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Lunar Reconnaissance Orbiter Project

Mission Flight Rules and Constraints

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CM FOREWORD

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

Questions or comments concerning this document should be addressed to:

LRO Configuration Management Office
Mail Stop 431
Goddard Space Flight Center
Greenbelt, Maryland 20771

Signature Page

Prepared by:

_____ _____
Richard S. Saylor Jr Date
LRO Ground Systems & Operations Lead
HTSI/GSFC

Reviewed by:

_____ _____
Martin Houghton Date
LRO Deputy Mission System Engineer
NASA/GSFC, Code 599

Approved by:

_____ _____
Dave Everett Date
LRO Mission System Engineer
NASA/GSFC, Code 599

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1.0 INTRODUCTION

The primary objective of the LRO mission is to conduct investigations that support future human exploration of the Moon. The mission will launch late in 2008 and will take measurements of the Moon for at least one year.

1.1 SCOPE AND PURPOSE

This document will define all mission flight rules and constraints for the LRO mission. Often during the design and development of a mission, rules and constraints are identified to handle particular situations or conditions. This document captures those items to aid the mission operations team in development of the detailed flight procedures and operation plans. Items captured either as a flight rule or a constraint will cover orbiter level as well as any ground system rules.

1.2 ORGANIZATION

All flight rules and constraints will be captured in a series of tables. Each table will contain an item identifier, the rule/constraint, rationale for the item, and any exceptions to the rule. Flight rules and constraints are grouped according to the orbiter/ground segment functional subsystem or component.

1.3 CLASSES

Flight rules and constraints are categorized by class indicating the severity of the item. There are four classes of flight rules as follows:

Class A: Violation of this rule would result in the loss of the mission, in the loss of key objectives (specifically the loss of the capability to collect measurement data), in orbiter damage, or the loss of consumables.

Class B: Violation of this rule would result in loss or degradation of measurement data required to meet full mission success. Minimum mission success criteria would still be met.

Class C: Violation of this constraint would result in less optimum performance of the orbiter or temporary measurement data loss. Violation of this rule may not necessary affect the ability of the mission to meet full mission success criteria.

Class D: Violation of this rule may not lead to any loss of data or service, but could if compounded by additional circumstances. The rules are captured to provide the preferred way of implementing operations activities to prevent these situations.

1.4 RULE NUMBERING DEFINITION

Each rule/constraint is given a number for ease of identification in operations and procedures. The number gives information about class and the subsystem that the rule applies to as follows:

FR-<SubSystem>-<XXX>-<Class> where:

FR: Identifies that this is a flight rule

<subsystem>: Identifies which orbiter or ground segment component the rule applies

<XXX>: Three digit numbering for the rules. It should be noted that all rules are number sequentially. Numbers may not be consecutive for rules belonging to a particular subsystem.

<Class>: Classification of the rule

An example rule identification is: "FR-C&DH-001-B". The identification provides that this is the first C&DH flight rule and it is classification as "B".

1.5 FLIGHT RULE IMPLEMENTATION

The flight rule and constraints will identify what implementation is planned to address each rule or constraint. Table 1-1 describes the different implementation approaches.

Table 1-1: Rule Implementation Categories

Approach	Description
S/C Safing	Safing checks will be running as part of the on-board safing scheme
Mission Database	Limits or alerts will be configured in the mission command and telemetry database.
Ops Procedure	Checks and warnings will be implemented in both command procedures and flight procedures to ensure the operators are aware.
Ground System	Rules and error checking is built into the ground software to check for errors.

2.0 LRO MISSION FLIGHT RULES

The following sections provide tables for each major subsystems/components that a flight rule has been identified. The major subsystems list is defined in Table 2-1.

Table 2-1: Subsystem Identification List

Subsystem	Description
C&DH	Command & Data Handling
COMM	RF Communications System
CRAT	CRaTER Instrument
DLRE	Diviner Instrument
FSW	Flight Software (Includes C&DH and GN&C SW)
GN&C	Guidance Navigation & Control
LAMP	LAMP Instrument
LEND	LEND Instrument
LOLA	LOLA Instrument
LR	Laser Ranging System
LROC	LROC Instrument
MINI-RF	Mini-RF Instrument
OPS	Operations
PAYLD	Payload Suite (Applied to all instruments)
PDE	Propulsion Deployment Electronics
PROP	Propulsion
PSE	Power System

2.1 LRO FLIGHT SEGMENT RULES

The Table 2-2 provides the entire database listing of LRO flight rules and constraints. The table is sorted by subsystem grouping as identified in Table 2-1 and highlights any items that are classified as either “A” or “B”.

