

NING06ED46C

LRO S-Band TT+C Subsystem

Modifications 1-2

(1/9/07 - 8/2/07)

SCAN

AMENDMENT OF SOLICITATION/ MODIFICATION OF CONTRACT		1. CONTRACT ID CODE	PAGE OF 1 2
2. AMENDMENT/MODIFICATION NO. One (1)	3. EFFECTIVE DATE See Block 16C	4. REQUISITION/PURCHASE REQ. NO. See Block 12	5. PROJECT NO. (If applicable) Code 451
6. ISSUED BY National Aeronautics and Space Administration Goddard Space Flight Center Space Sciences Procurement Office Greenbelt, MD 20771		7. ADMINISTERED BY (If other than Item 6) Julie Janus (301) 286-4931	

8. NAME AND ADDRESS OF CONTRACTOR (No., street, county, State, and Zip Code)

General Dynamics C4 Systems
8201 E. McDowell Road
Scottsdale, Arizona 85252-1417

CODE (x)	9A. AMENDMENT OF SOLICITATION NO.	FACILITY CODE 9B. DATED (SEE ITEM 11)
X	10A. MODIFICATION OF CONTRACT/ORDER NO. NNG06ED46C	10B. DATED (SEE ITEM 13) May 23, 2006

11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS

The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offers is extended, is not extended. Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as amended, by one of the following methods:

(a) By completing Items 8 and 15, and returning Copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer Submitted; or (c) By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGEMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram Or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

12. ACCOUNTING AND APPROPRIATION DATA (If required)
BNC: GCE See Page 2 PPC: BX

13. THIS ITEM APPLIES ONLY TO MODIFICATIONS OF CONTRACTS/ORDERS,
IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.(x)

(x)	A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: (Specify authority) THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NO. IN ITEM 10A.
	B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (such as changes in paying office, appropriation date, etc.) SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(b).
	C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF:
X	d. OTHER (Specify type of modification and authority) Clause H.6, LIMITATION OF FUNDS (FIXED-PRICE CONTRACT) (1852.232-77) (MAR 1989)

E. IMPORTANT: Contractor Is not, Is required to sign this document and return _____ copies to the issuing office.

14. description of amendment/modification (Organized by UCF section headings, including solicitation/contract subject matter where feasible.)

This modification obligates incremental funding under this contract.

Accordingly:

Except as provided herein, all terms and conditions of the document referenced in Item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.

15A. NAME AND TITLE OF SIGNER (Type or print)		16A. NAME AND TITLE OF CONTRACTING OFFICER (Type or print) Julie Janus, Contracting Officer	
15B. CONTRACTOR/OFFEROR (Signature of person authorized to sign)	15C. DATE SIGNED	16B. UNITED STATES OF AMERICA BY  (Signature of Contracting Officer)	16C. DATE SIGNED January 9, 2007

1. Clause H.6, LIMITATION OF FUNDS, is revised as follows:

FROM BY TO

Firm-Fixed-Price \$2,399,312 \$2,399,311 \$4,798,623

The contract is fully funded.

2. ACCOUNTING AND APPROPRIATION DATA, is revised as follows:

<u>PR Number</u>	<u>G/L Account Number</u>	<u>Item Category</u>	<u>JOB</u>	<u>WBS Element</u>	<u>Internal Order Number</u>	<u>Cost Center</u>	<u>Fund Center</u>	<u>Fund</u>	<u>Amount</u>
4200184493	6100.2550	2550	51	342556.06.01.10.02	FC000000	515670	51	ESAX22007D	\$2,399,311

3. All other terms and conditions remain the same.

-- End of Modification Number 1 --

AMENDMENT OF SOLICITATION/ MODIFICATION OF CONTRACT	1. CONTRACT ID CODE	PAGE OF 1 5
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2. AMENDMENT/MODIFICATION NO. Two (2)	3. EFFECTIVE DATE See Block 16C	4. REQUISITION/PURCHASE REQ. NO. See Block 12	5. PROJECT NO. (If applicable) Code 451
6. ISSUED BY CODE 460 National Aeronautics and Space Administration Goddard Space Flight Center Space Sciences Procurement Office Greenbelt, MD 20771		7. ADMINISTERED BY (If other than Item 6) CODE 460 Julie Janus (301) 286-4931	

8. NAME AND ADDRESS OF CONTRACTOR (No., street, county, State, and Zip Code)

General Dynamics C4 Systems
8201 E. McDowell Road
Scottsdale, Arizona 85257

CODE (X)	FACILITY CODE
9A. AMENDMENT OF SOLICITATION NO.	9B. DATED (SEE ITEM 11)
X 10A. MODIFICATION OF CONTRACT/ORDER NO. NNG06ED46C	10B. DATED (SEE ITEM 13) May 23, 2006

11. THIS ITEM ONLY APPLIES TO AMENDMENTS OF SOLICITATIONS

The above numbered solicitation is amended as set forth in Item 14. The hour and date specified for receipt of Offers is extended, is not extended. Offers must acknowledge receipt of this amendment prior to the hour and date specified in the solicitation or as amended, by one of the following methods:

(a) By completing Items 8 and 15, and returning Copies of the amendment; (b) By acknowledging receipt of this amendment on each copy of the offer Submitted; or © By separate letter or telegram which includes a reference to the solicitation and amendment numbers. FAILURE OF YOUR ACKNOWLEDGEMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATE SPECIFIED MAY RESULT IN REJECTION OF YOUR OFFER. If by virtue of this amendment you desire to change an offer already submitted, such change may be made by telegram or letter, provided each telegram Or letter makes reference to the solicitation and this amendment, and is received prior to the opening hour and date specified.

12. ACCOUNTING AND APPROPRIATION DATA (If required)
BNC: GCE N/A PPC: BX

13. THIS ITEM APPLIES ONLY TO MODIFICATIONS OF CONTRACTS/ORDERS,
IT MODIFIES THE CONTRACT/ORDER NO. AS DESCRIBED IN ITEM 14.(x)

(x)	A. THIS CHANGE ORDER IS ISSUED PURSUANT TO: (Specify authority) THE CHANGES SET FORTH IN ITEM 14 ARE MADE IN THE CONTRACT ORDER NO. IN ITEM 10A.
	B. THE ABOVE NUMBERED CONTRACT/ORDER IS MODIFIED TO REFLECT THE ADMINISTRATIVE CHANGES (such as changes in paying office, appropriation date, etc.) SET FORTH IN ITEM 14, PURSUANT TO THE AUTHORITY OF FAR 43.103(b).
X	C. THIS SUPPLEMENTAL AGREEMENT IS ENTERED INTO PURSUANT TO AUTHORITY OF: FAR 52.243-1, CHANGES – FIXED PRICE (AUG 1987)
	d. OTHER (Specify type of modification and authority)

E. IMPORTANT: Contractor Is not, Is required to sign this document and return 3 copies to the issuing office.

14. description of amendment/modification (Organized by UCF section headings, including solicitation/contract subject matter where feasible.)

This modification provides for a revision to Attachment A, Statement of Work and Attachment C, Deliverable Items List and Schedule, under Clause J.1, List of Attachments, and as agreed to by both parties without an increase to the estimated firm-fixed-price.

Accordingly:

Except as provided herein, all terms and conditions of the document referenced in Item 9A or 10A, as heretofore changed, remains unchanged and in full force and effect.

15A. NAME AND TITLE OF SIGNER (Type or print) Tricia Lord Brumm, Principal Specialist, Contracts	16A. NAME AND TITLE OF CONTRACTING OFFICER (Type or print) Julie Janus, Contracting Officer	
15B. CONTRACTOR/OFFEROR  (Signature of person authorized to sign)	15C. DATE SIGNED 08/02/07	16B. UNITED STATES OF AMERICA BY  (Signature of Contracting Officer)
		16C. DATE SIGNED 8/2/07

1. Revise Clause B.1, Deliverable Requirements, as follows:

Item #	Description	Reference	Quantity	Delivery Date
1	SOW Requirements (431-SOW-000303)	C.1 & J.1	See C.1 & J.1	See C.1 & J.1
2	Performance Specification (431-SPEC-000121)	C.1 & J.1	See C.1 & J.1	See C.1 & J.1
3	Deliverable Items List and Schedule (431-LIST- 000304)	C.1 & J.1	See C.1 & J.1	See C.1 & J.1
4	DoD Industrial Plant Equipment (Form DD 1419)	NFS 1852.245-70	See G.1	See G.1
5	NASA Property in the Custody of Contractors (NASA Form 1018)	NFS 1852.245-73	See I.1	See I.1
6	New Technology Reports	G.1	See G.1	See G.1
7	Monthly Progress Reports	C.3	See C. 3	See C. 3
8	Final Report	C.2	1H/1E	February 4, 2008
9	Small Business Subcontracting Reports	H.3 & I.1	See H.3 & I.1	See H.3 & I.1
10	Commercial Transportation Bills	I.1	See FAR 52.247-67	See FAR 52.247-67
11	Protoflight S-Band TT&C Subsystem	SOW Section 5.6	1	October 15, 2007
12	Flight Qualified S-Band TT&C Subsystem	SOW Section 5.6	1	January 4, 2008
13	Connector Savers	SOW Section 5.7	1 for every external connector	with Item #11 and #12

