L8 Mission Operations Center (MOC) Overview

The L8 Mission Operations Center (MOC) is comprised of the Mission Operations Element (MOE), Collection Activity Planning Element (CAPE), Flight Operations Team (FOT) and Ground Systems Infrastructure (GSI) team. All operational systems within the MOC are run on Virtual Machines. The MOE includes four primary functions: Telemetry, Command & Control; Planning and Scheduling; Flight Dynamics; and Mission Monitor & Analysis. Additional mission operations functions of flight software and mass storage management are also performed by the MOE. The CAPE builds and manages collection activity requests from the user community and the Long-Term Acquisition Plan (LTAP). The CAPE provides the data to Planning and Scheduling. The FOT operates the MOE and CAPE at the MOC and interfaces with the GNE. The GSI team manages the MOC infrastructure.

A limited number of MOC functions are available through remote access. Remote access to selected MOC functions such as trending data, observatory subsystem real-time telemetry and operational products & reports allow FOT members or observatory engineering support staff to support operations without being present in the MOC. Observatory commanding is not performed via remote access.

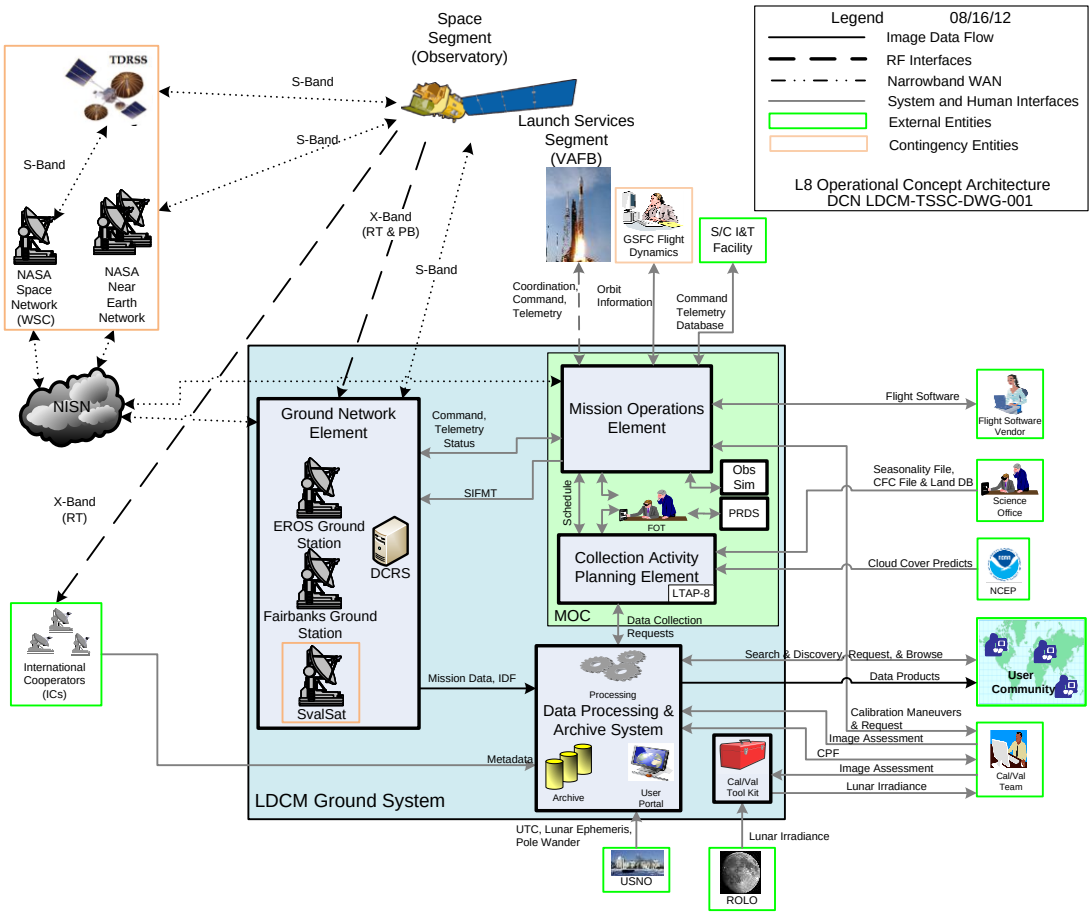

Figure 1L8 Ground System Architecture

1.1 MOC Interfaces

The MOC has a variety of external interfaces that are both internal and external to the Ground System.