Table 2-2: LRO Mission Flight Rules and Constraints

No	Rule ID	System	Class	Mission Phase	Title	Rule/Constraint	Rationale/Description	Implementation
1	FR-C&DH-033-C	C&DH	C	All	C&DH Reset Counter Management	The C&DH Reset counter shall be reset to zero after cause of the problem was determined and resolved.	Spacecraft performs power cycle after 3 successive processor resets have occurred. If the counter is not reset, on the 3rd reset, the spacecraft will perform a power cycle.	Ops Procedure
2	FR-COMM-019-D	COMM	D	All	Ka-Band TWTA Turn-on	The TWTA shall be turned on 300 seconds before turning on the Ka modulator.	TWTA needs 300 seconds to warm-up	Ops Procedures Grnd System Rules
3	FR-COMM-045-B	COMM	B	All	Hotswitching Omni/HGA	RF Switch shall not be commanded while S-Band transmitter is on. Commanding the RF switch should be done while transmitter is off.	Prevent possible damage to RF components.	Ops Procedure
4	FR-COMM-046-C	COMM	C	All	S-Band/Ka-Band Transmitters turn-off	S-Band and Ka-Band transmitter shall be powered off after LOS.	Prevent possible thermal and power issues.	Ops Procedure
5	FR-CRAT-034-B	CRAT	B	All	CRaTER High Temperature	CRaTER shall not operate when the instrument temperature is greater than 35 degrees C for more than 60 seconds.	Damage to instrument could occur.	S/C Safing Mission Database
6	FR-DLRE-003-B	DLRE	B	All	DLRE Minimum Power On Temperature	DLRE should not be powered on when any DLRE temperature sensor is reading less than -20°C.	Lubrication in the actuators is not rated below -20°C and the lubricant will not flow properly which may damage the actuators.	Ops Procedures
7	FR-DLRE-004-C	DLRE	C	All	DLRE Power-Off Safing	DLRE should be "safed" 34 (TBR) seconds prior to the instrument power-off command being sent.	Instrument can be safed by sending the DLRE "safe" command or withholding the DLRE heartbeat. If power is removed before instrument is "safed" then the DLRE detectors may be destroyed.	S/C Safing Ops Procedures
8	FR-DLRE-005-D	DLRE	D	All	DLRE Power-On Delay	A minimum of 5 minutes must pass between DLRE power-off and subsequent DLRE power-on commands.	Five minutes are required for FPGA voltages to drain to a point that allow proper power-up phasing. If power on occurs faster than 5 minutes, power-on transient will increase significantly.	Ops Procedures
9	FR-DLRE-006-B	DLRE	B	All	DLRE Solar Avoidance	DLRE Shall not be allowed to scan and shall remain "safed" unless: - S/C is nadir pointing and in lunar orbit - DLRE is completely shaded by the S/C - DLRE representative specifically approves scanning	DLRE can not look into the Sun, if it does, DLRE dectectors may be destroyed.	On-Board Safing Ops Procedures

