

3.2.3 LGN Stations

3.2.3.1 General

GS70: The GNE shall have the capability to receive X-band data and S-band data concurrently while sending S-band data.
Rationale: Matches the performance specification for the observatory.

GS595: The GNE shall position and track the antenna for the observatory.
Rationale: It is needed to position and track the antenna for the observatory tracking using the predicted state vectors (program track) and switch to autotrack with increased signal strength using S and X band signals.

GS88: The GNE shall accept predicted state vectors in TLE and IIRV formats.
Rationale: Compatibility with present practice and LDCM MOE operations concept (IIRV). TLE is a contingency-mode format.

GS657: The GNE shall accept commands, schedule requests, and acquisition data only from the MOC.
Rationale: In preservation of spacecraft physical security. This applies to LDCM inputs for the LDCM Observatory it does not preclude multi-mission support.

GS655: The GNE shall remove all artifacts of the space to ground transmission such as encoding and randomization to produce mission data files in the same format as stored on the Observatory recorder.
Rationale: This function is allocated to GNE and not other elements of the ground system. GNE will not pull apart or process the files beyond how they are stored on the recorder.

GS656: The GNE shall interface with the observatory RF suitcase to perform interface testing.
Rationale: In support of the mission level I&T plan.

GS1843: The GNE shall support troubleshooting and resolution of voice and data anomalies.
Rationale: Troubleshooting requires support from both ends for voice and data networks.

GS1844: The GNE shall coordinate interface fault isolation and recovery with the MOC whenever required.
Rationale: Troubleshooting of GNE interfaces must be worked by staff on both sides of the interface.

3.2.3.2 S-Band

GS662: The GNE shall transmit command data to and receive telemetry from the Observatory via S-band.
Rationale: Compatibility with observatory RD stated capability.

GS555: The GNE shall support an S-band downlink within the frequency range of 2200 MHz and 2290 MHz.
Rationale: This represents the entire spectrum allocation for Earth Science missions for telemetry downlink.

GS556: The GNE shall support an S-band uplink within the frequency range of 2025 MHz and 2108 MHz.
Rationale: This represents the entire spectrum allocation for Earth Science missions for uplink.

GS547: The GNE shall support selectable error-correction decoding on the S-band downlink compliant with CCSDS 131.0-B-1, sections 3.1 and 4.
Rationale: Error correction codes from CCSDS 131 were chosen to ensure integrity of the downlink and because the standard is widely adopted.

GS548: The GNE shall support selectable error-correction encoding on the S-band uplink compliant with CCSDS 231.0-B-1.
Rationale: Error correction codes from CCSDS 231 were chosen to ensure integrity of the uplink and because the standard is widely adopted.

GS549: The GNE shall support selectable de-randomization of the S-band downlink in accordance with CCSDS-131.0-B-1.
Rationale: Derandomization is required to ensure successful demodulation and CCSDS standards are widely adopted.

GS550: The GNE shall support BPSK modulation of the S-Band uplink compliant with CCSDS 401.0-B-17.
Rationale: This is consistent with the bus design as given in the Space to Ground ICD 70-P58230P.

GS3264: The GNE shall support OQPSK demodulation of the S-band downlink compliant to the CCSDS-401.0-B-17.
Rationale: This is consistent with the bus design as given in the Space to Ground ICD 70-P58230P. Add link from GNE78.

GS593: The GNE shall support LHC polarization for the S-band uplink and downlink.
Rationale: Consistent with the Space to Ground ICD.

GS551: The GNE shall provide 54 dBW Effective Isotropic Radiated Power (EIRP) for all S-band uplinks.
Rationale: Compatible with heritage 9m LGN antennas supporting a reasonable link margin.

GS552: The GNE shall provide a minimum clear-sky S-band G/T at 5 degrees elevation of 20 dB/K.
Rationale: Compatible with heritage 9m LGN antennas supporting a reasonable link margin.

GS553: The GNE shall support a configurable uplink sweep range of +/- 160 KHz about the center frequency.
Rationale: Standard practice.

GS554: The GNE shall support a configurable uplink sweep rate of 5-35 KHz per second.
Rationale: Standard practice.

GS546: The GNE shall support S-band telemetry data rate of 32 kbps (64 Ksymbols/sec after coding) during manuevers and off-nominal operations.
Rationale: Consistent with the space to ground ICD.

GS1772: The GNE shall support realtime and stored S-band telemetry data from the Observatory at an aggregate rate of 1 Mbps (2 Msymbols/sec after coding) nominally.
Rationale: This rate supports the playback and realtime aggregate rates from the observatory during nominal operations.

GS650: The GNE shall support commanding rates of 2 ksps and 64 ksps on the S-band uplink.
Rationale: This range of standard rates goes from the low-rate tumbling TDRSS case all the way up to a maximum which supports a large stored command load in a single LGN contact.

3.2.3.3 Command and Telemetry Data Handling

GS545: The GNE shall generate and report real-time S-band link quality statistics.
Rationale: In support of GNE operations and maintenance staff troubleshooting and GNE to MOE interface agreement.

GS543: The GNE shall transmit command data received at the LGN Stations to the Observatory with rate buffering as needed.
Rationale: Only buffering and delays for communication protocol between MOE and GNE, and any rate buffering to match the MOE transfer rate with the S/C uplink data/symbol rate. Command authentication will fail if commands arrive out of sequence. This also supports responsiveness of the commanding path for real-time commanding. It does not include NISN transfer time.

GS544: The GNE shall forward telemetry frames from real-time Virtual Channels to the NISN network incurring only minimal time for the removal of the communication artifacts.
Rationale: Minimal delay of real-time telemetry to maximize efficiency of station contacts. This time begins when the last RF symbol of a transfer frame is received and ends when the first bit of the encapsulated packet hits the NISN. It does not include the NISN transfer time.

GS654: The GNE shall store all telemetry data from the Observatory for a minimum of 7 days from time of receipt.
Rationale: Seven days supports transition to backup MOC in the event of a primary MOC failure without loss of telemetry data.

GS664: The GNE shall initiate the retransmission of data to the MOE within 1 hour of receiving the retransmission request from the FOT.

Rationale: One hour supports manually-initiated retransmission.

GS666: The GNE shall provide real-time telemetry and command services while simultaneously flowing playback telemetry from a prior pass or from the station archive to the MOE.
Rationale: Since stored telemetry transfer could potentially take hours, this capability is required.

3.2.3.4 X-Band

GS565: The GNE shall support an X-band downlink within the frequency range of 8024 MHz and 8400 MHz.
Rationale: This represents the entire X-band spectrum allocation for Earth science missions. The OLI data rate of <300 Mbps (with overhead) will likely require use of the entire allocation.

GS3082: The GNE shall receive mission data and stored telemetry from the Observatory via X-band.
Rationale: Compatibility with observatory RD stated capability.

GS592: The GNE shall accept X-band data which is formatted compliant with the "class 1" specification of CFDP given in CCSDS 727.0-B-4 CCSDS File Delivery Protocol Blue Book.
Rationale: A non-proprietary standard was chosen based on availability of COTS receiving hardware/software for LGN and IC stations. This file-based protocol supports the file-based onboard storage requirements.

GS560: The GNE shall support rate 7/8 LDPC error-correction decoding on the X-band downlink compliant with GSFC-STD-9100.
Rationale: Error detection and correction is necessary to know when retransmission of data files is required. LDPC is the protocol employed by the spacecraft.

GS562: The GNE shall support selectable derandomization of the X-band downlink in accordance with CCSDS-131.0-B-1.
Rationale: Randomization of the X-band downlink will be necessary to ensure demodulation performance and the CCSDS standard is widely adopted.

GS563: The GNE shall support OQPSK modulation of the X-band downlink compliant with CCSDS-401.0-B-17.
Rationale: This is consistent with the bus design as given in the Space to Ground ICD 70-P58230P.

GS564: The GNE shall provide a clear-sky X-band G/T at 5 degrees elevation of 31 dB/K or better.
Rationale: Compatible with heritage 9m LGN antennas supporting a reasonable link margin.

GS566: The GNE shall support LHC polarized X-band downlink channel.
Rationale: Consistent with Space to Ground ICD.

GS568: The GNE shall support single X-band carrier with multiple virtual channels.
Rationale: Consistent with Space to Ground ICD. The OLI (RT), OLI (PB), TIRS (RT), TIRS (PB) and SSOH will be in separate virtual channels in the X-band downlink as specified in the Space to Ground ICD (Doc. No. 70-P58230P).

GS559: The GNE shall support a data rate of 384 Mbps on the X-band carrier.
Rationale: Consistent with the Space to Ground ICD. This data rate is before the application of 7/8 LDPC forward error correction codes.

3.2.3.5 Mission Data Handling

GS89: The GNE shall generate and report real-time X-band link quality statistics.
Rationale: This information is important to troubleshoot the observatory and GNE performance and maintenance troubleshooting.

GS74: The GNE shall send X-band data unit status to the MOE.
Rationale: Used for closing the loop on file downlink status with MOE for subsequent retransmission or deletion.

GS73: The GNE shall be capable of ingesting mission data from IC stations.
Rationale: In support of station validation and IC data validation and evalution activities.

GS84: The GNE shall store X-band data downlinked at each LGN station for at least 90 days.
Rationale: Supports retransfer to DPAS when required. Ninety days is consistent with DPAS recovery requirements and the time required to procure additional hardware or media to expand local storage in the event of a catastrophic loss of DPAS.

3.3 Mission Operations Center

Note: the MOC requirements apply to both the primary and backup MOC, except where noted. Also, the requirements apply to each location of the MOC (e.g. EROS or GSFC), except where noted.

3.3.1 General

GS1722: The MOC shall support pre-launch activities, launch, commissioning, normal ops, and decommissioning.
Rationale: The MOC must be developed early to support pre-launch testing and must be operational through decommissioning for decommissioning to be successful.

GS1723: The MOC shall provide the capability to conduct FOT training activities concurrent with and without interruption of mission activities.
Rationale: Supports training of new staff and testing / certification of new staff.

GS1724: The MOC shall maintain electronic documentation of operating procedures for FOT use.
Rationale: Allows ready and quick access to documentation from all workstations/terminals at any time.

GS1725: The MOC shall maintain configuration control of electronic documentation.
Rationale: Source documents and procedures will be under configuration management so the electronic documentation system must support the configuration control process.

GS1726: The MOC shall restrict access to electronic documentation to authorized personnel.
Rationale: Procedures and documentation will contain sensitive information from security and IT security points of view.

GS1309: The MOC shall provide a controlled repository of engineering data and products.
Rationale: Note that this contains the Project Database as well.

GS1859: The bMOC shall have a maintained copy of the controlled repository.
Rationale: The bMOC would use this copy of the controlled repository upon failover.

GS1857: The MOC shall synchronize all controlled repositories.
Rationale: The controlled repositories are used to synchronize configuration data between each MOC instance.

GS1858: The MOC shall have the capability to periodically archive and restore the primary operational repository.
Rationale: The data in the repositories is very important and so a backup and restore capability is required to ensure data integrity.

GS1855: The bMOC shall be capable of satellite mission operations within 48 hours of loss of the primary MOC.
Rationale: Redundancy - Designed such that no single credible failure permanently precludes the LDCM from completing the mission. To ensure Observatory health and

safety, support the mission, and avoid data loss during a potentially critical time, the bMOC must be capable of being operational by the time the onboard command load expires and imaging halts.

GS1856: The bMOC shall be capable of performing satellite mission operations for a minimum of 21 consecutive days.
Rationale: Redundancy - Designed such that no single credible failure permanently precludes the LDCM from completing the mission. Provide sufficient resources to meet mission requirements for at least a long-term scheduling period without requiring replication of a full-up MOC. 21 days provides a period of time to supplement the bMOE with additional workstations.

3.3.2 Project Database

GS831: The MOC shall manage a Project Database (PDB) that consists of the observatory T&C database and the ground segment database.
Rationale: The PDB enables configuration management of all telemetry and command definitions across all LDCM development organizations.

GS832: The MOC shall maintain a copy of the PDB in a controlled repository accessible by authorized operators.
Rationale: The controlled repository houses configuration data like the PDB.

GS1690: The MOC shall provide configuration management of the PDB.
Rationale: Changes to telemetry and command definitions must be carefully coordinated across the entire project.