Source	Destination	Data Product
MOC	GNE	Contact Forecast Requests Confirmed Contact Schedule Acquisition Data Scene-Interval-File Mapping Table GSE Directives Commands
MOC	DPAS	User Request Types and Parameters Collection Status Updates Collection Cancellation Confirmation Collection Request IDs Confirmed Contact Schedule Acquisition Data Scene Transmit Schedule
MOC	Flight Software Vendor	Stored Memory Loads Memory Dump Ground Reference Image Data (copy)
MOC	FDF	Orbit Products Orbit Maneuver Plans
MOC	CARA	Ephemeris Orbit Maneuver Plans
MOC	SN	Command Uplink Data Acquisition Data Schedule Requests
MOC	NEN	Command Uplink Data Acquisition Data Schedule Requests
MOC	Data Acquisition Manager	External Collection Requests
MOC	Mission Management Office	Reports
GNE	MOC	Contact Forecast Confirmation CFDP Status Messages GSE RT Status GSE Post Pass Reports S-Band RT Telemetry S-Band PB Telemetry X-Band PB Telemetry Housekeeping Telemetry (S&X-Band recorded)
DPAS	MOC	External Collection Requests Status Requests Cancellation Requests Scene Metadata Collection Request IDs
NCEP	MOC	Cloud Cover Predicts

Flight Software Vendor	MOC	Flight Software Updates Ground Reference Image Data
FDF	MOC	Orbit Products
CARA	MOC	Collision Avoidance Data
SN	MOC	Telemetry Data Confirmed Schedule Housekeeping Telemetry (recorded by the SN)
NEN	MOC	Telemetry Data Confirmed Schedule Housekeeping Telemetry (recorded by the GN)
USNO	MOC	Pole Wander
Data Acquisition Manager	MOC	Collection Requests Seasonality Record Updates Request Approval/Disapproval
Science Office	MOC	Cloud Fraction Climatology File Original Seasonality File Land Database File

Table 1 - MOC External Interfaces

1.2 Telemetry, Command & Control

The MOC Telemetry, Command and Control functions build command loads for transmission to the observatory. Command loads are built to implement observatory activity schedules and flight software updates. Observatory activity schedules are received from the MOC Planning & Scheduling function. Nominal daily command loads are automatically rule- and constraint- checked prior to uplinking. Commands are encrypted and routed to the LGN or through the SN for transmission to the observatory.

The Telemetry functions monitor the L8 observatory beginning with the receipt of real-time (RT) and stored housekeeping telemetry from the LGN or through the SN. Housekeeping telemetry is monitored and limit checked. Out of limit values trigger visual indicators, alarms, or other notification (e.g. paging) of the Flight Operations Team (FOT). The Telemetry functions also process X-band Stored State of Health (SSOH) downlinked to the LGN.

The L8 MOC accomplishes the Telemetry, Command and Control functions through utilizing the Integrated Test and Operations System (ITOS), a MYK-15a, Data Management System (DMS), and a collection of FOT generated scripts.

1.3 Planning and Scheduling (P&S)

Planning and Scheduling (P&S) functions plan/coordinate and schedule observatory and ground station activities. Key inputs to this function are the routine health & safety maintenance requirements of the observatory. The CAPE generates the high level instrument imaging mission schedules. The collection activity request is done to satisfy the requirements established in the LTAP, Calibration & Validation requests, International Cooperator requests and user requests. Upon receipt of the collection activity request, the MOC converts/assigns requested scenes to imaging intervals – periods of time when imaging sensor data is collected. Imaging intervals are assigned a unique identifier and the MOC will

maintain a Scene to Interval Mapping Table (SIMT). The imaging interval identifier is referenced in MOC commands for downlink and management of data (files) in observatory mass storage. The P&S reads in the Scene to Interval File Mapping Table (SIFMT) to determine which file identifiers are available for use. Any collections marked as protected are identified within the observatory commands so as to be protected from overwriting in observatory mass storage.

In addition to the CAPE collection activity requests, P&S plans and schedules

- Ground station contacts including those to the LGN, ICs, and those performed through the SN and GN.
- Downlink of housekeeping and mission data
- SSR memory management unprotect and retransmit events
- Upload of stored command loads
- Observatory activities including orbit adjustments, maneuvers, and other special events
- Lunar, solar, and other non-Earth imaging calibration activities

In order to develop activity plans and schedules, the FOT also performs activity management functions such as activity prioritization, activity resource allocation, and allocation of operational constraints. Mission health and safety activities are given higher priority over image collections.

Incorporating the collection activity requests, the P&S functions will plan and schedule observatory activities, perform constraint checking and schedule de-confliction, and generate the observatory activity schedule. Planning and Scheduling nominally generates an activity schedule every 24 hours, and each schedule encompasses 72 hours of observatory operations. Activity schedules are generated more frequently in response to updated cloud cover data, priority requests or other special circumstances. Activity schedules are provided to the CAPE, DPAS, and LGN stations for feedback/planning purposes.

The L8 MOC accomplishes the Planning and Scheduling functions through utilizing flexplan, CAPE, DMS and a collection of FOT generated scripts.