<u>Item #</u>	<u>Description</u>	<u>Reference</u>	<u>Quantity</u>	<u>Delivery Date</u>
14	Mating Connectors	SOW Section 5.8	1 set of external connectors per TT&C Subsystem, plus two additional sets per TT&C Subsystem (Total of 6 sets)	with Item #11 and #12
15	Electrostatic Discharge (ESD) Caps	SOW Section 5.8	1 for every external connector; 1 closeout cap for every test connector	with Item #11 and #12
16	Shipping Containers	SOW Section 5.8	1 for each S-Band Transponder	with Item #11 and #12
17	Spare diplexer, switch, coupler	SOW Section 5.8	1 ea.	With item #12
18	Transponder Test Controller	SOW Section 5.9	1	With Item #11

(End of text)

2. Revise Clause C.1, Scope of Work, as follows:

The Contractor shall provide the personnel, materials and facilities, except as otherwise provided in the contract, necessary to provide the items described below and as described under Section J, Attachment A, entitled "Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Statement of Work, Revision A" dated March 20, 2007, Attachment B, entitled "Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Performance Specification" dated February 8, 2006, and Attachment C, entitled "Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Deliverable Items List and Schedule, Revision A" dated March 20, 2007. In addition, the Contractor shall provide the items specified under contract clause B.1.

3. Revise Clause F.3, Advance Notice of Shipment, as follows:

ITEM	DESCRIPTION	QTY	DELIVERY DATE	SHIPPING CLASS
11	Protoflight S-Band TT&C Subsystem	1	October 15, 2007	I
12	Flight Qualified S-Band TT&C Subsystem	1	January 4, 2008	I
13	Connector Savers	1 for every external connector	with Item #11 and #12	I
14	Mating Connectors	1 set of external connectors per TT&C Subsystem, plus two additional sets per TT&C Subsystem (Total of 6 sets)	with Item #11 and #12	I
15	Electrostatic Discharge (ESD) Caps	1 for every external connector; 1 closeout cap for every test connector	with Item #11 and #12	I
16	Shipping Containers	1 for each S-Band Transponder	with Item #11 and #12	I
17	Spare diplexer, switch, coupler	1 ea.	With item #12	I
18	Transponder Test Controller	1	With Item #11	I

4. Revise Clause J.1, List of Attachments, as follows:

<u>Attachment</u>	<u>Description</u>	<u>Date</u>	<u>No. of Pages</u>
A	Statement of Work (SOW) (431-SOW-000303), Revision A	March 20, 2007	34
B	Performance Specification (431-SPEC-000121)	February 8, 2006	84
C	Deliverable Items List and Schedule (431-LIST-000304), Revision A	March 20, 2007	9
D	Small Business Subcontracting Plan	March 31, 2006	12
E	Safety and Health Plan	April 14, 2006	6

5. In consideration of this modification agreed to herein as complete equitable adjustment based on the discussions between NASA/GSFC and General Dynamics on June 21, 2007, via teleconference, the Contractor hereby releases the Government from any and all liability under this contract for further equitable adjustment attributable to such facts or circumstances giving rise to the proposal for adjustment, which negotiations resulted in GD supporting the Preliminary Interface Testing in return for 3 RTAX 2000 devices.
6. All other terms and conditions remain the same.

-- End of Modification Number 2 --

Attachments: Attachment A, Statement of Work, Revision A, dated March 20, 2007 (34 pages)

Attachment C, Deliverable Items List and Schedule, Revision A, dated March 20, 2007 (9 pages)

Lunar Reconnaissance Orbiter Project

S-Band Telemetry, Tracking and Command Subsystem Statement of Work

March 20, 2007



**Goddard Space Flight Center
Greenbelt, Maryland**

TABLE OF CONTENTS

		<u>Page</u>
1.0	Introduction	1-1
1.1	General Information	1-1
1.2	General Requirements	1-1
2.0	Applicable and Referenced Documents	2-1
2.1	Applicable Documents	2-1
2.2	Referenced Documents	2-1
3.0	Management, Reporting, Documentation and Reviews	3-1
3.1	Management and Reporting	3-1
3.2	Documentation	3-1
3.3	Reviews And Meetings	3-1
3.3.1	Preliminary Design Review	3-1
3.3.2	Critical Design Review	3-2
3.3.3	Pre-Environmental Review	3-3
3.3.4	Pre-Shipment Review	3-3
3.3.5	Technical Interchange Meetings	3-3
3.3.6	Notification to NASA/GSFC Contracting Officer and Contracting Officer Technical Representative	3-3
4.0	Engineering	4-1
4.1	General Requirements	4-1
4.2	Engineering Documentation	4-1
4.2.1	Interface Control Document	4-1
4.2.2	Drawing Package	4-1
4.2.3	Preliminary Design Review Presentation Package	4-1
4.2.4	Critical Design Review Presentation Package	4-2
4.2.5	Data Delivery Package	4-3
4.2.6	Verification Test Plan	4-4
4.2.7	Verification Test Procedures	4-4
4.2.8	Preliminary Interface Testing	4-4
4.3	Thermal Analysis	4-4
4.3.1	Thermal Model	4-5
4.3.2	Thermal Model Documentation	4-5
4.3.3	Thermal Testing	4-6
4.4	Structural Analysis	4-6
5.0	Hardware Manufacture	5-1
5.1	S-Band Transponder	5-1
5.2	S-Band Diplexer	5-1
5.3	S-Band RF Transfer Switch	5-1
5.4	S-Band Directional Coupler	5-1
5.5	Integrated Subsystem Assembly	5-1

5.6	Connector Savers.....	5-1
5.7	Supporting Hardware.....	5-1
5.8	Ground Support Equipment.....	5-2
6.0	Quality Assurance.....	6-1
6.1	General Requirements	6-1
6.1.1	Quality Assurance Plan/Manual.....	6-1
6.1.2	Surveillance of the Contractor.....	6-1
6.1.3	Configuration Management.....	6-2
6.1.4	Anomaly Reporting	6-3
6.2	System Safety Requirements.....	6-3
6.3	Reliability Requirements	6-4
6.3.1	Failure Modes and Effects Analysis.....	6-4
6.3.2	Electrical, Electronic, and Electromechanical Parts Stress Analyses.....	6-4
6.3.3	Worst-Case Analyses.....	6-4
6.3.4	Limited-Life Items.....	6-5
6.4	Ground Support Equipment.....	6-5
6.5	Design Verification Requirements	6-5
6.5.1	Verification Requirements.....	6-5
6.5.2	Analysis/Trending/Reporting Of Test Data.....	6-6
6.5.3	Demonstration of Failure-Free Operation	6-6
6.6	Workmanship Standards and Processes	6-6
6.6.1	Workmanship: Use of Alternate Workmanship Standards.....	6-6
6.6.2	Training and Certification of Contractor Personnel	6-6
6.6.3	Hardware Handling, Cleaning And Packaging.....	6-6
6.6.4	Electrostatic Discharge Control Requirements.....	6-7
6.6.5	Workmanship Requirements For Printed Circuit Boards, Soldered Assemblies, Harnessing, and Fiber Optics	6-7
6.7	Electrical, Electronic, and Electromechanical Parts Requirement	6-8
6.7.1	General.....	6-8
6.7.2	Custom Devices.....	6-9
6.7.3	Plastic Encapsulated Microcircuits.....	6-9
6.7.4	Radiation Hardness.....	6-9
6.7.5	Parts Age Control	6-9
6.7.6	Government Industry Data Exchange Program Alerts and Problem Advisories.....	6-9
6.7.7	Reuse of Parts and Materials	6-10
6.7.8	Part Notification of Failure.....	6-10
6.8	Materials, Processes and Lubrication Requirements.....	6-10
6.8.1	Materials Selection Requirements	6-10
6.8.2	Vacuum Outgassing of Polymeric Materials.....	6-10
6.8.3	Stress Corrosion Cracking of Inorganic Materials	6-11
6.8.4	Lubrication Systems	6-11
6.8.5	Process Selection Requirements.....	6-11
6.8.6	Fasteners	6-11
6.8.7	Materials Procurement Requirements	6-11

6.8.8 Dissimilar Metals..... 6-11

7.0 Contamination Control Requirements..... 7-1

7.1 Thermal Vacuum Bakeouts 7-1

7.2 External Cleanliness 7-1

8.0 Handling, Storage, Packaging, Preservation, and Delivery..... 8-1

Appendix A. Abbreviations and AcronymsA-1

1.0 INTRODUCTION

1.1 GENERAL INFORMATION

The Lunar Reconnaissance Orbiter (LRO) mission objective is to conduct investigations that will be specifically targeted to prepare for and support future exploration of the Moon. This includes:

- Characterization of the lunar radiation environment, biological impacts, and potential mitigation.
- Key aspects of this objective include determining the global radiation environment, investigating the capabilities of potential shielding materials, and validating deep space radiation prototype hardware and software.
- Develop a high-resolution global, three-dimensional geodetic grid of the Moon and provide the topography necessary for selecting future landing sites.
- Assess in detail the resources and environments of the Moon's polar regions.
- High spatial resolution assessment of the Moon's surface addressing elemental composition, mineralogy, and regolith characteristics.
- The on-board S-Band transponder will be used to receive commands and transmit telemetry and tracking data to Earth-based ground stations.