No	Rule ID	System	Class	Mission Phase	Title	Rule/Constraint	Rationale/Description	Implementation
10	FR-DLRE-007-C	DLRE	C	All	DLRE Minimum Scan Temperatures	DLRE shall not be commanded to begin scanning or allowed to scan when either the DLRE actuator temperature sensor is reading less than 0°C or the S/C bus voltage is less than 28 volts.	DLRE actuators do not generate sufficient torque to overcome lubricant viscosity below 0°C. Actuator torque is also affected by the bus voltage. Actuators may "stall" during nominal scanning which cause DLRE fault protection to safe the instrument.	Ops Procedures
11	FR-GN&C-001-C	GN&C	C	All	Reaction Wheel Turn-On	If any of the reaction wheels are turned off, they must remain off for at least 3 seconds before wheels can be turned on.	Time delay is needed to ensure the "soft-start" circuitry works correctly. If the wheel is turned off & on without waiting for 3 seconds, the well may not work properly.	Ops Procedures
12	FR-GN&C-002-C	GN&C	C	All	SA Position for Thruster Maneuvers	Before each thruster Delta-V maneuver, the solar array should be placed in the indexed position.	Solar array needs to be in the indexed position to ensure the proper spacecraft CG properties and avoid any thermal or contamination issues.	S/C Safing Ops Procedures
13	FR-GN&C-010-B	GN&C	B	All	System Momentum Limit	Momentum dumps (Delta-H) shall be performed within 1 day if the system momentum exceeds 110 nms (TBR).	If momentum dump is not performed, system momentum may increase beyond wheel capacity.	Ops Procedures
14	FR-GN&C-021-C	GN&C	C	All	GSE STOP Commanding	The ground shall send a STOP command to the GCE before issuing the INDEX, HOME or TRACK commands		Ops Procedures
15	FR-GN&C-036-B	GN&C	B	All	Sun Angle Violation	The mission shall prevent the Sun from entering the 60 degrees cone about the +Z axis.	Prevent possible damage to instruments. Some instruments are not affected, others have doors, but in general, the instrument should not pass or look at the Sun	S/C Safing Grnd System
16	FR-LAMP-022-B	LAMP	B	All	LAMP Bright Object Avoidance	LAMP boresight shall not be pointed within 15 degrees of the Sun with either the aperture door or fail safe door open	Possible thermal damage to instrument	Grnd System Ops Procedure S/C Safing
17	FR-LAMP-023-B	LAMP	B	All	LAMP Excessive Count Rates	When the detector high voltage is > 2000 V, the LAMP boresight shall not be pointed within 20 degrees of the Sun with either the aperture door or fail safe door open	Possible thermal damage to instrument	Inst. Safing S/C Safing
18	FR-LAMP-024-B	LAMP	B	All	LAMP Excessive Count Rates #2	When the detector high voltage is > 2000 V and the aperture door or fail safe door open, no portion of the LAMP slit as viewed through the aperture shall ever be pointed to any sources on the LAMP Bright Star Avoidance List	Possible thermal damage to instrument	Ops Procedure

No	Rule ID	System	Class	Mission Phase	Title	Rule/Constraint	Rationale/Description	Implementation
19	FR-LAMP-025-B	LAMP	B	All	LAMP LVPS Configuration	From launch until LAMP is fully commissioned, power shall be applied to only one side of the LVPS	LAMP has a state-machine timeout that with both low voltage supplies on and the C&DH failing to operate, the state-machine will activate the HVPS and enter into state machine mode within 32 seconds. With only one side powered, the timeout is 18 hours. (Note: Only one LTS channel is active with only one LVPS side operating.)	Ops Procedure
20	FR-LAMP-026-B	LAMP	B	All	LAMP Operations after Anomaly	LAMP Authorization is required to perform any instrument operations following an anomaly where the instrument was shut down.	Ensure instrument team is involved with the planning and execution of any troubleshooting and recovery.	Ops Procedure
21	FR-LAMP-027-B	LAMP	B	All	LAMP Initial HV Turn-On	LAMP Initial HV turn-on shall occur once the following requirements are met: (i) Spacecraft environment has reduced ambient pressures to <5x10-6 torr for 15 days. (ii) The aperture door shall be open. Note: If the aperture door is failed closed, a failsafe door open turn on may be considered. (iii) The detector door shall be open. Note: If the detector door is failed closed, opening the valve may be considered as a backup to evacuate the detector housing and a vent valve based HV activation may be used. (iv) >24 hours of decontamination heating of the OAP mirror and grating shall have been performed. (v) The LAMP temperature reference point shall be between –5<T<+35ºC. (vi) HV turn on shall be a critical command. (vii) Initial turn on shall require a real time link and a step-wise HV ramp up.	Ensure instrument is safe for high voltage activation	Ops Procedure
22	FR-LAMP-028-B	LAMP	B	All	LAMP General HV Turn-ON	LAMP temperature shall be within -5 and +35 degrees C before turning on HV	Ensure instrument is safe for high voltage activation	Ops Procedure