1.4 Flight Dynamics (FD)

The MOC Flight Dynamics functions include

- Orbit analysis and propagation
- Maneuver planning in order to support orbit maintenance, off-nadir imaging, calibration, and decommissioning maneuvers
- Calibration of any observatory on-board attitude sensors or propulsion components
- Generation of predicted ground station and SN contact/view periods
- Processing of on-board ephemeris data to produce predicted ephemeris that support planning and scheduling events
- Processing of on-board attitude sensors data to produce attitude history data

The L8 MOC accomplishes the Flight Dynamics functions through utilizing the Flight Dynamics System (FDS). The FDS combines FreeFlyer (FF) and Multi-mission Three-Axis Stabilized Attitude Support System (MTASS) (Matrix Laboratory [MATLAB]).

1.5 Mission Monitor and Analysis (MM&A)

All housekeeping telemetry for the mission is stored on-line by the MOC to support Mission Monitor and Analysis functions. The FOT, CVT and engineers use a suite of analysis tools within the MOC to perform long-term trending, analysis, anomaly investigation, etc. With these functions, authorized personnel generate automated and user-definable statistics, plots, and reports. The MOC sends processed housekeeping telemetry data to the DPAS in the form of engineering reports for use in image processing and image assessment by the CVT.

The L8 MOC accomplishes the Mission Monitor and Analysis functions through utilizing archiva and DMS.

1.6 Flight Software Management

Modifications or updates to observatory flight software are performed by the development contractors/organizations for the spacecraft and imaging sensors. Flight software modifications/updates are provided to the MOC for upload to the observatory. All flight software update command loads are tested first on the observatory simulator prior to upload to the flight observatory. The MOC maintains version control of the observatory flight software.

1.7 On-board Mass Storage Management

The MOC manages the observatory mass storage by monitoring mass storage utilization, scheduling mass storage data downlink and by monitoring the downlink of imaging sensor data through data receipt status messages received from the LGN stations. Imaging sensor data that has been successfully received by the LGN station is commanded by the MOC to be unprotected and available for overwriting in observatory mass storage. Successful receipt is indicated in the GNE Post Pass Report (GPR) received by the MOC from the LGN stations. Sensor data previously downlinked by the observatory but without successful receipt confirmation at any LGN station, is retransmitted on command. The MOC determines retransmission requirements, generates and uplinks the commands to do so.

The L8 MOC accomplished On-board Mass Storage Management by utilizing ITOS, an L8-specific File Accounting Tool (LFAT), and DMS.

1.8 MOC Interface to Simulators

The L8 Observatory Simulators are integrated within the L8 MOC. The L8 Observatory Simulators are used by the FOT to simulate interactions between the MOC and the flight L8 Observatory. There is a high fidelity observatory simulator that receives and executes commands, and generates simulated telemetry for analysis by FOT personnel. This high fidelity simulator simulates the capabilities of the observatory and its subsystems, including the L8 imaging sensors. The MOC also has a lower fidelity simulator that does not simulate all subsystems. The observatory simulators are used for FOT training, procedure validation, maneuver rehearsals/validation, flight software updates testing/validation and anomaly investigation/resolution.

1.9 Autonomy

The MOC operates in a 10 hours by 7 days mode for nominal operations. Unattended operations include autonomous contacts with ground stations, downlink of housekeeping and mission data, real-

time monitoring of the housekeeping telemetry data, monitoring of imaging sensor data receipt acknowledgements, and commanding to unprotect received mission data. The MOC system is capable of autonomously monitoring and reporting MOC systems status. Any mission-critical anomalies detected in housekeeping telemetry or within the MOC system cause the MOC to autonomously activate a notification and call-in system for the FOT.

In addition to the applications specified in each of the functional areas, the MOC utilizes Attention! Alarm Manager (AM) for notification of on-call staff.

1.10 Backup MOC

The L8 mission maintains a backup MOC that has all the capabilities of the MOC, and interfaces to the observatory simulator in the primary MOC via network connection. The bMOC is be located at the Goddard Space Flight Facility in a building separate from the primary MOC, so that it can serve as a backup in the event of a critical failure, malicious attack, or natural disaster at the primary MOC facility. The primary MOC routinely shares/updates command and control data and information with the bMOC so that the bMOC can assume operations of the L8 with no risk to mission health and safety, and minimal impact to image data collection.

1.11 L8 MOC Ground Systems Infrastructure (GSI) Team

The L8 MOC Ground Systems Infrastructure (GSI) Team is responsible for the Operations and Maintenance (O&M) of the L8 MOC Ground Systems Infrastructure. The GSI performs network administration, systems administration, IT Security Engineer, and database administration. The L8 MOC is independent from most GSFC services and GSI maintains the MOC's independent firewalls, network and active directory systems.

In addition to providing and installing their respective MOC Element Systems (MOE and CAPE); each vendor provides a level of Sustaining Engineering Support for their respective applications as defined in their contracts.