This document defines the work to be performed for Contractor design, development, fabrication, and delivery of the S-Band Telemetry, Tracking and Command (TT&C) Subsystem for the LRO Mission.

1.2 GENERAL REQUIREMENTS

The Contractor shall provide the facilities, personnel, services, tools, equipment, and materials necessary to design, analyze, manufacture, inspect, test, and deliver:

- One (1) Protoflight S-Band Transponder
- One (1) Flight Unit S-Band Transponder
- Five (5) Flight Unit S-Band RF Diplexers
- Three (3) Flight Unit RF Transfer Switch
- Three (3) Flight Unit S-Band Directional Coupler
- Necessary cabling, connections, harness and other interconnects required to integrate these components into a Protoflight and a Flight S-Band TT&C Subsystem

The Contractor shall generate a matrix listing each section in this document reflecting either compliance or non-compliance. Areas of non-compliance need to be addressed by the Contractor showing how they plan to meet the requirement(s) or why it will remain non-compliant.

2.0 APPLICABLE AND REFERENCED DOCUMENTS

All applicable and reference documentation identified in this document shall apply in the situations where they are specifically referenced. In the event of a conflict between this document and the Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Performance Specification (431-SPEC-000121), this document shall take precedence.

2.1 APPLICABLE DOCUMENTS

431-LIST-000304	Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Deliverable Items List and Schedule
431-PLAN-000131	Spacecraft/Orbiter Performance Assurance Implementation Plan
431-PROC-000179	Lunar Reconnaissance Orbiter Project Configuration Management Procedure
431-PROC-000180	Reconnaissance Orbiter Data Management Procedure
431-RQMT-000174	Lunar Reconnaissance Orbiter Mission Assurance Requirements
431-SPEC-000121	Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Performance Specification
GPR-8730.1	Calibration and Metrology GSFC Procedural Requirements

2.2 REFERENCED DOCUMENTS

431-HDBK-000093	LRO Component Mechanical Interface Control Drawing Guidelines Handbook
541-PG-8072.1.2	GSFC Fastener Integrity Requirement Procedures and Guidelines
ANSI/ESD S20.20	Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)
ASTM E-595	Standard Test Method for Total Mass Loss and Collected Volatile, Condensable Materials for Outgassing
EEE-INST-002	Instructions for EEE Parts Selection, Screening, Qualification, and Degrating
GPR 7120.1	Program and Project Management Goddard Procedural Requirements
GSFC S312-P-003	Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses
GSFC-STD-7000	General Environmental Verification Specification (GEVS) for GSFC Flight Programs and Projects
IEST-STD-CC1246	Product Cleanliness Levels and Contamination Control Program
IPC-2221	Generic Standard on Printed Board Design
IPC-2222	Sectional Design Standard for Rigid Organic Printed Boards
IPC-2223	Sectional Design Standard for Flexible Printed Boards
IPC-6011	Generic Performance Specification for Printed Boards

IPC-6012	Qualification and Performance Specification for Rigid Printed Boards
IPC-6013	Qualification and Performance Specification for Flexible Printed Boards
IPC-A-600	Acceptability of Printed Boards
IPC-D-275	Design Standard for Rigid Printed Boards and Rigid Printed Board Assemblies
MIL-STD-889	Dissimilar Materials
MIL-STD-1629	Procedures for performing an FMEA
MSFC-STD-3029	Selection of Metallic Materials for Stress Corrosion Cracking Resistance
NASA-8739.2	Workmanship Standard for Surface Mount Technology
NASA-STD-8739.1	Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies
NASA-STD-8739.3	Soldered Electrical Connection
NASA-STD-8739.4	Crimping, Interconnecting Cables, Harnesses, and Wiring
NASA-STD-8739.5	Fiber Optic Terminations, Cable Assemblies, and Installation
NASA-STD-8739.7	Electrostatic Discharge Control (Excluding Electrically Initiated Explosive Devices)

3.0 MANAGEMENT, REPORTING, DOCUMENTATION AND REVIEWS

3.1 MANAGEMENT AND REPORTING

The Contractor shall designate a single individual who will be given full responsibility and authority to manage and administer all phases of the work specified by the contract, and ensure that all objectives are accomplished within schedule and cost constraints.

The Contractor shall designate and identify by name a single individual who shall serve as a point of contact with the Goddard Space Flight Center (GSFC) Contracting Officer Technical Representative (COTR) for all technical aspects of the LRO S-Band TT&C Subsystem.

The Contractor shall provide for managing all resources, controlling schedules, managing all engineering, manufacturing and procurement activities, configuration management (CM), quality assurance (QA), documentation control, and distribution.

The Contractor shall prepare and present to the National Aeronautics and Space Administration (NASA)/GSFC COTR monthly status via telecom and a written report. The report shall be a summary presentation of the period's progress, problem areas, and activities on-going and planned. The Contractor shall generate a list of significant milestones that will enable the NASA/GSFC COTR to ascertain program progress.

In addition, every week, on an agreed day by both the COTR and Contractor, the later shall provide an informal report through email on the current status of the TT&C Subsystem for that particular week. It should also comment on situations developed since the last report and developments planned for the following week. Additionally, it should also comment on potential problems the contractor might foresee that could affect the contract development, if any. An informal and short telephone call might follow to clarify questions and discuss issues.

3.2 DOCUMENTATION

The Contractor shall ensure the generation and delivery of all documentation as called for in the Contract.

In addition to that documentation specifically called for in the Contract, upon request by the NASA/GSFC COTR, the Contractor shall make available a copy of any document or data generated during this contract performance for review by the GSFC. This includes, but is not limited to, technical reports and memorandums, drawings, schematics, studies, analyses, parts and materials data, test data, alerts, etc.

3.3 REVIEWS AND MEETINGS

The following reviews shall be performed to fulfill the requirements as detailed within the Program and Project Goddard Procedural Requirements (GPR 7120.1)

3.3.1 Preliminary Design Review

The Contractor shall organize and present a Preliminary Design Review (PDR) to a GSFC Review Team at the Contractor's facility, unless otherwise agreed to by the Contractor and GSFC, on a date defined in the contract. The PDR shall demonstrate that the preliminary design

meets requirements for the system of interest with acceptable risk. The review shall show that the correct design option has been selected, interfaces identified, and verification methods have been satisfactorily described. An understanding of all interfaces, mechanical and thermal, and necessary interactions with the GSFC design team, as described in Sections 4.3 and 4.4, shall be demonstrated. The Review presentation package shall address all program management, design, analysis, manufacturing, test, and QA activities outlined in this document and the Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Performance Specification (431-SPEC-000121) in sufficient detail to meet the review requirements. This review shall cover programmatic, technical, test and verification, and QA topics. This review shall provide an opportunity to review drawings and all analyses before the expenditure of large scale resource, and shall establish the basis for proceeding with the detailed design.

The Contractor shall provide to GSFC a PDR Presentation Package and all other required deliverable data in accordance with the contract schedule. Refer to Section 4.2.3 and the contract schedule for the list of required deliverable data.

Review minutes shall be prepared and, as a minimum, shall include attendance, action items, action item accomplishment responsibility and agreements. All items shall be in sufficient detail to be self-explanatory. A Design Review Report shall be prepared following the review and, as a minimum, contain meeting notice, agenda, review meeting minutes described above and responses to all recommendations and action items.

3.3.2 Critical Design Review

The Contractor shall organize and present a Critical Design Review (CDR) to a GSFC Review Team at the Contractor's facility, unless otherwise agreed to by the Contractor and GSFC, on a date defined in the contract. The CDR shall demonstrate a final detailed design using completed drawings and analyses. The review shall demonstrate overall conformance of the requirements specified in the Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Performance Specification (431-SPEC-000121) and this document. Drawings and analyses should be released or ready for final review and approval. An implementation of all interfaces, mechanical and thermal, and necessary interactions with the GSFC design team, as described in Sections 4.3 and 4.4, shall be demonstrated. The review shall also include a manufacturing readiness, materials, quality control, and processes intended for production. This review shall cover programmatic, technical, test and verification, and QA topics. This review shall provide an opportunity to review drawings and all analyses before the start of Flight Unit fabrication.