GS835: The MOC shall construct the ground segment database to define any Ground Support Equipment (GSE) directives or telemetry to be processed by the MOC.
Rationale: The LGN stations use a telemetry format to send station status to the MOE and receive directives from the MOE. These formats must be managed through the PDB.

GS834: The MOC shall ingest and verify the observatory telemetry & command (T&C) database and updates provided by the Spacecraft vendor.
Rationale: To receive definitions for all spacecraft bus T&C formats.

GS1683: The MOC shall ingest and verify the OLI telemetry and command database and updates provided by the instrument provider.
Rationale: To receive OLI definitions for all instrument T&C formats.

GS3106: The MOC shall ingest and verify the TIRS telemetry and command database and updates provided by the instrument provider.
Rationale: To receive definitions for all instrument T&C formats.

GS1209: The MOC shall provide command telemetry, planning, and scheduling, mission monitor and analysis, flight dynamics, and memory management databases to the PDB.
Rationale: So MOE can 'backup' to the PDB.

GS1210: The MOC shall provide the capability to retrieve command telemetry, planning and scheduling, mission monitor and analysis, flight dynamics, and memory management databases from the PDB.
Rationale: Allows MOE to 'restore' from the PDB.

3.3.3 MOC Facility

3.3.3.1 General

GS28: The MOC facility shall provide floor space for MOC systems.
Rationale: The MOC facility is also expected to house all the MOC hardware.

GS1306: The MOC facility shall provide power and floor space to host the Observatory Simulator.
Rationale: The Observatory Simulator will also be housed in the active MOC.

GS1305: The MOC facility shall provide power and floor space to host the SN-provided SNAS workstation.
Rationale: The SN provides a SNAS workstation for SN scheduling purposes which must also be accommodated within the MOC facility.

GS3003: The GSFC MOC facility shall provide power and floor space to support the launch support room.
Rationale: GSFC will be the primary MOC during launch.

GS793: The MOC facility shall restrict physical access to allow entry to authorized personnel only.
Rationale: For both physical security of the mission and IT security of protected network connections within the MOC facilities.

GS947: The MOC facility shall monitor and regulate power, temperature and humidity conditions within the MOC.
Rationale: These environmental variables are important for the proper operation of MOC equipment.

GS1845: The MOC facility shall notify MOC personnel of problems with power, temperature or humidity.

Rationale: The MOC will be unstaffed for periods of time so remote notification is necessary to allow quick response when a problem occurs before equipment is damaged.

GS1302: The MOC facility shall provide commercial voice communications systems.
Rationale: For the FOT to conduct routine business.

GS1303: The MOC facility shall provide long distance capability on a subset of commercial voice lines.
Rationale: Some long distance calling will be required in performance of regular FOT duties.

GS43: The MOC facility shall provide commercial phone services to support fax transmissions.
Rationale: The fax machine requires a phone line.

GS44: The MOC facility shall provide a master time signal for the MOC systems.
Rationale: Both for time synchronization of PC workstations and time synchronization of front end processing equipment.

GS800: The MOC facility shall provide a redundant source of facility time signals.
Rationale: To ensure that a single failure does not preclude the time synchronization capability.

GS1304: The MOC facility shall provide conditioned power from two different distribution panels.
Rationale: The goal is to divide systems between the two feeds so that you gracefully degrade if you drop a panel.

GS32: The MOC facility shall provide full uninterruptible battery-backup of all power distributed to all MOC components.
Rationale: The uninterruptible power sources are only to provide for graceful shutdown of all MOC hardware. This does not have to provide 24 hours of runtime to match GS34.

GS34: The MOC facility shall provide a backup power source within 24 hours of power failure.
Rationale: Providing backup power at the MOC within 24 hours avoids activating the bMOC and operating from a backup facility due to a simple loss of power.

3.3.3.2 MOC-Provided Hardware

GS1297: The MOC shall provide a clearly identified public Internet access workstation for FOT use.

Rationale: This is for timecards etc and also access to DPAS for submitting requests into the front end. This workstation and the Internet connection are fully airgapped from everything else in the room. It will also be clearly marked as being an unsecure workstation.

GS40: The MOC shall provide two wall-mounted displays measuring 40" diagonally or larger for sharing MOE workstation displays.
Rationale: The FOT uses these to share important displays with a large group during key activities, such as during post-launch deployments.

GS1301: The MOC shall provide the capability to send and receive fax transmissions from/to hardcopy.
Rationale: Fax is a backup method for LGN scheduling, a backup method for IC station scheduling and also an important method of communications with foreign IC stations.

GS42: The MOC shall provide color and black and white printing capabilities.
Rationale: The FOT uses these capabilities for printing trending and analysis reports.

GS799: The MOC facility shall provide UTC clock and countdown clock displays with unobstructed visibility from the console positions.
Rationale: All spacecraft operations are referenced to UTC time.

3.3.3.3 MOC VLAN

GS537: The MOC shall be capable of providing public Internet connectivity to the public Internet access workstation only.
Rationale: This is only for the air-gapped Internet access terminal.

GS1307: The MOC shall provide a network to host the Observatory Simulator.
Rationale: The Observatory Simulator uses the network connection to communicate with the MOE.

GS1296: The MOC shall provide a network to host the SN-provided SNAS workstation.
Rationale: The SN uses a network connection to communicate with the central SN scheduling entity.

GS1686: The MOC shall provide a network to host the MOE.
Rationale: The MOE uses the network connections to talk to all interfacing entities.

GS1687: The MOC shall provide a network to host the CAPE.
Rationale: The CAPE uses a network connection for all interfaces.

GS922: The MOC shall monitor for MOC network security violations and initiate paging to the appropriate personnel.
Rationale: In support of physical and IT security requirements related to the mission and the Restricted IO Net.

GS923: The MOC shall restrict computer access to authorized personnel.
Rationale: In support of physical and IT security requirements related to the mission and the Restricted IO Net.

3.3.4 Collection Activity Planning Element

3.3.4.1 General

GS585: The CAPE shall plan and schedule the image data collections for both instruments on the observatory.
Rationale: Image data collections need to be planned and scheduled for the observatory throughout the lifetime of the mission.

GS1245: The CAPE shall be capable of modeling impacts from proposed IC and LGN GS changes, without impacting CAPE operations.
Rationale: Modeling is required to evaluate changes to the GNE stations or the network of IC stations.

GS3065: The CAPE shall be capable of providing multiple concurrent operators log on access.
Rationale: The CAPE needs to be accessible by both the DAM and at least two DAPs so that more than one person can be performing tasks related to the planning and scheduling of image data collection requests during normal operations and additionally another three or more DAP access during launch and early orbit for intial modelling purposes.

3.3.4.2 Planning and Scheduling

GS50: The CAPE shall generate image data acquisition requests based on the seasonality records.
Rationale: The LTAP-8 seasonality records must be converted into image data collection requests to be properly planned and scheduled by the CAPE software.

GS52: The CAPE shall generate internally deconflicted image data collection schedules.

Rationale: The CAPE's main function is to daily generate a list of the best 400 image data collections and to make sure they are conflict free. This will ensure that in a nominal case the collection requests are accepted into the MOE Master Integrated Schedule without issue.

GS147: The CAPE shall ingest seasonality records from an external source.
Rationale: The LTAP-8 seasonality file is delivered to the CAPE from the LDCM Science Team approximately once yearly and must subsequently be ingested into the CAPE database so that it's records can be managed and scheduled by the CAPE software.

GS146: The CAPE shall ingest and maintain global climatology data.
Rationale: The CAPE will be using global cloud fraction climatology data to adjust the priorities of image data collection requests and therefore must be able to ingest this data from an external source.

GS51: The CAPE shall provide a configurable capability to adjust the priority of image data collection requests based on global predicted cloud cover.
Rationale: The CAPE will be using daily cloud cover prediction data to adjust the priorities of image data collection requests and the adjustments can be weighted based on the reliability of the cloud cover prediction data at each path/row.

GS631: The CAPE shall provide the capability to schedule image data collections based on a configurable prioritization scheme.
Rationale: The scheduling for LDCM is an improved version of the heritage Landsat 7 approach which is a rule-based prioritization scheme.

GS53: The CAPE shall generate image data collection schedules based on configurable engineering constraints.
Rationale: The constraints of both mission resources and data collection activities will be configurable and the scheduling routines must be able to use the latest constraints when generating a deconflicted schedule.

GS589: The CAPE shall be capable of forecasting image data collections for periods spanning up to the life of the mission.
Rationale: The DAPs will need the capability to make adjustments to mission resources and the LTAP-8 in an offline system in order to analyze the long-term affects of those changes.

GS47: The CAPE shall be capable of planning and scheduling image data collections over the entire WRS-2 grid.
Rationale: All image data collections are requested based on path/row combinations provided by the WRS-2 grid and therefore the CAPE must be able to plan and schedule the image data collections by these path/row combinations.

GS49: The CAPE shall provide the capability to schedule off-nadir data collection.

Rationale: The LDCM system requires the capability for off-nadir image data collections (up to 15 degrees either side) and therefore the CAPE must be able to accept and initiate these types of requests as well as add them to plans and schedules.

GS48: The CAPE shall provide the capability to schedule priority image data collections.
Rationale: The LDCM system requires the ability to take priority image data collections that can be downlinked before other non-priority requests. Therefore, the CAPE must have the capability to accept, initiate, and plan and schedule priority requests as well as flag them as priority requests to the MOE.

GS54: The CAPE shall provide the capability to schedule image data collection requests from external users.
Rationale: The LDCM system allows external users (ICs and individual users) to submit image data collection requests via the User Portal and the CAPE must therefore provide the capability to receive these external image data collection requests and incorporate them into plans and schedules.

GS630: The CAPE shall provide the capability to create data collection requests.
Rationale: There may be situations where the User Portal is down or the link from the User Portal to the CAPE is broken. Therefore, the CAPE will provide the capability to create data collection requests for users that call in the details of their requests. This includes imaging requests placed by the Cal/Val team.

GS46: The CAPE shall plan and schedule data collection requests referenced to the WRS-2 path/row coordinate system.
Rationale: The majority of users use the WRS-2 path/row coordinate system to specify data collections, instead of latitude/longitude data.

GS1215: The CAPE shall plan and schedule data collection requests based on observatory resource availability.
Rationale: Image data collection requests need certain resources reserved in order to be scheduled and resources cannot be overbooked. Therefore, an integral part of the process of scheduling image data collections is to check the availability of all required resources and only schedule an image data collection if resources are available during the time period of the collect. The instrument (OLI and TIRS) is one example of a resource.

GS638: The CAPE shall verify successful data capture of requested scene collections.
Rationale: An image data collection that is unsuccessfully captured due to unacceptable cloud cover may be re-scheduled at a later time. Therefore, the CAPE must be able to check the success or non-success of a captured image data collection request and make the determination if it should be re-scheduled or not.

3.3.4.3 IC Interface

GS45: The CAPE shall plan and schedule real-time image data collections for International Cooperators.
Rationale: The LDCM system has agreements with certain ICs which allow them to submit image data collection requests via the User Portal. Therefore, the CAPE must provide the capability to receive these IC image data collection requests and incorporate them into plans and schedules. All the prioritization requirements apply to IC requests as well.

GS588: The CAPE shall be capable of planning and scheduling IC image data collections based upon the availability of the IC ground stations.
Rationale: The IC image data collections cannot use over-booked IC resources. Therefore the CAPE scheduling routines must consider the IC resource availabilities when generating schedules using these resources.

3.3.4.4 Reporting

GS206: The CAPE shall report status of image data collection requests on request.
Rationale: The Data Acquisition Planners may want or need to see status of particular image data collection requests.

GS645: The CAPE shall provide a configurable reporting capability.
Rationale: The Data Acquisition Planners that use the CAPE software may want to generate user-defined image data collection planning and scheduling reports.

3.3.5 Mission Operations Element

3.3.5.1 General / Administrative

GS63: The MOE shall have the capability to accommodate scheduling for a single physical antenna which is both an LGN station and an IC station.
Rationale: The present Landsat 7 mission incorporates an International Cooperator station (in Alice Springs, Australia) which receives realtime data for the IC and also operates as a recorder dump station as part of the LGN. This station has two station identifiers within the system and receives seperate schedules for each class of operations. The LDCM implementation may vary from this approach, as long as both the LGN functionality and the IC requirements are all accomodated by the implementation.