No	Rule ID	System	Class	Mission Phase	Title	Rule/Constraint	Rationale/Description	Implementation
23	FR-LAMP-029-B	LAMP	B	All	LAMP Latch Operation	Opening LAMP instrument Latch shall be performed when orbiter attitude is safe, HV is off, and LAMP temperature is between -5 and +35 degrees	Safe conditions for first latch opening	Ops Procedure
24	FR-LAMP-030-B	LAMP	B	All	LAMP Aperture Door Opening	LAMP Aperture Door shall be opened once the following conditions are met: - LAMP in safe attitude - Temperature between -5 and +35 degrees - Fail-safe door is closed	Safe conditions for opening aperture door	Ops Procedure
25	FR-LAMP-031-B	LAMP	B	All	LAMP Detecture Door Opening	LAMP Detecture Door shall be opened once the following conditions are met: - Spacecraft environment is < $5x10^{-6}$ torr - Optic decon heater on for at least 24 hours - Both mirror and grating heaters shall be on - Temperature between -5 and +35 degrees - Fail-safe door is closed	Safe conditions for opening detector door	Ops Procedure
26	FR-LAMP-032-B	LAMP	B	All	LAMP Vent Valve HV Activation	Vent Valve Activation shall occur when the following conditions are met: - At least 7 days have passed since the valve opening - Aperture door is open - Decon heater on for at least 24 hrs - LAMP temperature is between -5 and +35 degrees	Safe conditions for vent valve activation	Ops Procedure
27	FR-LOLA -052-B	LOLA	B	All	LOLA Laser Operation	Laser output shall be disabled during any thruster maneuvers or attitude slew maneuvers.	Since lasers are limited life items, prevent wasting of laser shots when instrument may not be pointed at the Moon.	Ops Procedure
28	FR-LR-012-B	LR	B	All	HGA Gimbal motion at low temperature	Gimbal motion should be prohibited when the fiber optic temperature is below -10º C.	Operations of the HGA gimbals below -10º C may cause damage to the fiber optic cables running from the LR receiver to the LOLA instrument.	S/C Safing Ops Procedures
29	FR-MINI-RF-013-C	MINI-RF	C	All	Mini-RF - LROC Operations	Mini-RF shall not operate simulataneously with LROC NAC data collection and storage activities.	If both instruments are sending high data rate (LROC NAC and Mini-RF high rate), the data will exceed the Space Wire bandwidth.	Ops Procedures

No	Rule ID	System	Class	Mission Phase	Title	Rule/Constraint	Rationale/Description	Implementation
30	FR-MINI-RF-014-C	MINI-RF	C	All	Mini-RF Data Collections	Mini-RF shall plan operating opportunities around available data storage capability.	LROC and Mini-RF share the same spacecraft recorder partition. When Mini-RF operates, LROC will need to account for the data collection from Mini-RF.	Ops Procedures
31	FR-MINI-RF-016-C	MINI-RF	C	All	Solar Array position for Mini-RF operation	Solar array shall be positioned in the Beta 90 while Mini-RF operations are planned.	To avoid solar array blockage, the solar array will be parked in the beta 90 position.	Ops Procedure S/C Safing
32	FR-MINI-RF-018-C	MINI-RF	C	All	Mini-RF and LROC Decon Heater	Mini-RF can not operate when LROC Decon. Heater is in use.	Mini-RF Power Amp and LROC Decon Heater share the same relay within the PDE box. Mini-RF operations will need to be coordinated around LROC Decon. Heater Operations.	Ops Procedure
33	FR-OPS-008-C	OPS	C	All	Spacecraft Clock Adjustments	Spacecraft clock adjustments shall not be performed within 10 (TBR) minutes of an LROC NAC image command.	Clock adjustments on LRO are expected to be infrequent, but an adjustment close to an LROC NAC image may cause timing problems in data processing.	Ops Procedures
34	FR-OPS-009-C	OPS	C	All	Delta-H prior to Yaw Maneuver	Operations shall schedule a Delta-H maneuver prior to any Yaw maneuver. Yaw maneuvers are performed prior to each monthly SK maneuver and twice a year.	If yaw maneuvers are performed without a Delta-H, the larger maneuver with high system momentum can cause large excursions away from the nominal path.	Ops Procedures
35	FR-OPS-011-C	OPS	C	All	Laser Ranging Operations	Laser Ranging shall not be performed when the spacecraft attitude does not allow a line of sight from the LR ground site to the LR receiver.	Avoid any potential issues with the LR hitting any other parts of the orbiter. While analysis shows the laser energy can not damage any detectors or sensors, this is just "good practice".	Ops Procedures
36	FR-OPS-037-B	OPS	B	All	Command Rate Limit for Ops RTSs/ATSs	Operations shall limit ATS and RTS commands to no more than 5 commands per second.	Spacecraft FSW can process up to 8 commands per second. Limiting the ground to 5 provides margin for on-board safing RTSs	Grnd System (MPS)
37	FR-OPS-038-C	OPS	C	All	LROC Recorder Allocation	The MOC shall provide a daily recorder allocation based on data downlinked and pass schedule.	Provides an allocation to LROC each day to prevent recorder partition from filling.	Grnd System
38	FR-OPS-039-D	OPS	D	All	USN S-Band Telemetry Rate Limit	USN S-Band telemetry rate shall not exceed 128kbps	USN link can not support any higher rates. The 128kbps link is assuming HGA operations	Grnd System
39	FR-OPS-040-D	OPS	D	All	WS1 S-Band Telemetry Rate Limit	WS1 S-Band telemetry rate shall not exceed 256kbps	WS1 link can not support any higher rates. The 256kbps link is assuming HGA operations	Grnd System