The Contractor shall provide to GSFC a CDR Presentation Package and all other required deliverable data in accordance with the contract schedule. Refer to Section 4.2.4 and the contract schedule for the list of required deliverable data.

Review minutes shall be prepared and, as a minimum, shall include attendance, action items, action item accomplishment responsibility and agreements. All items shall be in sufficient detail to be self-explanatory. A Design Review Report shall be prepared following the review and, as a minimum, contain meeting notice, agenda, review meeting minutes described above and responses to all recommendations and action items.

3.3.3 Pre-Environmental Review

The Contractor shall organize and conduct a Pre-Environmental Review (PER) at the Contractor's facility, unless otherwise agreed to by the Contractor and GSFC, before the environment test program begins. This review shall demonstrate overall conformance of the requirements specified in the Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Performance Specification (431-SPEC-000121) and this document for this phase of the procurement. This review shall cover programmatic, technical, test and verification, and QA topics. This review shall also provide an opportunity to review test plans and procedures and all analyses required to approve the testing of the hardware.

3.3.4 Pre-Shipment Review

The Contractor shall hold a Pre-Shipment Review (PSR) at the Contractor's facility, unless otherwise agreed to by the Contractor and GSFC, at the completion of verification tests and prior to shipment of the hardware to GSFC. A PSR shall be held prior to the delivery of each hardware item. A Data Delivery Package (Section 4.2.5) shall be presented for review at each PSR.

3.3.5 Technical Interchange Meetings

The Contractor shall plan for informal, face-to-face Technical Interchange Meetings (TIM) to be held at the facilities selected by GSFC. These TIMs shall support review and coordination of technical issues including, but not limited to, parts, test plans, test procedures, software changes, design modifications, and design analyses. The TIM meeting notice shall be seven calendar days in advance of each meeting.

3.3.6 Notification to NASA/GSFC Contracting Officer and Contracting Officer Technical Representative

The Contractor shall notify the NASA/GSFC COTR at least ten calendar days in advance of all mandatory hardware inspections, test activities, and deliveries at either the Contractor's or a sub-Contractor's facility to allow timely participation by the NASA/GSFC QA parties.

4.0 ENGINEERING

4.1 GENERAL REQUIREMENTS

The Contractor shall perform analyses of the technical and environmental requirements specified in the Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Performance Specification (431-SPEC-000121) to ensure compliance of the hardware fabrication and to assemble the documentation necessary to ensure its usability by NASA/GSFC users.

4.2 ENGINEERING DOCUMENTATION

The system engineering analyses of the detailed design and subsequent fabrication and assembly, test, and inspection of the Transponder shall result, as a minimum, in the following technical documentation, as required in the Contract. Contractor format is suitable for this documentation.

4.2.1 Interface Control Document

The Contractor shall provide a document or documents that define, in detail, all performance, functional, and environmental specifications and all electrical, thermal, and mechanical interfaces described in Lunar Reconnaissance Orbiter Mechanical Interface Control Drawing Guidelines Handbook (431-HDBK-000093). Thermal interface information shall include thermal coatings on exterior surfaces and internal telemetry locations. Draft, preliminary and final reports shall be provided in accordance with the Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Deliverable Items List and Schedule (431-LIST-000304).

4.2.2 Drawing Package

The Contractor shall provide a drawing package that includes, but is not limited to:

ELECTRICAL: assembly and interface drawings (board level schematics available on request)

MECHANICAL: assembly and interface drawings

SOFTWARE: flowcharts, control logic, architecture, and structure of embedded software

Preliminary and final reports shall be provided in accordance with the Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Deliverable Items List and Schedule (431-LIST-000304).

4.2.3 Preliminary Design Review Presentation Package

The Contractor shall provide a PDR Presentation Package prior to the PDR, as described in Section 3.3.1, per the contract schedule. The Review presentation package shall address all program management, design, analysis, manufacturing, test, and QA activities outlined in this SOW and the Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Performance Specification (431-SPEC-000121) in sufficient detail to meet the review requirements. At a minimum, the design package should cover the following areas:

- Program Management
- Preliminary design for the EU
- Functional/Performance Requirements compliance
- Mounting interface approach
- Physical Characteristics compliance
- Electrical Characteristics compliance
- Life Requirements compliance
- Environmental Requirements compliance
- Thermal design and analysis results, including GSFC interface
- Mechanical/Structural design and analyses results, including GSFC interface
- Quality Assurance
- Verification test plan (including performance test description)
- Coupon program plan
- Non-destructive examination and defect acceptance criteria for workmanship
- Radiation hardness assessment (if applicable)
- Manufacturing flow with inspection points
- Facilities
- Materials and Processes
- Contamination Control
- Flight Heritage
- Verification Matrix
- Handling Guidelines

4.2.4 Critical Design Review Presentation Package

The Contractor shall provide a CDR Presentation Package prior to the CDR, as described in Section 3.3.2, per the contract schedule. The Review presentation package shall address all program management, design, analysis, manufacturing, test, and QA activities outlined in this document and the Lunar Reconnaissance Orbiter Project S-Band Telemetry, Tracking and Command Subsystem Performance Specification (431-SPEC-000121) in sufficient detail to meet the review requirements. At a minimum, the design package should cover the following areas:

- Program Management
- Final detailed design for the Engineering and Flight Units
- Functional/Performance Requirements, demonstration of specification compliance
- Mounting interface implementation
- Physical Characteristics compliance
- Electrical Characteristics compliance
- Life Requirements compliance

- Environmental Requirements compliance
- Updates to any analyses presented at PDR
- Quality Assurance
- Verification test plan (including Performance Test Description)
- Coupon program plan and status
- Radiation hardness assessment (if applicable)
- Manufacturing flow with inspection points
- Facilities
- Materials and Processes
- Contamination Control
- Flight Heritage
- Verification Matrix
- Handling Guidelines

4.2.5 Data Delivery Package

The Data Delivery Package shall be made available for review during mandatory inspections and PSRs for each of the different hardware deliverables. This package shall also be delivered with each end item with the level of detail required of that item. The package should be comprised of, but not limited to, the following data:

All Items:

- As-Built vs. As-Designed Parts List, (includes serialization/revisions)
- Final Drawing Package (including rework instructions, if any)
- Critical Parameters Trend Data,
- Problem/anomaly reporting (complete copies of report)
- Deviations/Waivers/open items/nonconformances and their dispositions,
- Class I Material Review Board (MRB) complete copies of reports
- List of Materials and Processes used,
- Log of total operating time,
- List and status of all identified Life-Limited Items,
- Verification matrix, test data and reports,
- Flight connector mate/demate log (Flight Unit only)
- Photograph Documentation (Pre-Closure and Closed)
- Certificate of Conformance
- Performance Analysis Report
- Thermal Analysis Report
- List of Open Items with proposed closure dates

4.2.6 Verification Test Plan

A Verification Test Plan shall be generated by the contractor to perform verification tests identified in the Lunar Reconnaissance Orbiter Project S-Band Telemetry, Tracking and Command Subsystem Performance Specification (431-SPEC-000121) document. Verification tests must demonstrate acceptable performance over the specified range of performance requirements, measure performance parameters and reveal inadequacies in manufacturing and assembly such as workmanship or material problems.

The plan should state the purpose of each test, state acceptance criteria, describe in detail the test method and instrumentation, and give the sequence of the tests. The plan should include a test matrix summarizing all tests that will be performed on the Transponder.

This plan shall be a contractor controlled document and shall indicate all changes made after the initial approval by the GSFC. After verification test plan approval, no changes shall be made without written NASA/GSFC COTR approval. Preliminary and final reports shall be provided in accordance with the Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Deliverable Items List and Schedule (431-LIST-000304).

4.2.7 Verification Test Procedures

The Contractor shall generate Verification Test Procedures. The verification procedures shall be step-by-step instructions for performing tests outlined by the Verification Test Plan. The procedures should define the environmental conditions for the tests, required equipment and facilities, test constraints, use of diagnostic or performance test software, operating conditions, tolerance on all input stimuli, data to be recorded and pass/fail limits. Test procedures shall also include Safe-to-Mate procedures to verify that ground support equipment (GSE) can safely be mated to interfaces and that interfaces are safe to accept mating with the GSE.

Verification test procedures shall be contractor controlled documents and shall indicate all changes made after the initial release for review to the NASA/GSFC COTR. Any additional changes shall be provided to the NASA/GSFC COTR for review.

4.2.8 Preliminary Interface Testing

The Vendors shall coordinate with GSFC the lending of a breadboard assembly of the unit so initial interface testing can be performed to verify compatibility of the spacecraft's C&DH, Flight Software and dedicated RF ground support equipment with the breadboard assembly.