GS818: The MOE shall perform planning & scheduling of all observatory activities, generating short-term (72 hour) and long-term (21 day) schedules.
Rationale: Control & Monitoring - Plan and execute all satellite housekeeping (including flight dynamics) activities.

GS819: The MOE shall perform command generation for all observatory activities.
Rationale: Control & Monitoring - Plan and execute all satellite housekeeping (including flight dynamics) activities.

GS827: The MOE shall decommutate, convert, limit sense and archive all S-band data received from the observatory.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS1203: The MOE shall establish, monitor, and manage connections with SN, NEN and LGN.
Rationale: Control & Monitoring - Plan and execute all satellite housekeeping (including flight dynamics) activities.

GS820: The MOE shall monitor and manage the observatory health & safety.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS1204: The MOE shall provide flight dynamics support for orbit and attitude determination, control, and prediction.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS1205: The MOE shall generate commands to perform image data collection and recovery from mass storage.
Rationale: Image Acquisition - Build, maintain, and execute an image acquisition plan based on science and operational priorities

GS1802: The MOE shall perform image data accounting.
Rationale: Image Data Support - Deliver at least 98.8% of the science data acquired by the observatory

GS1236: The MOE shall generate and deliver products, events and reports to a controlled repository.
Rationale: Archive - Archive all LDCM data and products for the life of the mission

GS821: The MOE shall be the sole interface for commands between the elements of the ground system and the space-ground communications links.
Rationale: Control & Monitoring - Plan and execute all satellite housekeeping (including flight dynamics) activities

3.3.5.2 Availability and Reliability

GS836: The MOE shall support mission operations 24-hours per day, 7 days per week.
Rationale: Availability - Support 10 years of mission life

3.3.5.3 Telemetry, Command and Control

GS1268: The MOE shall establish, manage and terminate the forward links with the LGN, SN and NEN.
Rationale: Control & Monitoring - Plan and execute all satellite housekeeping (including flight dynamics) activities

GS824: The MOE shall process observatory telemetry that is compliant with CCSDS Packet Telemetry recommendations as defined in CCSDS 131.0-B-1, CCSDS 132.0-B-1 and CCSDS 133.0-B-1.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS825: The MOE shall implement observatory commanding that is compliant with the CCSDS Telecommand recommendations as defined in CCSDS 231.0-B-1, CCSDS 232.0-B-1, and CCSDS 232.1-B-1.
Rationale: Control & Monitoring - Plan and execute all satellite housekeeping (including flight dynamics) activities

GS106: The MOE shall encrypt command uplinks and support authentication.
Rationale: Communications - Encrypt the forward link and authenticate commands

GS1269: The MOE shall provide the capability to assign levels of command authority.
Rationale: Control & Monitoring - Plan and execute all satellite housekeeping (including flight dynamics) activities

GS1270: The MOE shall provide the capability to enable and disable commanding for individual operators.
Rationale: Control & Monitoring - Plan and execute all satellite housekeeping (including flight dynamics) activities

GS1271: The MOE shall provide the capability to construct realtime commands and uplink command loads to the observatory.
Rationale: Control & Monitoring - Plan and execute all satellite housekeeping (including flight dynamics) activities

GS878: The MOE shall generate software memory loads for uplink to the S/C from flight software images provided by the FOT, S/C and instrument Flight Software vendor facilities.
Rationale: Control & Monitoring - Plan and execute all satellite housekeeping (including flight dynamics) activities

GS850: The MOE shall generate and manage command constraint definitions.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS1272: The MOE shall provide the capability to manage the transmission of hazardous and critical commands.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS138: The MOE shall process and monitor telemetry data from the observatory while on the launch pad.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS1275: The MOE shall assess data quality of S-band telemetry.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS1276: The MOE shall perform calibration and conversion of S-band telemetry.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS1273: The MOE shall perform limit checking of S-band telemetry.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS1668: The MOE shall process SSR status telemetry from the spacecraft.
Rationale: Image Data Support - Deliver at least 98.8% of the science data acquired by the observatory

GS1669: The MOE shall evaluate X-band data unit status received from the GNE.
Rationale: Image Data Support - Deliver at least 98.8% of the science data acquired by the observatory

GS1670: The MOE shall evaluate X-band data unit status received from the spacecraft.
Rationale: Image Data Support - Deliver at least 98.8% of the science data acquired by the observatory

GS1671: The MOE shall generate X-band data unit retransmit commands.
Rationale: Image Data Support - Deliver at least 98.8% of the science data acquired by the observatory

GS1672: The MOE shall generate X-band data unit unprotect commands.

Rationale: Image Data Support - Deliver at least 98.8% of the science data acquired by the observatory

3.3.5.4 Planning & Scheduling

GS841: The MOE shall schedule all activities for the observatory except those autonomously executed by the S/C.
Rationale: Control & Monitoring - Plan and execute all satellite housekeeping (including flight dynamics) activities

GS848: The MOE shall generate a Master Schedule of Activities and deliver to the controlled repository.
Rationale: Archive - Archive all LDCM data and products for the life of the mission

GS852: The MOE shall schedule all routine, periodic and special activities based on a priority scheme.
Rationale: Control & Monitoring - Plan and execute all satellite housekeeping (including flight dynamics) activities

GS1278: The MOE shall schedule activities based on input events as per PDB definitions.
Rationale: Control & Monitoring - Plan and execute all satellite housekeeping (including flight dynamics) activities

GS845: The MOE shall automatically process electronic CAPE scene requests.
Rationale: Image Acquisition - Build, maintain, and execute an image acquisition plan based on science and operational priorities. Note that CAPE scene requests flag OLI and TIRS explicitly.

GS1673: The MOE shall generate and deliver to the controlled repository scene to interval reports.
Rationale: Image Acquisition - Build, maintain, and execute an image acquisition plan based on science and operational priorities

GS1277: The MOE shall process schedules for the LGN, SN and NEN networks.
Rationale: Derived

GS1279: The MOE shall process candidate schedules against constraints defined in the PDB.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS1280: The MOE shall generate user-defined reports.
Rationale: Image Acquisition - Build, maintain, and execute an image acquisition plan based on science and operational priorities

GS1674: The MOE shall be capable of delivering reports to the controlled repository.
Rationale: Archive - Archive all LDCM data and products for the life of the mission

GS849: The MOE shall provide the As-Flown Master Schedule of Activities to a controlled repository.
Rationale: Archive - Archive all LDCM data and products for the life of the mission

GS636: The MOE shall generate IC ground station contact schedules for each IC ground station.
Rationale: Each IC station needs a contact schedule for the LDCM observatory. The schedule is specific to each station.

3.3.5.5 Mission Monitor and Analysis

GS884: The MOE shall monitor the configuration of the observatory and detect deviations from expected states.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS885: The MOE shall produce an as-flown timeline that reflects the activities as they executed.
Rationale: Image Acquisition - Build, maintain, and execute an image acquisition plan based on science and operational priorities

GS1283: The MOE shall provide a generic interface to support analytical modeling including telemetry, directive control and report distribution to support mission modeling
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS891: The MOE shall provide access to trending and analysis capabilities via the Internet for analysis by remote users.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS823: The MOE shall allow authorized remote users to access system functions for viewing realtime and historical data via an Internet web-accessible interface.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS1284: The MOE shall provide the capability to export operator-specified ingested data to current PC-based media.
Rationale: Image Data Support - Provide operational trending of key LDCM parameters

3.3.5.6 Flight Dynamics

GS1285: The MOE shall provide support for attitude determination, control and prediction.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS1286: The MOE shall provide support for orbit determination, control and prediction.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS1287: The MOE shall provide the capability to perform attitude and orbit hardware calibration.
Rationale: Image Data Support - Plan and execute spacecraft maneuvers in support of calibration

GS123: The MOE shall plan and execute maneuvers of the Observatory.
Rationale: Image Data Support - Plan and execute spacecraft maneuvers in support of calibration

GS1288: The MOE shall provide the capability to both manually and automatically generate and distribute flight dynamics products.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS118: The MOE shall coordinate and respond to orbital debris alerts from the provider of conjunction assessments.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS826: The MOE shall generate and maintain a WRS-2 path/row to time translation table throughout the course of the mission.
Rationale: Image Data Support - Collect data referenced to the WRS-2 grid

3.3.5.7 Memory Management

GS1240: The MOE shall provide the capability to modify any reprogrammable memory locations in the observatory.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS1675: The MOE shall process memory dump information from the observatory.

Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS1289: The MOE shall maintain the ground reference image.
Rationale: Archive - Archive all LDCM data and products for the life of the mission

GS1676: The MOE shall provide support for maintenance of FOT-owned memory areas.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS903: The MOE shall manage the Solid State Recorder (SSR) to include dumping and re-dumping of science and engineering data.
Rationale: Image Acquisition - Build, maintain, and execute an image acquisition plan based on science and operational priorities

GS1239: The MOE shall maintain statistics of the image data collection for the life of the mission.
Rationale: Image Acquisition - Build, maintain, and execute an image acquisition plan based on science and operational priorities

3.3.5.8 Product Generation, Distribution and Archive

GS1290: The MOE shall generate engineering data products within 72 hours of receipt of the data.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS1291: The MOE shall provide the capability to notify product users of product availability.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS909: The MOE shall provide archive and restoration support for a controlled repository accessed by authorized users.
Rationale: Archive - Archive all LDCM data and products for the life of the mission

3.3.5.9 Event Generation, Logging and Report Operations

GS1292: The MOE shall publish log messages to a centralized log.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS1293: The MOE shall provide authorized users the capability to filter and display event messages and logs.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS1295: The MOE shall monitor the event log and notify appropriate personnel based on user-specified criteria.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

3.3.5.10 Automation

GS1677: The MOE shall automatically detect ground system and spacecraft anomalies and page on-call personnel.
Rationale: Control & Monitoring - Monitor and maintain the health and safety of the observatory.

GS1678: The MOE shall support automated passes with the GNE.
Rationale: Autonomy - Provide 72 hours of autonomous operations in support of mission data receipt and acknowledgement.

GS822: The MOC shall support a single 8-hour by 5-day shift (M-F) approach and shall operate autonomously whenever not staffed.
Rationale: Autonomy - Provide 72 hours of autonomous operations in support of mission data receipt and acknowledgement. Initially the FOT will staff the active MOC 24 hours per day. This staffing will gradually reduce down to this long-term goal of 8x5. It is expected to take some time to mature FOT understanding and adjust automation procedures before the 8x5 staffing will be realized.

GS915: The MOE shall be capable of autonomously updating the on-board ATS command load based on CAPE schedule change requests.
Rationale: Image Acquisition - Execute priority collections requested at least 12 hours prior to next over-flight of the target.

3.4 Data Processing and Archive System

3.4.1 General

GS204: The DPAS shall provide priority processing based on collection priority.
Rationale: Per the Level 1 priority imaging requirement.

GS599: The DPAS shall collect metrics that include user statistics, data collection, data quality, throughput, availability, data volumes, and product distribution.
Rationale: Collection of metrics is fundamental to LDCM success.

GS816: The DPAS shall provide the capability to generate browse for all reflective and thermal earth data acquired.
Rationale: Supports changes in technology and science technology. Browse are georeferenced. This includes nadir and off-nadir scenes. Reflective data will be used to generate a three-band color-composite browse; thermal data will be used to generate a one-band browse.

GS3044: The DPAS shall produce 30m full-spatial resolution browse data generated from the highest level of processing that is achievable. (i.e. L1G or L1T)

Rationale: Supports full spatial resolution browse that are geographically referenced so users may utilize for reference or graphic illustration.

GS3045: The DPAS shall provide the capability for on-demand processing for all earth data acquired.
Rationale: On-demand processing supports cal/val product generation, standard product generation, and allows for a smaller cache.

3.4.2 EROS Facility

GS1591: The EROS Facility shall provide physical infrastructure to host the DPAS and GNE equipment.
Rationale: Facility infrastructure includes electrical power, floor space, HVAC, lighting, and a grounding grid system to support all of the GS equipment at EROS.

GS1576: The EROS Facility shall restrict physical access to allow entry to authorized personnel only.
Rationale: USGS institutional requirement to comply with NIST security policy 800-53.

GS3077: The EROS Facility shall restrict computer access to authorized personnel.

Rationale: USGS institutional requirement to comply with NIST security policy 800-53.

GS3075: The EROS Facility shall monitor for network security violations and notify appropriate personnel.
Rationale: USGS institutional requirement to comply with NIST security policy 800-53.