No	Rule ID	System	Class	Mission Phase	Title	Rule/Constraint	Rationale/Description	Implementation
40	FR-OPS-041-D	OPS	D	All	Daily ATS Uplink	For normal operations, the operations team will uplink an ATS load each day.	Ensures the latest input products are used in the generation of the ATS and provides the best possible LROC targetting	Ops Procedure
41	FR-OPS-042-D	OPS	D	All	Daily ephermis Table Uplink	For normal operations, the operations team will uplink a new spacecraft and Lunar ephermis tables each day.	Ensures the latest products are being used by the spacecraft FSW.	Ops Procedure
42	FR-OPS-043-D	OPS	D	All	Battery Depth of Discharge	For normal operations, the nominal depth of discharge for activities shall not exceed 20%	Exceptions are required for large lunar eclipses in 2010 and 2011. Limiting depth of dischage to 20% will extend battery life.	Grnd System
43	FR-OPS-044-D	OPS	D	All	Operations Requests/Inputs	All daily requests/inputs for the planning process shall arrive by Noon (local time).	Ensure proper time in receiving and processing request for generation/verification of daily ATS load.	Ops Procedure
44	FR-OPS-047-B	OPS	B	All	Tracking & Ranging following separation	Tracking & Ranging shall occur within 2 hrs following separation	Data is needed to plan for MCC which occurs at L+24 hrs	Ops Procedure
45	FR-OPS-058-D	OPS	D	All	HGA Station Target	HGA station target shall be updated prior to each AOS.	Ensures the maximum link performance and verifies that the HGA is in position for LR operations.	Ops Procedure
46	FR-OPS-059-A	OPS	A	All	Thruster maneuvers during Ground Contact	All thruster maneuvers shall be performed during ground contacts.	Ensure safe monitoring and assist in troubleshooting problems.	Ops Procedure Grnd System
47	FR-OPS-060-A	OPS	A	All	Non-Routine Activities	All Non-Roution Activities shall be either monitored or performed by the operations team.	Ensure safe monitoring and assist in troubleshooting problems.	Ops Procedure
48	FR-OPS-061-C	OPS	C	All	Daily Table Loads	Operations shall manually perform daily table loads which includes the ATS and the two ephermis tables.	Ensure safe monitoring and assist in troubleshooting problems.	Ops Procedure
49	FR-OPS-062-C	OPS	C	All	LOLA HK data during Laser Ranging	LOLA HK data shall be unfiltered in the S-Band link during laser ranging supports.	LOLA HK data is used to monitor ground base laser performance and timing.	Ops Procedure Grnd System
50	FR-OPS-020-C	OPS	C	All	Monthly SK Maneuver Sequence	The 2 SK maneuvers shall be performed on two separate orbits.	The entire sequence including Delta-H is estimated to take 140 minutes. This duration exceeds the power rule since during the sequence, the SA will need to be indexed.	Ops Procedure
51	FR-PDE-048-C	PDE	C	Early Cruise	Deployment Command Timing	Deployment commands for both the HGA and SA shall be spaced with 1 second interval.	Issue is only valid if deployment commands are performed using either RTS or ATS	Ops Procedure SA Deploy RTS
52	FR-PROP-049-B	PROP	B	All	Thruster Catalyst Bed Operations	Each thruster catalyst bed shall be turned on at least 30 minutes prior to any thruster maneuvers.	Prevent damaging of catalyst bed and reducing thruster performance.	Ops Procedure