4.3 THERMAL ANALYSIS

The vendor thermal analysis shall show that the device and/or the electronic part junction temperatures are within the Electrical, Electronic, and Electromechanical (EEE) parts de-rating guidelines for operation in a vacuum environment. Analysis shall prove that component will be within junction derating temperatures when spacecraft thermal interface is at maximum qualification temperature and when component is operating at maximum power dissipation. By analysis or by similarity to other flight qualified parts, vendor shall also prove that start up at minimum survival temperature is not an issue. Thermal model and thermal model documentation

as described below shall be provided with each Thermal Analysis Report. All analysis results shall be summarized in a Contractor-format for the Thermal Analyses Report, to be provided for review as per the contract schedule. LRO Thermal requires an analysis report at PDR, CDR, and at PSR.

4.3.1 Thermal Model

The Contractor shall provide a reduced thermal model with approximately 10 nodes (i.e., six nodes for exterior packaging box, four for interior components of interest). If 10 nodes are insufficient to capture appropriate internal to external resistances, then under agreement with LRO thermal systems lead, slightly larger models will be considered. The reduced thermal model shall also contain node(s) that approximately represents each internal telemetry point.

The thermal model will include an adequate level of detail to predict, under worst case hot, cold, and safe-hold conditions, all critical temperatures, including those that drive operational and survival temperature limits and heater power. Worst-case conditions will include a rational combination of the effects of design tolerances, fabrication uncertainties, material differences, and degradation due to aging. Models should use conservative property values for conduction, emission, and multi-layer insulation (MLI) effective emittance, and consider contact resistance.

4.3.2 Thermal Model Documentation

Model documentation shall identify the nodalization, the thermal couplings and masses such that the GSFC can recreate the model in the System Improved Numerical Differencing Analyzer (SINDA) thermal analyzer. It is preferable, however, that the vendor delivers the reduced model in SINDA format if convenient.

Thermal model documentation shall include, but not necessarily be limited to, the following information:

- a. Graphical figures showing node locations and coordinate system
- b. Graphical and/or table showing surface coatings matched to node numbers
- c. Tables providing the following information
 - Nodal thermal capacitance
 - Linear node-to-node conductors
 - Fixed radiation node-to-node conductors (if any).
 - Array data (e.g., temperature dependent properties, time varying power arrays, etc.)
 - Listing of nodes where operational and survival heater power is to be applied, associated nodes used for heater control, maximum heater power, heater ON/OFF set points, type of heater (bang-bang or proportional), and mission mode power profiles.
 - Detailed description of any special logic/algorithms utilized (e.g., heater control logic, Variable Conductance Heat Pipe [VCHP] logic, Capillary Pumped Loop [CPL]/Looped Heat Pipe [LHP] logic, etc.). No proprietary code will be allowed.
 - Detailed description of logic and use for any user provided subroutines
 - Listing of component power dissipations and the nodes they are applied to

- Listing of materials used along with their applicable thermo-optical and material properties
 - Listing correlating thermal model node(s) to each reference location where a monitored temperature sensor is placed
- d. Listing of temperature limits assigned to monitored temperature sensor(s). The appropriate node number(s) in the thermal model will be identified. The following two types of temperature limits will be provided.
- Flight Operational limits
 - Qualification limits

4.3.3 Thermal Testing

All components must be thermally cycled in a thermal vacuum chamber rather than in an air filled chamber. All components shall be flight like blanketed and cycled eight times with the thermal interface held at the qualification temperatures listed above at the thermal interface. Durations shall be four hours. If the component is sensitive to orbit transience, component performance shall be monitored during hot to cold transitions at a rate that a flight like orbit average case might experience.

Cold Start Requirement

All components shall demonstrate cold start from minimum survival temperature during thermal vacuum testing.

Survival Range Test

All components shall be exposed to hot and cold survival limits at the spacecraft interface during thermal vacuum testing.

4.4 STRUCTURAL ANALYSIS

A structural analysis shall be performed on the Flight Unit structure to ensure the capability to withstand and survive launch and ascent loads. The effects of any thermal inputs shall be reflected in the analyses as appropriate. The results of these analyses shall be summarized in a Contractor format Mechanical Analyses Report that will be provided to the NASA/GSFC COTR for review.

5.0 HARDWARE MANUFACTURE

5.1 S-BAND TRANSPONDER

The Contractor shall manufacture and test one Protoflight Unit S-Band Transponder and one Flight S-Band Transponder to meet the requirements of the Lunar Reconnaissance Orbiter Project S-Band Telemetry, Tracking and Command Subsystem Performance Specification (431-SPEC-000121).

5.2 S-BAND DIPLEXER

The Contractor shall procure and test five Flight S-Band RF Band-Reject Filter / Diplexer assemblies to meet the requirements of the Lunar Reconnaissance Orbiter Project S-Band Telemetry, Tracking and Command Subsystem Performance Specification (431-SPEC-000121). The Contractor must obtain the concurrence of the NASA/GSFC COTR before selecting a diplexer for procurement.

5.3 S-BAND RF TRANSFER SWITCH

The Contractor shall procure and test three Flight S-Band RF Transfer Switch assemblies to meet the requirements of the Lunar Reconnaissance Orbiter Project S-Band Telemetry, Tracking and Command Subsystem Performance Specification (431-SPEC-000121). The Contractor must obtain the concurrence of the NASA/GSFC COTR before selecting a RF Transfer Switch for procurement.

5.4 S-BAND DIRECTIONAL COUPLER

The Contractor shall procure and test three Flight S-Band RF Directional Coupler assembly to meet the requirements of the Lunar Reconnaissance Orbiter Project S-Band Telemetry, Tracking and Command Subsystem Performance Specification (431-SPEC-000121).

5.5 INTEGRATED SUBSYSTEM ASSEMBLY

The Contractor shall procure or manufacture the necessary cables, harness and interconnects to assemble the components of the TT&C Subsystem into an integrated Protoflight TT&C Subsystem and a Flight TT&C Subsystem. The Contractor shall integrate the components of Sections 5.1, 5.2, 5.3, 5.4, and 5.5 into an integrated TT&C Subsystem Assembly. The Contractor shall test the integrated TT&C Subsystem assembly for compliance with all component requirements.

5.6 CONNECTOR SAVERS

Flight Units shall be tested with connector savers to minimize mates and demates. Connector savers shall be delivered with each Flight Unit.

5.7 SUPPORTING HARDWARE

The Contractor shall provide the following supporting hardware:

- One set of the mating half of the external connectors for each delivered Unit, plus two additional sets per contract delivery schedule
- Electrostatic Discharge (ESD) flight protective caps, as applicable
- Closeout caps for test connectors

The Contractor shall provide two shipping containers, which will be used to ship the TT&C Subsystems from the vendor to GSFC. The shipping containers shall have temperature monitors and recorders, humidity recorders, and equipped with shock recorders. The Protoflight TT&C Subsystem shall use the same shipping containers as the Flight TT&C Subsystem. The design should be compliant with the Lunar Reconnaissance Orbiter Mechanical Interface Control Drawing Guidelines Handbook (431-HDBK-000093).

5.8 GROUND SUPPORT EQUIPMENT

The Contractor shall provide GSE to support integration and test (I&T) activities at the Orbiter level. GSE includes:

- Transport caps
- Transponder Test Controller

6.0 QUALITY ASSURANCE

6.1 GENERAL REQUIREMENTS

6.1.1 Quality Assurance Plan/Manual

The Contractor shall implement a Quality Management System that meets the intent of the requirements of American National Standards Institute (ANSI)/International Organization for Standardization (ISO)/American Society for Quality (ASQ) Q9001 (1994 or 2000 version) or equivalent. The Contractor shall submit a Quality Management Plan to GSFC, detailing how the requirements in Sections 6, 7, and 8 will be met. GSFC shall be notified of any changes to the QA program.

6.1.2 Surveillance of the Contractor

The work activities and operations of the contractor, subcontractors, and suppliers are subject to evaluation, review, survey, and inspection by GSFC representative.

The Contractor shall provide the GSFC representative with documents, records, equipment, and workings areas within their facilities that are required by the representative to perform their overview activities.

6.1.2.1 Government Source Inspection

The Government may elect to perform inspections at a supplier's plant. The following statement shall be included on all contract or subcontract documents: "All work on this order is subject to inspection and test by the Government at any time and place".

The Government QA Representative who has been delegated NASA QA functions on this procurement shall be notified immediately upon contractor receipt of any supplier/ subcontractor orders. The Government QA Representative shall also be notified 48 hours in advance of the time that articles or materials are ready for inspection or test.

6.1.2.2 Contractor Source Inspection

The Contractor shall ensure that its contract or subcontract documents impose the applicable requirements on subcontractors and other suppliers. The subcontractor and other suppliers shall in turn impose the requirements on their procurement sources.