GS1577: The EROS Facility shall monitor its application software and equipment to determine any system failures and process the failures.
Rationale: Monitoring and reporting enables fault detection and trending. This requirement is an industry best practice. It is necessary to alert the operations staff with the errors of all origin (H/W, S/W etc.,) with the details (like IP, host name, process code etc.) for enabling proper and timely mitigation.

GS3074: The EROS Facility shall monitor and regulate the temperature and humidity in each area that houses server equipment.
Rationale: It is essential that the operators/engineers get notified if room temperature or humidity exceeds the normal operating conditions.

GS3073: The EROS Facility shall log all software and equipment activities.
Rationale: It is planned to keep a log of all software and equipment activities across the LDCM Ground System.

GS1584: The EROS Facility shall provide full battery-backup power for 20 minutes.
Rationale: This is enough time to gracefully shut down the system for an extended power loss, to carry power over during short disruptions caused by weather conditions, and/or carry over power during generator start-up.

GS1585: The EROS Facility shall provide a backup power source within 24 hours of power failure.
Rationale: The LDCM ground system needs a long term backup power source in the event of an extended outage of commercial power.

GS3078: The EROS Facility shall provide a network to connect the DPAS and GNE to the MOC.
Rationale: This is to allow network connectivity between the EROS MOC and the GNE and DPAS.

GS3072: The EROS Facility shall provide a network to host the DPAS.
Rationale: The DPAS network needs to support high-speed data transfers of large datasets, be highly available to support messaging, and contain multiple virtual networks to separate internal data from data that is presented to the public.

GS3071: The EROS Facility shall provide commercial voice communication service with local, long distance, and fax capabilities for the operators.
Rationale: Need to provide basic communication services that are essential for conducting routine business.

GS3070: The EROS Facility shall backup operating systems, system configurations, software installations, and databases.
Rationale: This requirement is for a backup and restore capability to ensure data integrity to make sure that devices and interfaces are also backed up for complete recovery/restoring of the Ground system.

GS3069: The EROS Facility shall provide a network to host the GNE capabilities at EROS.
Rationale: This is the specific capability to support the transfer of data from the GNE to the DPAS.

GS3068: The EROS Facility shall maintain an LDAP capability for use by GS elements for authentication.
Rationale: The use of LDAP authentication provides the ability to pass the same credentials from the user through the software. It minimizes the user workload in authentication and provides a process to validate security requirements and minimize system administrators workload. This includes protecting the LDAP from unauthorized access for read and write, as well as other IT security controls.

GS3067: The EROS Facility shall provide a network to the public for data product search and distribution.
Rationale: The public interface to LDCM is through the DPAS and there needs to be a network separation of the external and internal data.

GS3066: The EROS Facility shall provide a time source to synchronize servers, workstations, and network devices.
Rationale: Synchronized time is mandatory for effective logging and operation of computer elements and network resources and also will be very useful during anomaly analysis/troubleshooting. Logs must reflect the actual time events occurred to provide an accurate account and sequence useful in accounting and documenting successful system functions and for error condition root cause analysis.

3.4.3 Image Processing

3.4.3.1 Level 0 Processing

GS295: The DPAS shall generate Level 0 products for all reflective, thermal, and reflective+thermal data
Rationale: Continuity with Landsat 7 product suite. Used by international cooperators, and members of the science community who would like to process their own data. Level 0 is also the archive format. Data collections will nominally include both reflective and thermal data. Non-nominal collections may include reflective data only or thermal

data only. Level 0 products will include all bands acquired: reflective, thermal, or reflective + thermal.

3.4.3.2 Level 1 Processing

GS301:   The DPAS shall generate Level 1 data products for all reflective, thermal, and reflective + thermal data for all earth scenes acquired.
Rationale: Continuity with Landsat 7 product suite. This is the standard product used for high accuracy applications where precise geo-location or multi-temporal image registration is required (e.g., the Multi-Resolution Land Characteristics consortium's National Land Cover Data). This includes nadir and off-nadir scenes. The overriding necessity of terrain correction is band-to-band registration. Given the pushbroom focal plane technology, any relief will result in band-to-band misregistration if geocorrection is limited to systematic registration to the geoid; this misregistration would render the multispectral content of the data near useless. Data collections will nominally include both reflective and thermal bands. Non-nominal collections may include reflective bands only or thermal bands only. Level 1 products will include all bands acquired: reflective, thermal, or reflective + thermal.

GS806:   The DPAS shall have the capability to generate cal/val products for all reflective, thermal, and reflective + thermal data acquired.
Rationale: These products include shutter, lamp, lunar, solar and earth-view scenes. These data are used to derive calibration parameters, validate calibration parameters and verify instrument and product performance. Data collections will nominally include both reflective and thermal bands. Non-nominal collections may include reflective bands   or thermal bands only. Cal/Val products will include all bands acquired: reflective, thermal, or reflective + thermal.

GS305:   The DPAS shall have the capability to generate off-nadir products for all reflective, thermal, and reflective + thermal data acquired.
Rationale: Off-nadir is needed for rapid acquisition of priority images at up to one path offset and allows productive imaging while nadir is ocean. 15 degrees corresponds to imaging one path "over" from the current ground track, and is a small enough angle that much of the imaging quality is preserved (compared with nadir imaging.), given that the purpose of off-nadir images is different from the archival nature of nadir imaging. Data collections will nominally include both reflective and thermal bands. Non-nominal collections may include reflective bands only or thermal bands only. Off-nadir products will include all bands acquired: reflective, thermal, or reflective + thermal.

GS185:   The DPAS shall have the capability to produce WRS-2 scene-based products for all reflective, thermal, and reflective + thermal data for all Earth scenes acquired.
Rationale: Continuity with L7 - L4 to provide consistent products at defined ground locations. Data collections will nominally include both reflective and thermal bands. Non-nominal collections may include reflective bands only or thermal bands only.

WRS-2 products will include all data acquired: reflective, thermal, or reflective + thermal.

GS1866: The DPAS shall process all calibration data for all reflective data and all thermal data acquired.
Rationale: Calibration data (shutter, lamp, solar and lunar) are used to characterize the instrument and derive calibration parameters needed to create data products. Both reflective and thermal will collect calibration data.

GS1799: The DPAS shall generate product metadata reporting processing code version, algorithm version and auxiliary data version information, and an indication of sensor data included: reflective, thermal, or reflective + thermal.

Rationale: This information is important for users to determine whether faults discovered in a processor delivery apply to data they possess. It is also useful for evaluating and explaining why there may be differences in a product if it is ordered more than once. Data collections will nominally include both reflective and thermal bands. Non-nominal collections may include reflective bands only or thermal bands only. Metadata should include an indicator of bands acquired: reflective, thermal, or reflective + thermal.

GS1806: The DPAS shall apply calibration parameters to Level 0 processing.
Rationale: The application of calibration parameters is necessary for reflective and thermal bands, for Level 0 processing.

GS3262: The DPAS shall apply calibration parameters to Level 1 processing.
Rationale: The application of calibration parameters is necessary for reflective and thermal bands, for Level 1 processing.

3.4.3.3 Product Accuracy

Note: geometric accuracy requirements apply to nadir-imaged products only. Off-nadir geometric accuracy requirements are defined in section 3.3.3.4.

GS288: The DPAS shall relate reflective data within the product, after calibration, to Top of Atmosphere (TOA) reflectance with an absolute radiometric uncertainty of less than 3%, 1-sigma.
Rationale: Absolute calibration is required for retrieving surface reflectances. This ensures that the ground system correctly implements the data processing algorithms necessary to meet the OLI absolute radiometric uncertainty requirements.

GS289: The DPAS shall relate reflective data within the product, after calibration, to at-aperture spectral radiance with an absolute radiometric uncertainty of less than 5%, 1-sigma.

Rationale: Absolute calibration is required for retrieving surface reflectance (this is the historical Landsat requirement). This ensures that the ground system correctly implements the data processing algorithms necessary to meet the OLI absolute radiometric uncertainty requirements.

GS3099: The DPAS shall relate thermal data within the Level 1 products, after calibration, to at-aperture spectral radiance with an absolute radiometric uncertainty as specified in Table 3.1.
Rationale: Absolute calibration is required for retrieving surface reflectance (this is the historical Landsat requirement). This ensures that the ground system correctly implements the data processing algorithms necessary to meet the absolute radiometric uncertainty requirements.

Table 3.1 LDCM Thermal Digital Image Data Performance Requirements

Equivalent Blackbody Temperature Range	Absolute Radiance Uncertainty (1-sigma)
260K - 330K	<2%
240K - 260K	<4%
330K - 360K	<4%

GS1311: The DPAS shall generate Level 1G reflective data products with an internal geodetic pixel accuracy of 25 meters circular error at the 90% confidence level referenced to the WGS84 reference system, excluding the effects of terrain, after the removal of constant offsets.
Rationale: This is an internal error requirement on systematic products (L1Gs) with only shifts applied to the imagery (applied through precision correction weights related to X,Y, and/or Roll, Pitch corrections). Terrain correction is excluded and no corrections for yaw and orbital altitude errors are applied. This ensures that the ground system correctly implements the data processing algorithms necessary to meet the OLI Relative Geodetic Accuracy requirements.

GS284: The DPAS shall generate Level 1T reflective data products with internal accuracies sufficient to achieve an image-to-image co-registration accuracy of 12 meters in the along- and cross-track directions at the 90% confidence level, when projected to the WGS84 Earth ellipsoid surface, including compensation for the effects of terrain.
Rationale: Ensures the image internal geometric integrity necessary for applications that require accurate image-to-image registration such as land cover change detection. This ensures that the ground system correctly implements the data processing algorithms necessary to meet the OLI Image-to-Image Registration Accuracy requirements.

GS3100: The DPAS shall generate Level 1T thermal data products with internal accuracies sufficient to achieve an image-to-image co-registration accuracy of 45

meters in the along- and cross-track directions at the 90% confidence level, when projected to the WGS84 Earth ellipsoid surface, including compensation for the effects of terrain.
Rationale: Ensures the image internal geometric integrity necessary for applications that require accurate image-to-image registration such as land cover change detection. This accuracy is based on the RSS of the reflective band internal geometric accuracy requirement and the thermal to reflective band registration requirement.

GS285: The DPAS shall generate Level 1G reflective data products with a geodetic pixel accuracy of 65 meters circular error at the 90% confidence level referenced to the WGS84 reference system, excluding the effects of terrain.
Rationale: Provides absolute geolocation knowledge of 30 meters RMS which is consistent with recent (2005-2006) Landsat 7 performance. This is particularly important in a pushbroom architecture as terrain compensation is likely required to achieve band registration accuracy. Absolute geolocation knowledge is required to register the terrain data to the image data for proper processing. This ensures that the ground system correctly implements the data processing algorithms necessary to meet the OLI Absolute Geodetic Accuracy requirements.

GS3102: The DPAS shall generate Level 1G thermal data products with a geodetic pixel accuracy of 76 meters circular error at the 90% confidence level referenced to the WGS84 reference system, excluding the effects of terrain.
Rationale: Absolute geolocation knowledge is required to register the terrain data to the image data for proper processing. This accuracy is based on the Root Sum Square (RSS) of the reflective band geodetic accuracy requirement and the thermal to reflective band registration requirement.

GS283: The DPAS shall generate Level 1T reflective data products with a geodetic pixel accuracy of 12 meters circular error at the 90% confidence level referenced to the World Geodetic System, 1984 (WGS84) geodetic reference system, this includes correction for terrain.
Rationale: Ensures a high accuracy product suitable for GIS applications consistent with current Landsat 5 and 7 production systems. This ensures that the ground system correctly implements the data processing algorithms necessary to meet the OLI Geometric Accuracy requirements.

GS3101: The DPAS shall generate Level 1T thermal data products with a geodetic pixel accuracy of 42 meters circular error at the 90% confidence level referenced to the World Geodetic System, 1984 (WGS84) geodetic reference system, this includes correction for terrain.
Rationale: Ensures a high accuracy product suitable for GIS applications consistent with current Landsat 5 and 7 production systems. This accuracy is based on the RSS of the reflective band geodetic accuracy requirement and the thermal to reflective band registration requirement.