No	Rule ID	System	Class	Mission Phase	Title	Rule/Constraint	Rationale/Description	Implementation
53	FR-PROP-050-B	PROP	B	All	Insertion Thruster Configuration	When using the four insertion thrusters, all 8 attitude thrusters should be enabled.	All 8 attitude thrusters are required to maintain pointing when the four insertion thrusters are used.	Ops Procedure
54	FR-PROP-051-A	PROP	A	All	Propulsion system regulation	The pressurant valves shall not be opened until just prior to LOI.	Due to full fuel load and possible temperature changes, the tank pressure may exceed tank rating.	Ops Procedure Mission Database
55	FR-PROP-017-A	PROP	A	All	Latch Valves Operation	Latch valves will remain open throughout the mission once commanded during the early mission.	Latch valves are closed at launch, once commanded opened, the valves will remain in that state for the entire mission.	Ops Procedure
56	FR-PWR-035-C	PWR	C	All	PSE Switch services for DLRE	PSE switches OM3-13 and OM3-12 are jumpered together. When turning on OM3-13, the PSE will turn on OM3-12 (3ms delay). This causes a FDC violation since OM3-12 was not commanded. When activating the switches, OM3-12 should be commanded before/after the OM3-13 command.	To avoid false FDC violation.	Ops Procedure
57	FR-PWR-053-B	PWR	B	All	S/C Bus Voltage	The operating bus voltage should be between 27-34 volts.	Operating components outside nominal range will impact performance.	S/C Safing Mission Database
58	FR-SYSTEM-054-C	SYSTEM	C	All	Daily Off-Nadir Slews	Daily off-nadir slews shall be limited to 3 per day. Each slew shall not exceed 20 degrees and 20 minutes.	Limit science impact on entire instrument suite. The limit of 3 per day is for the orbiter. There could be cases where request come from LROC, LOLA and Mini-RF.	Ops Procedure Grnd System
59	FR-SYSTEM-055-C	SYSTEM	C	All	Monthly calibrations	Instrument monthly calibrations shall be limited to 2 orbits per month.	Limit science impact on entire instrument suite.	Ops Procedure
60	FR-SYSTEM-056-C	SYSTEM	C	All	Attitude Slews	All attitude slews for instrument and spacecraft calibrations shall be performed in eclipse.	Prevent violating any thermal or power limits.	Ops Procedure Grnd System
61	FR-SYSTEM-057-C	SYSTEM	C	All	Transitioning to Observing Mode from Sun-Safe	When transition to Observing mode from Sun-Safe, a quaternion override sequence shall be used to place the spacecraft in an inertial sun-pointing attitude.	Prevents any accidental sun violation	Ops Procedure
62	FR-SYSTEM-063-C	SYSTEM	C	All	Transitioning to inertial Sun-Point and Nadir pointing.	When transitioning from observing mode inertial sun-point to nadir pointing, a sequence of attitude points shall be computed.	Slew sequence will ensure no Sun Violation and allows a safe transition to nadir pointing.	Ops Procedure Grnd System
63	FR-SYSTEM-015-D	SYSTEM	D	All	Cruise Nominal Attitude	During Cruise, the nominal attitude in observing mode is inertial Sun-point	Best thermal and power configuration.	Ops Procedure Grnd System