The Contractor shall perform source inspection at the subcontractor's or supplier's facilities in accordance with the contract or subcontract documentation or when one or more of the following conditions exist:

In process, end item controls, or tests that are destructive in nature prevent the developer from verifying quality after delivery to the developer's facility.

It is not feasible or economical for the contractor to determine the quality of procured articles solely by inspections or tests performed at the contractor's facility.

Qualification tests are to be performed by the subcontractor or supplier.

Products are shipped directly from the source to NASA, by-passing the Contractor's inspection facilities.

6.1.2.3 Government Mandatory Inspection Points

The Government or its representative will perform the following Government Mandatory Inspection Points (MIP) listed below. The Government may request additional MIPs if a specific process prohibits inspection at a later time. MIPs are reviewed at the TIM and are mutually agreed upon prior to production under this contract.

MIPs to be performed:

- Inspect 100% solder
- Inspect 100% crimps
- Inspect 100% conformal coating, staking, and potting
- Rework Inspection
- Pre-closure Inspection
- Pre-Shipment Inspection / Data Review

6.1.3 Configuration Management

The Contractor's CM system (available for review on request) shall control the design and hardware/software by means of drawings, specifications, and other documents and shall ensure all applicable changes are reviewed in a systematic manner to determine the validity and impact on performance, schedule, and cost. The Contractor's CM system shall have a change classification and impact assessment process that ensures Class I changes are forwarded to the CO for approval prior to release/incorporation. Class I changes are defined as changes that affect form, fit, function, external interfaces, or requirements as stated within this document and the Lunar Reconnaissance Orbiter Project S-Band Telemetry, Tracking and Command Subsystem Performance Specification (431-SPEC-000121).

All other changes are considered to be Class II changes and shall be controlled and dispositioned by the contractor. All Class II changes shall be provided monthly to the COTR for review purposes. NASA/GSFC reserves the right to review all Class II changes for technical content to ensure the proper classification has been assigned. Any flight item that is found to be non-compliant with the quality, workmanship and performance requirements of the contract shall be dispositioned via a waiver or MRB, unless the affected item is reworked to restore compliance or is replaced with a fully compliant item. The Contractor shall submit Waivers to the COTR for final approval.

A Contractor QA Representative shall be a member of the Configuration Control Board (CCB). The QA activities shall be defined in the Contractor's Configuration Management Plan and described in detail in the Quality Assurance Plan in accordance with the Lunar Reconnaissance Orbiter Mission Assurance Requirements (431-RQMT-000174). Related portions of the plans shall be cross-referenced.

All Contractor's CM related activities and deliveries shall be done in accordance to the Lunar Reconnaissance Orbiter Project Configuration Management Procedure (431-PROC-000179).

The Contractor shall provide a Data Management Plan, which shall be compliant with the Lunar Reconnaissance Orbiter Data Management Procedure (431-PROC-000180).

6.1.4 Anomaly Reporting

Reporting of hardware anomalies to the NASA/GSFC COTR shall begin no later than the first power-on acceptance testing or the first cycle/actuation for mechanical items at the start of acceptance testing. The NASA/GSFC COTR shall be notified within 24 hours of each anomaly occurring during acceptance testing.

The Contractor's processes for review, disposition and approval of anomaly reports shall be described in their quality plan/manual or provided as a supplement document. In addition, the Contractor's anomaly reporting document shall describe the members of the MRB and Failure Review Board (FRB). The MRB and FRB shall include LRO GSFC participation. These processes shall ensure that positive corrective action has been taken to preclude recurrence and that appropriate audits and tests are performed to verify the implementation of the corrective action.

The Contractor shall routinely inform the LRO QA Representative of MRB and FRB meeting schedules and agendas with sufficient notice to permit LRO Project participation if desired by LRO.

At the Contractor's facility, NASA/Government representatives may participate in MRB/FRB activities as deemed appropriate by Government management or contract.

The NASA/GSFC COTR reserves disapproval rights on MRB and FRB decisions. To assure process consistency, the contractor shall provide the LRO Project access to their LRO anomaly reporting database. The project office shall be informed of decisions on MRBs and FRBs via e-mail or by mail.

The Contractor shall provide, as part of the monthly report, a list of all open anomaly reports and a separate list of the anomaly reports closed during the month. For each reported anomaly or nonconformance, there shall be a report that documents the investigation and engineering analysis needed to determine the cause and corrective actions to disposition the nonconformance, and identify any closed problem reports that do not have a definitive cause or corrective action. Reports shall be submitted to the NASA/GSFC COTR for review and approval of the disposition.

The supplier shall establish and maintain documented procedures to ensure product that does not conform to specific requirements is prevented from unintended use or installation. This control shall provide for identification, documentation, evaluation, segregation (when practical), disposition of nonconforming product, and for notification to the functions concerned.

6.2 SYSTEM SAFETY REQUIREMENTS

The Contractor shall supply detailed descriptions of the design, test, operation and inspection requirements for all flight hardware and materials, GSE, and their interfaces necessary for a valid identification, assessment, control and mitigation of documented hazards. This includes

technical information concerning hazardous and safety critical equipment, systems, operations, handling and materials. For all identified hazards, the Contractor shall also document hazard controls, verifications and tracking methods.

The Contractor shall provide technical support to the LRO Project for safety working group and technical meetings as necessary in conjunction with TIMs.

6.3 RELIABILITY REQUIREMENTS

The Contractor shall prepare and conduct the following set of reliability analyses.

6.3.1 Failure Modes and Effects Analysis

The Contractor shall perform a Failure Modes and Effects Analysis (FMEA) in accordance with the Procedures for Performing an FMEA (MIL-STD-1629). The FMEA shall identify failures at the functional level and address attendant consequences. This analysis shall be provided to the NASA/GSFC COTR for review. Preliminary and final reports shall be provided in accordance with the Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Deliverable Items List and Schedule (431-LIST-000304).

6.3.2 Electrical, Electronic, and Electromechanical Parts Stress Analyses

The Contractor shall perform parts stress analyses on EEE parts and devices as employed in the circuit designs of the Flight Item to certify conformance with the de-rating requirements of EEE parts. The analyses shall be documented, and justification shall be included for all applications that do not meet the de-rating criteria. The Contractor shall use the Instructions for EEE Parts Selection, Screening, Qualification, and De-rating (EEE-INST-002) NASA document to establish criteria. Contractor de-rating guidelines may be considered in place of EEE-INST-002 guidelines but shall be submitted for approval. This analysis shall be provided to the NASA/GSFC COTR for review. Preliminary and final reports shall be provided in accordance with the Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Deliverable Items List and Schedule (431-LIST-000304).

6.3.3 Worst-Case Analyses

The Contractor shall perform worst-case parameter analyses on performance critical or functional critical components for which excessive operating variations could compromise mission performance. The Contractor shall identify the worst-case analyses planned to assure the design meets critical performance and life requirements. Adequate margins in electronic circuits, optics, electromechanical devices, or other mechanical items (mechanisms) can be verified by analysis, testing or both. When verification by analysis is used, the analyses shall consider all parameters at worst-case limits and worst-case environmental conditions for the parameter or operation being evaluated. Similarly, when verification by testing is used, the testing shall be conducted to provide as direct a measure as possible of the critical performance or function while the element is subjected to worst-case parameter variations. Elements that may warrant worst-case analysis may include: control loops that require adequate phase and gain margin to operate properly, sensitive analog circuitry, power supply or switching circuitry, motor and actuator systems, electro-mechanical elements that require torque margin to operate over life

and environmental variations. Preliminary and final reports shall be provided in accordance with the Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Deliverable Items List and Schedule (431-LIST-000304).

Worst case analysis must be performed at a minimum where circuit and EEE parts used in the circuit do not meet or exceed derating criteria as specified in EEE-INST-002. Worst case analysis is not required where design margin can be demonstrated by analysis.

6.3.4 Limited-Life Items

The Contractor shall identify and manage limited-life items. Limited-life items include all hardware that is subject to degradation because of limited shelf life or expected operating times or cycles such that their expected useful life is less than twice the required life when fabrication, test, storage, and mission operation are combined. Preliminary and final reports shall be provided in accordance with the Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Deliverable Items List and Schedule (431-LIST-000304).

The LRO Project COTR shall approve the use of an item whose expected life is less than twice the mission design life.

6.4 GROUND SUPPORT EQUIPMENT

Mechanical and electrical GSE and associated software that directly interfaces with flight deliverable items shall be assembled and maintained to mitigate potential risk to flight hardware. Parts and materials selection and reporting requirements are exempted as long as deliverable flight item contamination requirements are not compromised. However, all GSE interfaces to flight hardware shall be flight quality (i.e., connectors, baseplates, etc.).

6.5 DESIGN VERIFICATION REQUIREMENTS

6.5.1 Verification Requirements

The Contractor shall implement a program to verify all requirements specified in the Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Performance Specification (431-SPEC-000121).