GS282: The DPAS shall generate Level 1T reflective data products with an OLI band-to-band co-registration accuracy of 4.5 meters in the along- and cross-track directions at the 90% confidence level.
Rationale: Though not quite as good as Landsat 7 band registration performance this requirement ensures band registration accuracy that is acceptable for spectral signature identification and achievable with an ALI-like architecture. This ensures that the ground system correctly implements the data processing algorithms necessary to meet the OLI Band-to-Band Registration Accuracy requirements.

GS3105: The DPAS shall generate Level 1T thermal data products with a thermal band-to-thermal band co-registration accuracy of 18 meters in the along- and cross-track directions at the 90% confidence level.
Rationale: Though not quite as good as Landsat 7 band registration performance this requirement ensures band registration accuracy that is acceptable for spectral signature identification and achievable with an ALI-like architecture. This accuracy corresponds to a pixel-fraction scaling of the 0.15 pixel reflective band requirement.

GS3103: The DPAS shall generate Level 1T thermal data products with a band-to-band co-registration accuracy of 30 meters or less in the along- and cross-track directions at the 90% confidence level between bands 1-9 and the two thermal bands.
Rationale: Though not quite as good as Landsat 7 band registration performance this requirement ensures band registration accuracy that is acceptable for spectral signature identification and achievable using separate reflective and thermal instruments. Note that the Landsat 7 band registration requirement was 0.28 pixels (LE90). Actual performance is significantly better.

3.4.3.4 Off-Nadir Product Accuracy

GS3063: The DPAS shall characterize the geodetic pixel accuracy of off-nadir Level 1G data products.
Rationale: Off-nadir pointing increases the sensitivity to absolute pointing knowledge errors and (less severely) to ephemeris errors. Line-of-sight deflection due to atmospheric refraction also becomes more significant off-nadir. These effects degrade the systematic geolocation accuracy from 65 m (CE90) at nadir to 80 m (CE90) at +/-15 degrees off-nadir. This is the expected performance of the products, but the GS requirement is only to characterize.

GS3062: The DPAS shall characterize the band-to-band registration accuracy of off-nadir Level 1T data products.
Rationale: Off-nadir pointing increases the sensitivity to relative pointing knowledge errors and to terrain effects degrading the band registration accuracy from 4.5 m (LE90) at nadir to 5.5 m (LE90) at +/-15 degrees off-nadir. This is the expected performance of the products, but the GS requirement is only to characterize.

GS3061: The DPAS shall characterize the image-to-image co-registration accuracy of off-nadir Level 1G data products.
Rationale: Off-nadir image-to-image registration must account for the case of +15 degree vs. -15 degree registration. The increased parallax in this image configuration substantially increases the sensitivity to terrain errors degrading the image registration accuracy from 12 m (LE90) at nadir to 18 m (LE90) at +/-15 degrees off-nadir. This is the expected performance of the products, but the GS requirement is only to characterize.

GS3060: The DPAS shall characterize the geodetic pixel accuracy of off-nadir Level 1T data products.
Rationale: Off-nadir pointing increases the sensitivity to pointing knowledge errors and to terrain effects and also makes control point correction somewhat more difficult. These effects degrade the L1T product accuracy from 12 m (CE90) at nadir to 16 m (CE90) at +/-15 degrees off-nadir. This is the expected performance of the products, but the GS requirement is only to characterize.

3.4.3.5 Image Assessment

GS1716: The DPAS shall support pre-launch instrument testing.
Rationale: Pre-launch instrument performance is validated through independent analysis by the government using ground system tools.

GS1712: The DPAS shall support on-orbit instrument checkout.
Rationale: Final instrument acceptance is supported through independent analysis by the government using ground system tools.

GS184: The DPAS shall maintain calibration parameters throughout mission life.
Rationale: Updated calibration parameters are needed to maintain radiometric, geometric and spatial performance of LDCM products throughout mission life.

GS238: The DPAS shall characterize radiometric performance of data.
Rationale: Radiometric performance includes absolute and relative radiometry, and all artifacts affecting the radiometric accuracy of the data.

GS240: The DPAS shall characterize geometric performance.
Rationale: Geometric performance includes absolute and relative geometry, and all measures that affect the geometric accuracy of the data

GS1718: The DPAS shall characterize spatial performance.
Rationale: Spatial performance is the MTF/PSF of the sensor and is used to verify the performance of the instrument.

GS242: The DPAS shall store the results of characterizations needed to determine radiometric, geometric and spatial performance.

Rationale: These characterizations are needed to determine calibration parameters and to evaluate the instrument and product performance.

GS311: The DPAS shall perform automated QA for selected sites.
Rationale: Some level of QA is performed for all scenes (e.g., scene quality), additional QA is performed on certain calibration sites. For example, the control point residuals for L1T processing provide additional geometric QA.

3.4.3.6 Metadata Generation

GS276: The DPAS shall generate entity metadata for all mission data with an indicator for reflective only, thermal only, and reflective + thermal.
Rationale: Metadata are needed to provide the general public with the ability to search and order LDCM data. This includes nadir and off-nadir scenes. Data collections will nominally include both reflective and thermal data. Non-nominal collections may be reflective-only or thermal-only. Metadata should include an indicator of data acquired: reflective only, thermal only, and reflective + thermal.

GS3250: The DPAS shall generate entity metadata for all Level 1 data with an indicator for reflective only, thermal only, and reflective + thermal.
Rationale: Metadata are needed to provide the general public with the ability to search and order LDCM data. This includes nadir and off-nadir scenes. Data collections will nominally include both reflective and thermal data. Non-nominal collections may be reflective-only or thermal-only. Metadata should include an indicator of data acquired: reflective only, thermal only, and reflective + thermal.

GS3249: The DPAS shall generate entity metadata for all Level 0 data with an indicator for reflective only, thermal only, and reflective + thermal.
Rationale: Metadata are needed to provide the general public with the ability to search and order LDCM data. This includes nadir and off-nadir scenes. Data collections will nominally include both reflective and thermal data. Non-nominal collections may be reflective-only or thermal-only. Metadata should include an indicator of data acquired: reflective only, thermal only, and reflective + thermal.

GS226: The DPAS shall generate pixel-level metadata for Level 0 data.
Rationale: Enables the construction of image masks based on metadata attributes for advanced analysis of each data product. This includes nadir and off-nadir scenes. Both reflective and thermal data, if available, may be used to generate pixel-level metadata.

GS3251: The DPAS shall generate pixel-level metadata for Level 1 data.

Rationale: Enables the construction of image masks based on metadata attributes for advanced analysis of each data product. This includes nadir and off-nadir scenes. Both reflective and thermal data, if available, may be used to generate pixel-level metadata.

GS1719: The DPAS shall assess cloud cover for all daytime Earth scenes collected.
Rationale: Provide the general public with the ability to search and order LDCM data that are not cloudy. This includes nadir and off-nadir scenes. Both reflective and thermal bands may be used to assess cloud cover.

GS216: The DPAS shall assess and report on the content and quality of all reflective, thermal, and reflective+thermal mission data.
Rationale: This is necessary to monitor instrument and product quality. Assessment and reporting enables fault detection and trending.

3.4.3.7 Throughput

GS188: The DPAS shall have the capability to ingest an average of at least 400 WRS-2 scene-equivalents of all reflective, thermal, and reflective + thermal mission data per 24 hour period.
Rationale: All complete intervals captured will be ingested. Data collections will nominally include both reflective and thermal bands. Non-nominal collections may include reflective bands only or thermal bands only.

GS1805: The DPAS shall have the capability to generate at least 400 Level 1 data products per day, using all bands collected: reflective, thermal, or reflective + thermal.
Rationale: Standard Level 1 data products will be generated for all scenes captured. Data collections will nominally include both reflective and thermal data, so the standard product storage area must be sized to accommodate L1T products that include both reflective and thermal bands. Non-nominal collections may include reflective bands only or thermal bands only.

GS163: The DPAS shall generate up to 40 cal/val data products per day, using all bands collected: reflective, thermal, or reflective + thermal.
Rationale: Cal/val scenes are ordered and processed on a routine basis to support operational cal/val activities. 40 scenes per day includes: lunar (14 per month), solar (1 every two weeks), dark (1 every two weeks), geometric supersites (36 scenes global (29 US, 7 international)), radiometric supersites (41 scenes global), random QA scenes (8 per day), and IC scenes (2 per day). Data collections will nominally include both reflective and thermal bands. Non-nominal collections may include reflective bands only or thermal bands only. Cal/val products will include all data acquired: reflective, thermal, or reflective + thermal.

GS171: The DPAS shall have the capability to reprocess mission data to Level 0 data for reflective, thermal, or reflective+thermal data.
Rationale: This capability is needed to deal with changes to Level 0 processing.

3.4.4 User Portal

3.4.4.1 Information Access

GS1729: The DPAS shall provide a secure LDCM project web site.
Rationale: The web site will provide controlled access and will strive to be un-hackable.

GS321: The DPAS shall provide the user community with technical information that describes LDCM data, products and systems.
Rationale: Providing the user community with product, system, and other information will reduce customer service questions. Reporting capabilities provide the public with all project information such as news reports, FAQs, science results, newsletter, production algorithms, etc

GS349: The DPAS shall provide the general public with non-discriminatory access to standard L1T data products.
Rationale: Continuity with Landsat 7 product suite. This is the standard product used for high accuracy applications where precise geolocation or multi-temporal image registration is required (e.g., the Multi-Resolution Land Characteristics consortium's National Land Cover Data).

GS332: The Ground System shall have the capability to distribute image processing source code, algorithms, and documentation.
Rationale: Encourages commercial adaptation of data processing capabilities. Also allow ICs to create their own data products.

GS319: The DPAS shall provide the capability to notify users of instrument and product anomalies.
Rationale: Providing the user community with product, system, and other information will reduce customer service questions.

GS320: The DPAS shall enable on-going communications and feedback with the user community.
Rationale: Providing the user community with product, system, and other information will reduce customer service questions.

3.4.4.2 Search & Discovery

GS1887: The DPAS shall provide a search capability for data products.
Rationale: This includes L0Ra and L1T products. Off-nadir products can also be searched via this capability.

GS334: The DPAS shall provide public access to LDCM metadata.
Rationale: The LDCM metadata includes L0Ra and L1T.

GS333: The DPAS shall provide public access to LDCM browse data.
Rationale: This is an access/distribution requirement as opposed to a production requirement.

GS3047: The DPAS shall generate full-spatial-resolution color-composite browse images using three reflective bands, each re-scaled from 16- to 8- bit by a means that preserves the dynamic range of valid data and seasonality.

Rationale: Sub-sampled browse are not always sufficient for determining image data quality for targets of interest due to clouds, shadows, and aerosol loadings.

GS3104: The DPAS shall generate full-spatial-resolution browse images using one thermal band, re-scaled from 16- to 8- bit by a means that preserves the dynamic range of valid data and seasonality.
Rationale: Sub-sampled browse are not always sufficient for determining image data quality for targets of interest due to clouds, shadows, and aerosol loadings.

GS1731: The DPAS shall support Open Geospatial Consortium (OGC) clients adhering to OGC standards.
Rationale: OGC compliance will enable support of standards based clients. The specific standards within the OGC are not specified here, but are left to L4 and design decisions.

GS342: The DPAS shall provide the capability for sending metadata notifications.
Rationale: Per Level 1 requirement to provide public with search and order capability.

GS339: The DPAS shall provide an inventory data management capability for authorized users.
Rationale: This allows proper data management of LDCM inventory holdings and products.

GS1733: The DPAS inventory shall comply with the Landsat Metadata Description Document.
Rationale: Needed for consistency with L1-L7 inventories.

GS348: The DPAS shall provide the capability to require all users to register before receiving LDCM data products.
Rationale: User registration is needed for reporting demographics. The capability is required; using the capability is a policy decision.

3.4.4.3 Order Interface

GS1880: The DPAS shall provide an authentication capability for confirming the authenticity of designated users.
Rationale: An authentication capability is required in order to challenge and identify designated users who have been granted special permission. This permission may include the ability to submit collection requests, bulk data orders, or requests to receive sensitive information not readily available to the general public.

GS344: The DPAS shall provide an interface for authorized users to submit data collection requests.
Rationale: A fraction of the daily image acquisitions and all of the priority image acquisitions are scheduled based on user requests.

GS1736: The DPAS shall provide an interface for authorized users to submit priority collection requests.
Rationale: A fraction of the daily image acquisitions and all of the priority image acquisitions are scheduled based on user requests.