Appendix A. Abbreviations and Acronyms

Abbreviation/ Acronym	DEFINITION
Acq.	Acquisition
ACK	Acknowledge
ACS	Attitude Control System
AM	Avionics Module
AOS	Acquisition of Signal
ApID	Application Identification
bps	Bits per second
BU	Boston University
C&DH	Command and Data Handling
Cal/Val	Calibration and Validation
CCSDS	Consultative Committee for Space Data Systems
CFDP	CCSDS File Delivery Protocol
Cmd	Command
CMO	Configuration Management Office
CRaTER	Cosmic Ray Telescope for Effects of Radiation
CSS	Coarse Sun Sensors
dB	decibel
DC	Direct Current
DDS	Data Distribution System
DLRE	Diviner Lunar Radiometer Experiment
DSN	Deep Space Network
EOL	End of Life
ELV	Expendable Launch Vehicle
EMC	Electromechanical compatibility
EPV	Extended Precision Vector
ETU	Engineering Test Unit
eV	electron Volts
FD	Flight Dynamics
FDF	Flight Dynamics Facility
FDC	Fault Detection and Correction
FDH	Fault Detection Handling
FOV	Field of View
FSW	Flight Software
Gbits	Gigabits
GHz	Gigahertz
GN&C or GNC	Guidance Navigation and Control
Gnd	Ground
GS	Ground System

Abbreviation/ Acronym	DEFINITION
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HDBK	Handbook
HK	Housekeeping
HGA	High Gain Antenna
HGADAS	High Gain Antenna Deployment Actuation System
HTRs	Heaters
HV	High Voltage
HVPS	High Voltage Power Supply
I&T	Integration and Test
ICD	Interface Control Document
IM	Instrument Module
IMU	Inertial Measurement Unit
IRU	Inertial Reference Unit
ITOS	Integrated test and Operations System
JPL	Jet Propulsion Laboratory
Kbps	Kilobits per second
km	kilometer
KSC	Kennedy Space Center
LAMP	Lyman-Alpha Mapping Project
LAN	Local Area Network
lbf	Pound force
LEND	Lunar Exploration Neutron Detector
LOI	Lunar Orbit Insertion
LOLA	Lunar Orbiter Laser Altimeter
LOS	Loss of Signal
LRO	Lunar Reconnaissance Orbiter
LROC	Lunar Reconnaissance Orbiter Camera
LTS	LAMP Terminator Sensor
LV	Launch Vehicle
µs	microseconds
m	meter
m/s	Meters per second
MB	Megabyte
Mbits	megabits
Mbps	Megabits per second
MCC	Midcourse Correction
MOC	Mission Operations Center
MOT	Mission Operations Team
MPS	Mission Planning System

Abbreviation/ Acronym	DEFINITION
ms	millisecond
N/A	Not applicable
NAC	Narrow Angle Camera
NASA	National Aeronautics and Space Administration
nm	nanometer
NM	New Mexico
OD	Orbit Determination
PDS	Planetary Data System
PDU	Packet Data Unit
PM	Payload Module
PROM	Programmable Read-Only Memory
PSE	Power System Electronics
R-T	Real-Time
RF	Radio Frequency
rpm	Revolutions per minute
RS	Reed-Solomon
RX	Receiver
SA	Solar Array
SADA	Solar Array Deployment Actuation
SBC	Single Board Computer
SC or S/C	Spacecraft
SCS	Sequence and Compression System
SEU	Single-Event Upset
SK	Station-Keeping
SSR	Solid State Records
ST	Star Tracker
STOL	System Test and Operations Language
SwRI	Southwest Research Institute
T&C	Telemetry and Command
TBD	To Be Determined
TBR	To Be Resolved
TCS	Thermal Control System
TO	Telemetry Output
TT&C	Telemetry, Tracking and Control
TX	transmitter
UCLA	University of California Los Angeles
USN	Universal Space Network
UTC	Universal Time Code
UV	Ultraviolet
V	Volt(s)

Abbreviation/ Acronym	DEFINITION
VC	Virtual Channel
VCDU	Virtual Channel Data Unit
W	Watt
WAC	Wide Angle Camera
WSC	White Sands Complex
Xmitter or TX	Transmitter