The Contractor shall provide a verification matrix defining the method of verification for each specific requirement of this contract. Verification methods shall include:

Inspection: Designated as (I) and represents inspection of the physical hardware by a customer appointed qualified inspector for compliance.

Analysis: Designated as (A) and represents documentation of performance or function through detailed analysis using all applicable tools and techniques.

Test: Designated as (T) and represents a detailed test of performance and/or functionality throughout a properly configured test setup where all critical data taken during the test period is captured for review.

In-process production evaluation tests and environmental stress screening tests shall also be considered to be verification tests.

6.5.2 Analysis/Trending/Reporting Of Test Data

The Contractor shall properly record, maintain and analyze test information during the normal test program to assess performance and flight worthiness and to aid in the identification and analysis of flight hardware failures and problems.

The Contractor shall also perform trend analyses to track measurable parameters that relate to performance stability and repeatability. Selected parameters shall be monitored for trends starting at component acceptance testing and continuing through the system I&T phases. These parameters will be compiled in a Trended Parameters List (TPL).

The reports will be delivered as part of the Data Delivery Package and presented at formal technical reviews as appropriate.

6.5.3 Demonstration of Failure-Free Operation

The Contractor shall have demonstrated a period of 100 hours of contiguous failure-free operation for each Unit prior to delivery.

6.6 WORKMANSHIP STANDARDS AND PROCESSES

6.6.1 Workmanship: Use of Alternate Workmanship Standards

GSFC recognizes that the Contractor may have an established workmanship program equivalent to the specific standards cited herein. In these instances, the contractor may use existing standards upon review and approval by the LRO Project COTR. It must be established that the developer's workmanship program fully encompasses the specific requirements of this section. It is the Contractor's responsibility to list all deviations from the baseline workmanship standards and to provide data supporting their position/rationale.

6.6.2 Training and Certification of Contractor Personnel

All personnel performing work on flight hardware requiring a prerequisite set of skills and competency shall be certified as having completed the required training, appropriate to their involvement.

6.6.3 Hardware Handling, Cleaning And Packaging

Qualified personnel in accordance with approved procedures that address cleaning, handling, packaging, tent enclosures, shipping containers, bagging, and purging shall perform the handling of flight hardware. Compatible packaging shall be selected so that hardware is not contaminated or otherwise degraded during shipping or storage. All personnel working on flight hardware shall be certified as having completed the required training and competency certifications prior to handling any flight hardware. This includes, but is not limited to, workmanship, clean room and ESD awareness courses.

6.6.4 Electrostatic Discharge Control Requirements

The Contractor shall document and implement an ESD Control Program suitable to protect the most ESD-sensitive instrument components at all levels of assembly and integration in accordance with the requirements of ANSI/ESD S20.20 or NASA-STD-8739.7.

All personnel who manufacture, inspect, test or otherwise process electronic hardware or who require unescorted access into ESD-protected areas shall be certified as having completed the required training, appropriate to their involvement prior to handling any electronic hardware.

6.6.5 Workmanship Requirements For Printed Circuit Boards, Soldered Assemblies, Harnessing, and Fiber Optics

The following workmanship standards shall apply to printed circuit boards, soldered assemblies, harnessing, and fiber optics.

6.6.5.1 Requirements for Printed Wiring Boards

a) Printed Wiring Board (PWB) Design:

Space Flight PWB designs shall not include features that prevent the finished board(s) from complying with the Class 3 Requirements of the appropriate manufacturing standard (e.g., specified plating thickness, internal annular ring dimensions, etc.).

IPC-2221, Generic Standard on Printed Board Design (for non-critical ground support equipment only as defined in S312-P-003 paragraph 1.4)

IPC-2222, Sectional Design Standard for Rigid Organic Printed Boards (for non-critical ground support equipment only as defined in S312-P-003 paragraph 1.4)

IPC-2223, Sectional Design Standard for Flexible Printed Boards

IPC-D-275, Design Standard for Rigid Printed Boards and Rigid Printed Board Assemblies

b) PWB Manufacture:

GSFC S312-P-003, Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses (the use of this procurement specification is critical in the procurement of "Flight" and "Critical Ground Support" boards)

IPC-6011, Generic Performance Specification for Printed Boards

IPC-6012, Qualification and Performance Specification for Rigid Printed Boards

IPC-6013, Qualification and Performance Specification for Flexible Printed Boards

IPC-A-600, Acceptability of Printed Boards

The Contractor shall provide PWB coupons to the LRO COTR, or to a GSFC-approved laboratory for evaluation. PWB coupon approval shall be obtained from COTR or a GSFC approved laboratory prior to population of flight PWBs.

6.6.5.2 Workmanship Requirements

The following workmanship requirements shall apply:

Conformal Coating and Staking: NASA-STD-8739.1, Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies;

Surface Mount Technology (SMT): NASA-8739.2, Workmanship Standard for Surface Mount Technology;

Hand Soldering Assemblies: NASA-STD-8739.3, Soldered Electrical Connection

Crimping, Wiring, and Harnessing: NASA-STD-8739.4, Crimping, Interconnecting Cables, Harnesses, and Wiring;

Fiber Optics: NASA-STD-8739.5, Fiber Optic Terminations, Cable Assemblies, and Installation

6.6.5.3 New or Advanced Packaging Technologies

Workmanship requirements or standards, including design, qualification, and acceptance requirements, specified by the Contractor for advanced packaging technologies, such as multi-chip modules (MCMs), stacked memories, chip on board, column-grid arrays (CGA) or ball grid arrays (BGA), shall be submitted to the NASA/GSFC COTR for review and approval prior to use.

Each Non-Standard Process document shall address process control, fabrication, inspection, training, and acceptance and rejection criteria. Test data and evaluation records shall be submitted as part of the process support for approval, as applicable.

6.7 ELECTRICAL, ELECTRONIC, AND ELECTROMECHANICAL PARTS REQUIREMENT

6.7.1 General

Flight Unit parts shall be selected and processed in accordance with the requirements as described in the Instructions for EEE Parts Selection, Screening, Qualification, and Derating (EEE-INST-002). All application notes in EEE-INST-002 will apply.

The minimum acceptable EEE part grade available for Flight Unit use on LRO is Class 2 with 100% Particle Impact Noise Detection (PIND) screening for cavity bodied devices and a sample Destructive Physical Analysis (DPA). This assumes that the radiation hardness requirements and system reliability goals are also being met. This would include parts costs, test costs, risk of test failures and reliability differences between both classes. The Contractor shall maintain an EEE Parts Identification List and shall review proposed parts with the NASA/GSFC COTR. Preliminary and final reports shall be provided in accordance with the Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Deliverable Items List and Schedule (431-LIST-000304).

6.7.2 Custom Devices

In addition to the applicable requirements of EEE-INST-002, custom microcircuits, hybrid microcircuits, MCM, Application-Specific Integrated Circuit (ASIC) and other non-standard application unique devices planned for Flight Unit shall be subjected to a parts-level design review (with GSFC participation). The design review shall address, at a minimum, de-rating of elements, method used to certify acceptable reliability, assembly and materials processes, methods for assuring adequate thermal matching of materials, and screening and qualification requirements.

6.7.3 Plastic Encapsulated Microcircuits

The use of Plastic Encapsulated Microcircuits (PEMs) is discouraged in the Flight Unit. However, when use is necessary to achieve unique requirements that cannot be found in hermetic high reliability microcircuits, plastic encapsulated parts, must meet the requirements of the Instructions for EEE Parts Selection, Screening, Qualification, and Derating (EEE-INST-002). All PEM(s) require NASA/GSFC COTR review and concurrence. PEM usage shall be presented at the Design Conformance Review and TIMs, as applicable.

PEMs usage will be considered on a case by case basis. Approval will depend on the heritage of the part, part usage history, space flight history, testing performed by the supplier/manufacturer, assembly environmental stress screening, and available test data.

6.7.4 Radiation Hardness

All Flight Unit parts shall be selected to meet their intended application in the on-orbit LRO radiation environment as defined in the Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Performance Specification (431-SPEC-000121). The radiation environment consists of two separate effects: total ionizing dose (TID) and single-event effects (SEE). The Contractor shall document the radiation hardness assessment for each part with respect to both effects and include this assessment as part of the CDR Presentation Package. Test plans and reports for parts that require radiation testing shall be submitted to the NASA/GSFC COTR for review.

6.7.5 Parts Age Control

Parts more than five years old require LRO COTR concurrence. Contractors shall present justification with inspection and test requirements.

6.7.6 Government Industry Data Exchange Program Alerts and Problem Advisories

Contractors shall keep sufficient selection and usage records for all flight parts and materials adequate to determine applicability of any issued Government Industry Data Exchange Program (GIDEP) alerts relevant to items used on LRO. The Contractor shall review and disposition all GIDEP Alerts for relevancy and impact. In addition, the Contractor shall review and disposition any NASA Alerts and Advisories provided to the developer by the LRO Project. Alert applicability, impact, and corrective actions shall be documented and status provided to the LRO Project on a monthly basis.