GS1216: The DPAS shall provide an interface for cal/val users to request cal/val data products.
Rationale: The Cal/Val Team has the authority to order products other than the standard product.

GS341: The DPAS shall provide the capability for standing order requests for cal/val products.
Rationale: Instead of ordering every scene to be processed, criteria (and processing parameters) are set to automatically order and process certain scenes (e.g., geometric supersites, lunar, solar) to reduce the load on the Cal/Val team.

GS347: The DPAS shall provide data and information regarding the status of product requests and collection requests.
Rationale: Allowing users to review status of request reduces customer service questions.

3.4.4.4 Distribution

GS390: The DPAS shall provide a capability for electronic data distribution to allow users to pull (download) data.
Rationale: Pull capability provides the lowest O&M cost method for electronic data distribution. This includes standard data products as well as ancillary and auxiliary data distribution.

GS324: The DPAS shall distribute web-enabled standard L1T products.

Rationale: Continuity with Landsat 7 product suite. This is the standard product used for high accuracy applications where precise geolocation or multi-temporal image registration is required (e.g., the Multi-Resolution Land Characteristics consortium's National Land Cover Data). This includes nadir and off-nadir scenes.

GS385: The DPAS shall make available auxiliary and ancillary information to authorized users.
Rationale: The intent of this requirement is to support the distribution of certain ancillary and auxiliary data that is deemed to be sensitive. Authorized users are a subset of registered users.

3.4.4.5 Throughput

GS164: The DPAS shall distribute at least 1250 L1 data products per day.
Rationale: Demand for LDCM data is expected to be very high, due to high data quality and non-discriminatory web-enabled data access for users. This requirement specifies a cost-effective initial capacity, based on analysis of historical analogs and expected LDCM costs. Each product will include all bands acquired: reflective, thermal, or reflective + thermal.

GS3050: The DPAS shall distribute up to 100 L0Rp products per day.
Rationale: Demand for LDCM data is expected to be lower than demand for L1T products. This number is based on analysis of current Landsat 5 and 7 data distribution and includes expected expansion due to a single standard recipe product. Each product will include all bands acquired: reflective, thermal, or reflective + thermal.

GS1796: The DPAS shall provide the capability to limit the maximum number of simultaneous connections for all users accessing the LDCM ordering system.
Rationale: Using this capability is a policy decision. Also, setting the connection limit is a policy decision as well. Implementation of this requirement could be handled by setting firewall rules, using CAPTCHA, etc.

GS1797: The DPAS shall provide the capability to limit the maximum number of simultaneous connections by a single user.
Rationale: Using this capability is a policy decision. Also, setting the connection limit is a policy decision as well. Implementation of this requirement could be handled by setting firewall rules, using CAPTCHA, etc.

GS1798: The DPAS shall provide the capability to limit the maximum distribution volume by a single user.
Rationale: Using this capability is a policy decision. Also, setting the volume limit is a policy decision as well.

3.4.5 Storage and Archive

GS395: The DPAS shall provide a data cache for L1 data products.
Rationale: The data cache is needed to support web-enabled data distribution. Each product will include all bands acquired: reflective, thermal, or reflective + thermal.

GS393: The DPAS shall provide storage to accommodate auxiliary information over the life of the mission.
Rationale: This is needed to support the mission and to support web-enabled distribution of auxiliary information.

GS407: The DPAS shall archive all mission data, metadata, algorithms, databases, source code, and documentation.
Rationale: The mission data archive is the major end product of LDCM. Mission data will include all data acquired: reflective, thermal, or reflective + thermal.

GS1780: The DPAS shall archive the pre-launch test data.
Rationale: Pre-launch data is needed for testing.

GS190: The DPAS shall have the capability to store at least 400 L0 data scene-equivalents per day.
Rationale: DPAS must be able to store all LDCM data received which is currently anticipated to be 400 scenes per day. L0 data will include all data acquired: reflective, thermal, or reflective + thermal.

GS1781: The DPAS shall have the capability to archive at least 400 mission data scene-equivalents per day.
Rationale: 400 scenes per day is consistent with previous Landsat missions when IC data is included. Mission data will include all data acquired: reflective, thermal, or reflective + thermal.

GS402: The DPAS shall manage the data in the archive.
Rationale: Managing the data will help protect the mission archive.

GS401: The DPAS shall monitor, assess, and report on the quality of archived data.
Rationale: Quality control of data.

GS412: The DPAS shall provide reporting capabilities.
Rationale: Standard and ad-hoc reports will be needed for data volumes, throughput, latency, errors, etc.

GS400: The DPAS shall provide the capability to export the holdings of the archive.

Rationale: May need to export the holdings because of new hardware, for the purpose of cloning the archive, etc.

GS403: The DPAS shall maintain an on-site backup of the archive.
Rationale: The on-site copy will provide quicker recovery of data.

GS406: The DPAS shall maintain an off-site backup of the archive.
Rationale: This provides disaster recovery support as well as prevents a single point of failure of the archive. The off-site archive includes a subset of the data in the archive. Scalability applies to the off-site archive as well as the operational archive.

GS622: The DPAS shall ensure the transport of all backed-up data to the off-site archive within 30 days of receipt in the operational archive.
Rationale: Backing up the data in a timely manor is critical to protect against catastrophic loss.

GS415: The DPAS on-site and off-site archives shall meet NARA standards.
Rationale: NARA standards ensure appropriate environment to protect data in the on-site and off-site archive.

3.5 External Interfaces

3.5.1 NASA Services

GS1834: The GS shall interface with the GSAPMSO, FDF, NISN, SN, and NEN per the PSLA.
Rationale: The GS will utilize NASA Services to support the mission. The PSLA encodes all the requirements the project has on the services.

GS1849: The GS shall be compliant with the Space Network User's Guide (SNUG) Version 8 for SN interfaces.
Rationale: The GS will utilize existing capabilities of the NASA Space Network (SN) Services.

GS1850: The GS shall be compliant with the Ground Network User's Guide (GNUG) Version 2 for NEN interfaces.
Rationale: The GS will utilize existing capabilities of the NASA Near Earth Network (NEN) Services.

GS1851: The GS shall be compliant with the NISN Services Document for NISN interfaces.
Rationale: The GS will utilize existing capabilities of the NASA Integrated Services Network (NISN) Services.

3.5.2 Vandenberg AFB

GS612: The GS shall receive data from the Launch Site during pre-launch activities involving the observatory.
Rationale: Used to verify observatory health.

GS580: The GS shall receive real-time observatory housekeeping data from the Launch Site in real time.
Rationale: Used to verify observatory health.

GS611: The GS shall receive recorded observatory data (science and housekeeping) from the Launch Site.
Rationale: Used to verify observatory health.

3.5.3 Spacecraft Vendor

GS784: The GS shall receive observatory data from the Spacecraft Vendor for test support.
Rationale: For GRT and MRT support as well as integration testing.

GS790: The GS shall interface with the Spacecraft Vendor for testing observatory/MOC telemetry and command compatibility.
Rationale: For GRT and MRT support as well as integration testing.

GS1848: The GS shall have the capability to receive a validated Observatory T&C Data Base and updates from the Spacecraft Vendor.
Rationale: In order to update the Project DataBase (PDB).

GS1838: The GS shall have the capability to receive flight software updates from the Flight Software Vendor.
Rationale: Post-launch the satellite vendor may provide flight software updates as necessary to correct anomalies or other situations.

3.5.4 Instrument Vendor

GS774: The GS shall have the capability to receive a validated Instrument T&C Data Base and updates from the Instrument Vendor.
Rationale: In order to update the Project DataBase (PDB).

GS775: The GS shall receive instrument data from the Instrument Vendor for test support.
Rationale: For MOE integration testing as well as ingest and processing.

GS1839: The GS shall have the capability to receive instrument flight software updates from the Instrument Vendor.
Rationale: Post-launch the instrument vendor may provide flight software updates as necessary to correct anomalies or other situations.

3.5.5 International Cooperators

GS59: The GS shall receive IC ground station availability from International Cooperators.
Rationale: The CAPE keeps track of resource data (availabilities, configuration, etc) for each resource that can be scheduled or reserved for image data collections The IC ground stations fall into this category, and therefore the CAPE must receive and process the IC availability data in order to generate valid image data collection schedules. This availability comes via a phone call or email to the FOT. The FOT manually enters availability outages into the CAPE.

GS587: The GS shall send IC ground station schedules to International Cooperators.

Rationale: Once the IC ground station schedules are generated they must be forwarded to each IC. The CAPE has the interface to the ICs for this purpose and will therefore forward the schedules.

GS1809: The GS shall have the capability to validate and exchange mission data, metadata, and L1 product data with International Cooperators.
Rationale: Consistent with historical agreements with Landsat International Cooperators. The USGS maintains an inventory of the global inventory of Landsat data and requires a mechanism to share data between archives to recover lost data or acquire mission data from ICs that have captured data not downlinked to the LGN.

3.5.6 United States Naval Observatory

GS1795: The GS shall receive Earth Orientation Parameters from the United States Naval Observatory (USNO).
Rationale: UTC data is needed for ground operation commands and data products which is consistent with historical mission ops practices.

3.5.7 Robotics Lunar Observatory

GS528: The GS shall interface with the Robotics Lunar Observatory (ROLO).
Rationale: The USGS lunar calibration program provides radiometric calibration and sensor stability monitoring for remote sensing satellite imaging instruments using the Moon.

3.5.8 National Centers for Environmental Prediction

GS145: The GS shall retrieve global cloud cover prediction data from the National Centers for Environmental Prediction (NCEP).
Rationale: The CAPE will be using cloud cover prediction data to adjust the priorities of image data collection requests and therefore must be able to ingest this data from an external source on a regular basis. NCEP has been deemed the appropriate provider of cloud cover prediction data for LDCM.

3.6 Algorithms

3.6.1 OLI

GS3345: The GS shall characterize relative gain using the histogram method.

Rationale: Detector gain differences can cause striping in products, updating the relative gains can reduce or eliminate striping.

GS3342: The GS shall calibrate bias models.
Rationale: Bias model parameters are used to create the radiance and reflectance products.

GS3341: The GS shall convert detector response to radiance.
Rationale: The final step to create a radiance product is to scale the digital numbers to radiance.

GS3339: The GS shall remove biases from each detector's response.
Rationale: The first step in creating a radiance and reflectance product is to remove the bias from each detector's response.

GS3335: The GS shall refine detector line of sight models.
Rationale: Refining the line-of-sight model enables creation of precision products.

GS3334: The GS shall process raw ancillary data.
Rationale: Filtering the raw ancillary data eliminates gross errors which would cause registration errors. Raw GPS and attitude data may be needed to produce a product that meets requirements.

GS3333: The GS shall project the line of sight to the surface of the Earth.
Rationale: Grid creation provides the resampler with a quick way to determine which detector samples are needed to create the fixed grid output pixels.

GS3330: The GS shall characterize detector response to the lamp.
Rationale: Characterizing the detector response to the stim lamp indicates instrument performance.

GS3328: The GS shall combine L1R SCA data into a single image.
Rationale: A single radiometrically corrected image enables full field of view characterizations to be performed which indicate instrument performance and product quality.

GS3327: The GS shall assess band registration accuracy.
Rationale: Band registration accuray indicates instrument performance and product quality.

GS3324: The GS shall characterize dropped frames.
Rationale: Eliminating dropped frames from characterizations improves the accuracy of the radiometric assessments.

GS3323: The GS shall assess geometric accuracy of terrain-corrected products.
Rationale: Geometric accuracy indicates instrument performance and product quality.

GS3322: The GS shall characterize saturated pixels.
Rationale: Eliminating saturated pixels from characterizations improves the accuracy of radiometric assessment.

GS3321: The GS shall correct sensor chip assembly discontinuity.
Rationale: Correcting for banding between SCAs may be needed to create quality products.

GS3318: The GS shall correct residual striping.
Rationale: Adjusting the gains of each detector, on a per-scene basis, may be needed to create quality products.

GS3315: The GS shall assess cloud cover using the AT-ACCA method.
Rationale: Per-scene cloud cover is needed to fulfill the LTAP.

GS3314: The GS shall convert pixels to reflectance.
Rationale: Reflectance is the standard product.

GS3311: The GS shall characterize radiometric stability over 60 seconds.
Rationale: Radiometric stability indicates instrument performance and product quality.

GS3310: The GS shall perform cloud cover assessment using the See5 method.
Rationale: Per-scene cloud cover is needed to fulfill the LTAP.

GS3306: The GS shall characterize detector operability.
Rationale: The number of inoperable detectors indicates instrument performance and product quality.

GS3302: The GS shall trend instrument performance.
Rationale: Instrument characteristics stability indicates instrument performance.

GS3301: The GS shall characterize striping.
Rationale: Striping indicates product quality and supports striping correction.

GS3300: The GS shall calibrate band alignment.
Rationale: Updating the band-to-band alignment provides the capability to improve product quality.

GS3297: The GS shall characterize relative gain using the 90-degree yaw maneuver data.
Rationale: Detector gain differences can cause striping in products, updating the relative gains can reduce or eliminate striping.

GS3305: The GS shall calibrate focal plane alignment.

Rationale: Legendre polynomials are used to create the standard product, updates may be necessary from time to time.

GS3329: The GS shall characterize image non-uniformity.
Rationale: Image uniformity indicates instrument performance and product quality.

GS3343: The GS shall calculate detector response statistics.
Rationale: Detector statistics (histogram statistics) are used for determining bias and assessing the performance of the instrument.

GS3344: The GS shall determine each detector's bias.
Rationale: Per-detector bias is needed to create the radiance and reflectance products.

GS3338: The GS shall characterize SCA overlap statistics.
Rationale: Characterizing the radiometric shift between SCAs indicates how much banding exists in the radiometric products.

GS3340: The GS shall linearize each detector's response.
Rationale: Due to the expected non-linear response of the detectors, an adjustment to the detector response is performed to allow a linear gain to be applied in order to create the radiance and reflectance product.

GS3337: The GS shall correlate ground control points with systematic products.
Rationale: Ground control points are used to refine the line-of-sight model to meet product requirements.

GS3336: The GS shall create detector line of sight models.
Rationale: The initial line-of-sight model is used to create the systematic product and as a basis for the refined model.

GS3332: The GS shall resample the radiance product to a fixed grid.
Rationale: The resampler produces the pixels in the fixed grid output.

GS3331: The GS shall characterize detector response to the solar diffuser.
Rationale: Characterizing the detector response to the solar diffuser indicates instrument performance and product quality.

GS3326: The GS shall assess geodetic accuracy of systematic products.
Rationale: Geodetic accuracy indicates instrument performance and product quality.

GS3325: The GS shall assess image registration accuracy.
Rationale: Image-to-image registration accuracy indicates geolocation consistency across time.

GS3320: The GS shall characterize impulse noise.

Rationale: Eliminating impulse noise from characterizations improves the accuracy of radiometric assessment.

GS3319: The GS shall adjust gains for temperature sensitivity.
Rationale: Adjusting the gains and biases due to small temperature variations may be needed to create quality products.

GS3317: The GS shall interpolate across pixels from inoperable detectors.
Rationale: Interpolating across inoperable detectors may be needed to create quality products.

GS3316: The GS shall set saturated pixels to Lmax.
Rationale: When an area in an image saturates striping occurs due to the different detector gains, setting the saturated areas to Lmax eliminates striping.

GS3313: The GS shall rescale radiance.
Rationale: Since reflectance is a floating point value between 0.0 and 1.0, standard products must be scaled to an integer to be of use to the user community.

GS3312: The GS shall summarize cloud cover assessment.
Rationale: Per-scene cloud cover is needed to fulfill the LTAP.

GS3309: The GS shall assess cloud cover using the temporal method.
Rationale: Per-scene cloud cover is needed to fulfill the LTAP.

GS3308: The GS shall characterize coherent noise.
Rationale: Coherent noise characterization indicates instrument performance and product quality.

GS3307: The GS shall characterize modulation transfer function using bridges.
Rationale: The MTF (edge response) indicates instrument performance and product quality.

GS3304: The GS shall trend detector gain.
Rationale: Stability of the detector gains indicates instrument performance.

GS3303: The GS shall characterize signal to noise ratio.
Rationale: Signal-to-noise ratio indicates instrument performance and product quality.

GS3299: The GS shall characterize nonlinear response.
Rationale: Detector nonlinearity indicates instrument performance and product quality. Updates to the nonlinearity lookup table (or model) may be needed to create products.

GS3298: The GS shall characterize lunar irradiance.
Rationale: Characterizing the irradiance of the moon and comparing it to the ROLO model indicates instrument performance and product quality.

GS3346: The GS shall calibrate sensor alignment.
Rationale: Updating the sensor-to-spacecraft alignment matrix provides the capability to improve product quality.

GS3296: The GS shall characterize modulcation transfer function using the moon.
Rationale: The MTF (edge response) indicates instrument performance and product quality.

GS3295: The GS shall characterize terrain occlusion.
Rationale: Pixels that are blocked by other pixels are put into a mask for the end user.

3.7 NASA Services

The requirements defined in the following sections are defined at the level of the PSLA. They are utilization requirements levied on NASA institutional services.

3.7.1 Space Network

3.7.1.1 General

GS677: The SN shall provide telemetry and command RF communications interfaces between the observatory and the MOC.
Rationale: The reason SN is in the system is to provide command and telemetry coverage for launch, deployments, maneuvers and emergency situations.

GS711: The SN shall provide the capability to receive S-band real-time telemetry and send S-band commands simultaneously.
Rationale: SN application to LDCM is for LEO and contingency monitoring and control only.

GS690: The SN shall provide the personnel and facilities to support interface and system test activities.
Rationale: SN must be ready for RF compatibility testing, GRT's and MRT's.

GS691: The SN shall perform RF interface testing with the S/C at the spacecraft I&T facility.
Rationale: To ensure interface compatibility.

GS695: The SN shall coordinate interface fault isolation and recovery with the MOC whenever required.
Rationale: Troubleshooting of SN interfaces must be worked by staff on both sides of the interface.

GS696: The SN shall support troubleshooting and resolution of voice and data anomalies.
Rationale: Troubleshooting of SN interfaces may need to be worked by staff on both sides of the interface.

GS692: The SN shall accept commands, schedule requests, and acquisition data only from the MOCs.
Rationale: To maintain security of the LDCM observatory.

GS722: The SN shall provide a SNAS workstation to support the SN interfaces.

Rationale: SNAS provides an interface for scheduling TDRSS contacts.

GS718: The SN shall provide real-time telemetry and command services while simultaneously flowing playback telemetry from a prior pass or from the station archive to the MOE.
Rationale: The SN shall provide real-time telemetry and command services while simultaneously flowing playback telemetry from a prior pass or from the station archive to the MOC.

3.7.1.2 Scheduling

GS704: The SN shall plan and schedule Observatory support contacts on request.
Rationale: SN is not a dedicated resource so contacts must be scheduled.

GS705: The SN shall accept schedule requests for specific contact times from the MOC for the purpose of scheduling ground contacts.
Rationale: The MOE will determine suitable contact windows for potential use.

GS707: The SN shall resolve contact resource conflicts with other missions.
Rationale: The MOE is not aware of the overall SN schedule.

GS697: The SN shall be capable of scheduling a station within 15 minutes if the station will be in view of the S/C in the event that the FOT declares a S/C Emergency.
Rationale: In support of rapid response to a spacecraft emergency.

GS706: The SN shall provide long-range predictions of planned site outages for planning and scheduling purposes.
Rationale: Supports the 28 day forecast schedule within the MOE.

GS1800: The SN shall provide a schedule of confirmed contacts for the upcoming operational week, each week.
Rationale: Provide an operational schedule of SN contacts.

GS708: The SN shall provide a schedule of contacts for the upcoming three weeks, each week.
Rationale: Provide a forecast schedule of contacts for long-term planning of bus activities

GS709: The SN shall accept the updated orbit data from the MOC to perform station scheduling.
Rationale: The MOE provides the observatory ephemeris so the SN can compute tracking data.

GS710: The SN shall be able to propagate the Observatory orbit using data provided by the MOC to perform station scheduling and tracking.

Rationale: The MOE will not compute the pointing angles for the TDRSS spacecraft.

3.7.1.3 S-Band

GS687: The SN shall support an S-band downlink within the frequency range of 2200 MHz and 2290 MHz.
Rationale: This represents the entire spectrum allocation for Earth Science missions for telemetry downlink.

GS688: The SN shall support an S-band uplink within the frequency range of 2025 MHz and 2108 MHz.
Rationale: This represents the entire spectrum allocation for Earth Science missions for uplink.

GS679: The SN shall support selectable error-correction decoding on the S-band downlink compliant with CCSDS 131.0-B-1, sections 3.1 and 4.
Rationale: Error correction codes from CCSDS 131 were chosen to ensure integrity of the downlink and because the standard is widely adopted.

GS680: The SN shall support selectable error-correction coding on the S-band uplink compliant with CCSDS 231.0-B-1.
Rationale: Error correction codes from CCSDS 231 were chosen to ensure integrity of the uplink and because the standard is widely adopted.

GS681: The SN shall support selectable derandomization of the S-band downlink in accordance with CCSDS-131.0-B-1.
Rationale: Derandomization is required to ensure successful demodulation and CCSDS standards are widely adopted.

GS682: The SN shall support BPSK modulation of the S-Band uplink compliant with CCSDS 401.0-B-17.
Rationale: This is consistent with the bus design as given in the Space to Ground ICD 70-P58230P.

GS3265: The SN shall support OQPSK demodulation of the S-band downlink compliant with CCSDS 401.0-B-17.
Rationale: This is consistent with the bus design as given in the Space to Ground ICD 70-P58230P.

GS678: The SN shall accept S-band telemetry data from the Observatory at 2.046 kbps and 3.997 kbps.
Rationale: Consistent with Space to Ground ICD (70-P58230P).

GS720: The SN shall provide an S-band command uplink data rate of 1.024 kbps.
Rationale: This is consistent with the Space to Ground ICD 70-P58230P.

3.7.1.4 Command and Telemetry Data Handling

GS712: The SN shall uplink commands and data to the observatory received from the MOC.
Rationale: SN contacts are for real-time commanding and monitoring.

GS714: The SN shall transmit command data received to the Observatory with rate buffering as needed.
Rationale: SN contacts are for real-time commanding and monitoring. Only buffering and delays for communication protocol between MOE and SN, and any rate buffering to match the MOE transfer rate with the TDRSS and S/C uplink data/symbol rates. Command authentication will fail if commands arrive out of sequence. This also supports responsiveness of the commanding path for real-time commanding. It does not include NISN transfer time.

GS716: The SN shall forward telemetry frames from real-time Virtual Channels to the NISN network incurring only minimal time for the removal of the communication artifacts.
Rationale: SN contacts are for real-time commanding and monitoring. Minimal delay of real-time telemetry to maximize efficiency of station contacts.

GS703: The SN shall provide real-time station status data to the MOC, including antenna angles, received signal strength, and any other station equipment status.
Rationale: In support of real-time troubleshooting by the Flight Operations Team.

GS702: The SN shall initiate the retransmission of data to the MOC within 1 hour of receiving the retransmission request.
Rationale: Provide the capability to retransmit data stored at the SN to the MOC.

GS700: The SN shall provide real-time telemetry and command services while simultaneously flowing playback telemetry from a prior pass or from the station archive to the MOE.
Rationale: Since stored telemetry transfer could potentially take hours, this capability is required.

GS701: The SN shall store all telemetry data from the Observatory for a minimum of 7 days, for possible retransmission to the MOC.
Rationale: Provide the capability to retransmit data stored at the SN to the MOC.

3.7.2 Near Earth Network

3.7.2.1 General

GS724: The NEN shall provide telemetry and command RF communications interfaces between the observatory and the MOC.
Rationale: The NEN provides additional ground stations (over LGN) to support maneuvers or anomalies where additional telemetry and command contact time is required.

GS762: The NEN shall provide the following services to/from the S/C simultaneously: 1) S-band Real-time Telemetry; 2) S-Band Playback Telemetry; 3) S-band Command.
Rationale: These modes are all services LDCM requires of the NEN network stations. Supports observatory capabilities.

GS725: The NEN shall provide communications interfaces via the Svalbard (SGS) location.
Rationale: NEN stations selected to provide optimal LEO coverage.

GS726: The NEN shall provide communications interfaces via the Wallops (WGS) location.
Rationale: NEN stations selected to provide optimal LEO coverage.

GS727: The NEN shall provide communications interfaces via the McMurdo (MGS) location.
Rationale: NEN stations selected to provide optimal LEO coverage.

GS728: The NEN shall provide communications interfaces via the Alaska (AGS) location.
Rationale: NEN stations selected to provide optimal LEO coverage.

GS741: The NEN shall provide the personnel and facilities to support interface and system test activities.
Rationale: The NEN must be ready for GRT and MRT testing before launch.

GS742: The NEN shall perform RF interface testing with the S/C at the spacecraft I&T facility.
Rationale: To ensure RF compatibility.

GS743: The NEN shall accept commands, schedule requests, and acquisition data only from the MOC.
Rationale: To preserve observatory security.

GS746: The NEN shall coordinate interface fault isolation and recovery with the MOC whenever required.
Rationale: Troubleshooting of NEN interfaces may need to be worked by staff on both sides of the interface.

GS747: The NEN shall support troubleshooting and resolution of voice and data anomalies.
Rationale: Troubleshooting of NEN interfaces may need to be worked by staff on both sides of the interface.

GS769: The NEN shall provide real-time telemetry and command services while simultaneously flowing playback telemetry from a prior pass or from the station archive to the MOE.
Rationale: It will take longer than the inter-pass period to transfer the stored telemetry data.

3.7.2.2 Scheduling

GS748: The NEN shall be capable of scheduling a station within 15 minutes if the station will be in view of the S/C in the event that the FOT declares a S/C Emergency.
Rationale: In support of rapid response to an observatory emergency.

GS755: The NEN shall plan and schedule LDCM observatory support contacts on request.
Rationale: The MOE will drive NEN scheduling.

GS756: The NEN shall accept schedule requests for specific contact times from the MOC for the purpose of scheduling ground contacts.
Rationale: The MOE flight dynamics capability will determine the contact times and propose them to the NEN.

GS757: The NEN shall provide long-range predictions of planned site outages for Planning and Scheduling purposes.
Rationale: In support of the 4 week forecast schedule.

GS758: The NEN shall resolve station resource conflicts with other missions.
Rationale: The MOE has no visibility into the overall NEN schedules.

GS1801: The NEN shall provide a schedule of confirmed contacts for the upcoming operational week, each week.
Rationale: Provide an operational schedule of NEN contacts.

GS759: The NEN shall provide a schedule of contacts for the upcoming three weeks, each week.
Rationale: Provide a forecast schedule of contacts for long-term planning of bus activities.

GS760: The NEN shall accept the updated orbit data from the MOC to perform station scheduling.
Rationale: The MOE will provide the satellite vectors necessary for the contacts.

GS761: The NEN shall be able to propagate the observatory orbit using data provided by the MOC to perform station scheduling and tracking.
Rationale: The MOE will not calculate the azimuth-elevation angles necessary for each station to track the observatory.

3.7.2.3 S-Band

GS738: The NEN shall support an S-band downlink within the frequency range of 2200 MHz and 2290 MHz.
Rationale: This represents the entire spectrum allocation for Earth Science missions for telemetry downlink.

GS739: The NEN shall support an S-band uplink within the frequency range of 2025 MHz and 2108 MHz.
Rationale: This represents the entire spectrum allocation for Earth Science missions for uplink.

GS730: The NEN shall support selectable error-correction decoding on the S-band downlink compliant with CCSDS 131.0-B-1, sections 3.1 and 4.
Rationale: Error correction codes from CCSDS 131 were chosen to ensure integrity of the downlink and because the standard is widely adopted.

GS731: The NEN shall support selectable error-correction encoding on the S-band uplink compliant with CCSDS 231.0-B-1.
Rationale: Error correction codes from CCSDS 231 were chosen to ensure integrity of the uplink and because the standard is widely adopted.

GS732: The NEN shall support selectable de-randomization of the S-band downlink in accordance with CCSDS-131.0-B-1.
Rationale: Derandomization is required to ensure successful demodulation and CCSDS standards are widely adopted.

GS733: The NEN shall support BPSK modulation of the S-Band uplink compliant with CCSDS 401.0-B-17.
Rationale: This is consistent with the bus design as given in the Space to Ground ICD 70-P58230P.

GS3266: The NEN shall support OQPSK demodulation of the S-band downlink compliant with CCSDS 401.0-B-17.
Rationale: This is consistent with the bus design as given in the Space to Ground ICD 70-P58230P.

GS3352: The NEN shall support a configurable uplink sweep rate of 5-35 KHz per second.

Rationale: This is consistent with the Space to Ground ICD 70-P58230P.

GS3351: The NEN shall provide 54 dBW Effective Isotropic Radiated Power (EIRP) for all S-band uplinks.
Rationale: This is consistent with the Space to Ground ICD 70-P58230P.

GS3350: The NEN shall support a configurable uplink sweep range of +/- 160 KHz about the center frequency.
Rationale: This is consistent with the Space to Ground ICD 70-P58230P.

GS3349: The NEN shall provide a minimum clear-sky S-band G/T at 5 degrees elevation of 20 dB/K.
Rationale: This is consistent with the Space to Ground ICD 70-P58230P.

GS3348: The NEN shall support LHC polarization for the S-band uplink and downlink.
Rationale: This is consistent with the Space to Ground ICD 70-P58230P.

GS1771: The NEN shall support S-band telemetry data rate of 32 kbps (64 Ksymbols/sec after coding) during manuevers and off-nominal operations.
Rationale: Consistent with the space to ground ICD.

GS770: The NEN shall support realtime and stored S-band telemetry data from the Observatory at an aggregate rate of 1 Mbps (2 Msymbols/sec after coding) nominally.
Rationale: This rate supports the playback and realtime aggregate rates from the observatory during nominal operations.

GS771: The NEN shall provide S-band command uplink data rates of 2 kbps and 64 kbps.
Rationale: The low rate supports emergencies when extra link margin is valuable. The high rate supports normal operations. Note that data are encrypted at the MOC and the data rates shown include encryption overhead already.

3.7.2.4 Command and Telemetry Data Handling

GS765: The NEN shall transmit command data received at the NEN stations to the Observatory with rate buffering as needed.
Rationale: Only buffering and delays for communication protocol between MOE and NEN, and any rate buffering to match the MOE transfer rate with the S/C uplink data/symbol rate. Command authentication will fail if commands arrive out of sequence. This also supports responsiveness of the commanding path for real-time commanding. It does not include NISN transfer time.

GS767: The NEN shall forward telemetry frames from real-time Virtual Channels to the NISN network incurring only minimal time for the removal of the communication artifacts.

Rationale: Minimal delay of real-time telemetry to maximize efficiency of station contacts. This time begins when the last RF symbol of a transfer frame is received and ends when the first bit of the encapsulated packet hits the NISN. It does not include the NISN transfer time.

GS754: The NEN shall provide real-time station status data to the MOC, including antenna angles, received signal strength, and any other station equipment status.
Rationale: In support of troubleshooting of NEN links by the Flight Operations Team.

GS753: The NEN shall initiate the retransmission of data to the MOC within 1 hour of receiving the retransmission request from the FOT.
Rationale: This allows manual retransmission of stored telemetry data.

GS751: The NEN shall provide real-time telemetry and command services while simultaneously flowing playback telemetry from a prior pass or from the station archive to the MOE.
Rationale: Since stored telemetry transfer could potentially take hours, this capability is required.

GS752: The NEN shall store all telemetry data from the Observatory for a minimum of 7 days from time of receipt.
Rationale: Seven days supports transition to backup MOC in the event of a primary MOC failure without loss of telemetry data.

3.7.3 NASA Integrated Services Network

3.7.3.1 Voice

GS668: The NISN shall provide secure dedicated Closed Circuit Loop (CCL) or Station Conferencing and Monitoring Assembly (SCAMA) voice communications between the launch MOC and:

- LGN Ground Stations
- NEN Ground Stations
- SN White Sands Control
- Flight Dynamics Facility
- Vandenberg Launch Control

Rationale: Details will be provided in a Voice Matrix. NISN will provide voice communications services throughout the mission.

3.7.3.2 Data

GS1766: The NISN shall provide secure dedicated IONET IP communications to:

- GSFC MOC
- Backup MOC
- LGN Ground Stations
- NEN Ground Stations
- SN White Sands Control
- Flight Dynamics Facility
- Observatory I&T Facility
- Vandenberg Launch Control

Rationale: Details to be provided in the Data Matrix. NISN will provide narrowband communications services throughout the mission.

GS670: The NISN shall provide the networks to support pre-launch interface and system test activities.
Rationale: NISN services required to support pre-launch testing.

GS671: The NISN shall transport real-time data within 2 seconds between LGN, SN, NEN and the MOC.
Rationale: Network performance requirement.

GS675: The NISN shall be capable of transporting 24 hours of observatory housekeeping data to the MOC within a 5 hour period.
Rationale: Data throughput requirement to support NEN / SN acquired S-band data analysis.

3.7.4 Flight Dynamics Facility

GS569: The FDF shall provide orbit analysis support to the MOC for the pre-launch and L&EO phases.
Rationale: Verify and augment project flight dynamics capabilities.

GS602: The FDF shall receive the launch vehicle separation vector from the Launch Site.
Rationale: Utilize FDF interface and analytical capabilities during launch phase.

GS571: The FDF shall generate acquisition vector products using the launch vehicle separation vector within one hour (TBR) of separation.
Rationale: Utilize FDF interface and analytical capabilities during launch phase.

GS604: The FDF shall distribute acquisition vector products to SN, NEN, and GNE.
Rationale: Distribution of initial acquisition vectors during launch and early orbit.

GS116: The FDF shall interface with the MOE to provide verification of onboard ephemeris and attitude data.

Rationale: Support GPS and GS MOE FD capabilities.

GS605: The FDF shall be capable of receiving definitive orbit products from the MOE.
Rationale: Support GPS and GS MOE FD capabilities.

GS601: The FDF shall perform validation of MOE-provided definitive orbit products.
Rationale: Support GPS and GS MOE FD capabilities.

GS575: The FDF shall be capable of providing predicted and definitive orbit products to the MOE.
Rationale: Support GPS and GS MOE FD capabilities.

4 Appendix A: Allocations

4.1 Latency

GS181: The GS shall assess scene quality and cloud cover assessment for all scenes within 12 days of observation.

Allocations:

- GNE - Space to ground and delivery to EROS (10 days)
- DPAS -- Generate L1 product, assess scene quality and cloud cover (2 days)

4.1.1 Ground Network Element (GNE)

This is the allocation for the amount of time required to collect a scene in an orbit that requires the most time before reaching an LGN for transmission, as well as the time for real time data capture by the GNE. This includes the reception of wideband data and reception/transmission of narrowband data. This also includes the time for the collection of scene data into intervals that are subsequently forwarded to the DPAS for processing. This includes processing a maximum scene interval under a peak resource utilization condition.

4.1.2 Data Processing and Archive (DPAS)

This includes waiting for the associated calibration intervals, ingest processing, level 1 product generation, scene quality assessment, cloud cover assessment, archive and cache interactions and updating the User Portal catalog.

4.2 Data Loss

GS1338: The GS shall deliver at least 99% of the mission data acquired by the observatory to the science data archive, measured on a quarterly basis.

Allocations:

- FOT - Command generation (0.1%)

- MOE - Command generation (0.1%)
- GNE - Availability related losses (0.6%)
- DPAS - Data processing and archiving (0.2%)

4.2.1 Flight Operations Team (FOT)

This is the allocation for user error by the FOT in generating command loads, scheduling LGN stations, etc.

4.2.2 Mission Operations Element (MOE)

This is the allocation for the generation of command loads by the MOE.

4.2.3 Ground Network Element (GNE)

This is the allocation for the space to ground communications, ground station availability, ground station processing, and mission data WAN transfer errors. The primary contributor to error, however, is ground station availability, since it drives recorder usage. An extended ground station outage at the wrong part of the orbit will fill the recorder and data will either be overwritten or not be able to be added to the recorder (a loss in either case).

4.2.4 Data Processing and Archive System (DPAS)

This is the allocation of data loss caused by failure to deliver mission data to the archive, or data loss within the archive. Examples of potential data loss within the archive include drive or media failure, data mishandling or malicious activity, or a bug in the data management software.

5 Appendix B: DOORS Attributes

GSRD v2.1 DOORS
Attributes 8-16-09