6.7.7 Reuse of Parts and Materials

EEE parts and materials, which have been installed in an assembly, and removed for any reason, shall not be used again for flight.

6.7.8 Part Notification of Failure

The contractor shall provide failure-reporting data to NASA/GSFC COTR within 72 hours of part failure determination.

6.8 MATERIALS, PROCESSES AND LUBRICATION REQUIREMENTS

6.8.1 Materials Selection Requirements

To qualify material for flight use, the material must have a satisfactory flight heritage relevant to LRO requirements or meet the following applicable selection criteria as defined herein for:

- Vacuum outgassing
- Stress corrosion cracking (SCC)
- Lubrication requirements
- Manufacturing process selection
- Fastener integrity

The Contractor shall create and maintain a Materials and Processes (M&P) Identification List and shall review proposed materials and processes with the LRO GSFC COTR. An As-Built Materials List (ABML) shall be included as part of the end item data package. Preliminary and final reports shall be provided in accordance with the Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Deliverable Items List and Schedule (431-LIST-000304).

Pure Tin, Zinc, and Cadmium are not acceptable for flight use.

6.8.2 Vacuum Outgassing of Polymeric Materials

Only materials that have a total mass loss (TML) less than 1.00% and a collected volatile condensable mass (CVCM) less than 0.10% shall be approved for use in a vacuum environment. Material vacuum outgassing shall be determined in accordance with the Standard Test Method for Total Mass Loss and Collected Volatile, Condensable Materials for Outgassing (ASTM E-595). If a material exceeds these maximum limits, the contractor shall be required to either replace with a compliant material or bring it into compliance via a vacuum bakeout, or to submit a Material Usage Agreement (MUA) for its usage. Preliminary and final reports shall be provided in accordance with the Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Deliverable Items List and Schedule (431-LIST-000304).

6.8.3 Stress Corrosion Cracking of Inorganic Materials

Materials used in structural applications shall be highly resistant to SCC as specified in the Selection of Metallic Materials for Stress Corrosion Cracking Resistance (MSFC-STD-3029). A MUA and a SCC evaluation form shall be submitted, contractor format acceptable, for each material usage that does not comply with the Selection of Metallic Materials for Stress Corrosion Cracking Resistance (MSFC-STD-3029) requirements.

6.8.4 Lubrication Systems

The Contractor's material list shall include lubrication usage. Lubricants shall be selected for use with materials on the basis of flight heritage and valid test results that confirm the suitability of the composition and the performance characteristics for each specific application, including compatibility with the anticipated environment and contamination concerns.

All lubricated mechanisms shall be life tested unless it can be established and documented that a valid flight heritage exists to an identical mechanism used in an identical flight application or to an identical mechanism that has been separately qualified by suitable life testing.

6.8.5 Process Selection Requirements

Materials and manufacturing process information shall be provided on the material list.

6.8.6 Fasteners

The contractor shall comply with the procurement and test requirements for flight hardware and critical GSE fasteners contained in the Goddard Space Flight Center Fastener Integrity Requirements Procedures and Guidelines (541-PG-8072.1.2). Traceability shall be maintained for every fastener lot.

6.8.7 Materials Procurement Requirements

Raw materials purchased by the contractor and its developers shall be accompanied by a Certificate of Compliance and, where applicable, the results of nondestructive, chemical and physical tests. When requested, this information shall be made available to the NASA/GSFC COTR for review.

6.8.8 Dissimilar Metals

To avoid electrolytic corrosion, dissimilar metals should not be used in direct contact unless protection against corrosion has been provided in accordance with the Dissimilar Materials (MIL-STD-889). Variances from this policy must be submitted to the government for approval.

7.0 CONTAMINATION CONTROL REQUIREMENTS

The Contractor shall establish the specific cleanliness requirements to minimize performance degradation and delineate the approaches to meet the LRO Project requirements.

7.1 THERMAL VACUUM BAKEOUTS

Thermal vacuum bake-out of the S-Band Transponder shall be performed before delivery. The parameters of such bakeouts (e.g., temperature, duration, outgassing requirements, and pressure) are specified in the Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Performance Specification (431-SPEC-000121).

A quartz crystal microbalance (QCM) or temperature controlled quartz crystal microbalance (TQCM) shall be incorporated during all thermal vacuum bakeouts. The QCM shall provide the outgassing rate data during the bakeout. This data shall be recorded and provided in the data package.

Although the thermal vacuum test is normally used for a final bakeout opportunity [usually in the last hot cycle], the individual components should be fully cured and baked out before thermal vacuum testing to minimize the length of time spent in the chamber.

7.2 EXTERNAL CLEANLINESS

All exterior hardware cleanliness shall be verified to be 450A, as described in the Product Cleanliness Levels and Contamination Control Program (IEST-STD-CC1246), upon delivery to GSFC.

8.0 HANDLING, STORAGE, PACKAGING, PRESERVATION, AND DELIVERY

Products shall be stored, preserved, marked, labeled, packaged, and packed to prevent loss of marking, deterioration, contamination, excessive condensation and moisture, or damage during all phases of the program. Stored and stocked items shall be controlled in accordance with documented procedures and be subject to quality surveillance.

The Contractor is responsible for providing an acceptable shipping container that protects the hardware appropriately.

While in a shipping container, the S-Band Transponder shall be wrapped in a non-ESD-generating vapor barrier with redundant maximum humidity indicators.

The shipping container shall also include shock and humidity indicators and shall be capable of prolonged shipping conditions. The Contractor shall document what action NASA/GSFC is to take if the sensors are tripped when hardware arrives at the NASA/GSFC receiving area. A copy of this document shall be included with shipping documentation.

By executing the act of product shipment, the supplier certifies that the product complies with all contract requirements. Prior to shipping, QA personnel shall ensure that:

- Fabrication, inspection, and test operations have been completed and accepted.
- All products are identified and marked in accordance with requirements.
- The accompanying documentation (developer's shipping and property accountable form) has been reviewed for completeness, identification, and quality approvals.
- Evidence exists that preservation and packaging are in compliance with requirements.
- Packaging and marking of products, as a minimum comply with Interstate Commerce Commission rules and regulations and are adequate to ensure safe arrival and ready identification at their destinations.
- The loading and transporting methods are in compliance with those designated in the shipping documents.
- Integrity seals are on shipping containers and externally observable shock or humidity monitors do not show excessive environmental exposure.
- In the event of unscheduled removal of a product from its container, the extent of re-inspection and retest shall be as authorized by NASA or its representative.
- Special handling instructions for receiving activities, including observation and recording requirements for shipping-environment monitors are provided where appropriate.

The Contractor's QA organization shall verify prior to shipment that the above requirements have been met and shall sign off appropriate shipping documents to provide evidence of this verification. The Contractor shall ship Freight On Board (FOB) to Greenbelt, Maryland. The Contractor will be held responsible for any damaged incurred during shipment.

Appendix A. Abbreviations and Acronyms

Abbreviation/ Acronym	DEFINITION
A	Analysis
ABML	As-Built Material List
ANSI	America National Standard Institute
ASIC	Application-Specific Integrated Circuit
ASQ	American Society for Quality
BGA	Ball Grid Arrays
CCB	Configuration Control Board
CDR	Critical Design Review
CGA	Column-Grid Arrays
CM	Configuration Management
CO	Contracting Officer
COTR	Contracting Officer Technical Representative
CVCM	Collected Volatile Condensed Mass
DPA	Destructive Physical Analysis
EEE	Electrical, Electronic, and Electromechanical
ESD	Electro Static Discharge
EU	Engineering Unit
FMEA	Failure Mode and Effect Analysis
FOB	Freight on Board
FRB	Failure Review Board
GEVS	General Environmental Verification Specification
GIDEP	Government Industry Data Exchange Program
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
I	Inspection
I&T	Inspection and Test
INST	Instrument
ISO	International Organization for Standardization
LRO	Lunar Reconnaissance Orbiter
M&P	Materials and Processes
MCM	Multi-Chip Modules
Mil	Military
MIP	Mandatory Inspection Point
MRB	Material Review Board
MSFC	Marshall Space Flight Center
MUA	Material Usage Agreement
NASA	National Aeronautics and Space Administration
PDR	Preliminary Design Review
PEM	Plastic Encapsulated Microcircuit

Abbreviation/ Acronym	DEFINITION
PER	Preliminary Environmental Review
PIND	Particle Impact Noise Detection
PSR	Pre-Shipment Review
PWB	Printed Wiring Board
QA	Quality Assurance
QCM	Quartz Crystal Microbalance
RQMT	Requirement
SCC	Stress Corrosion Cracking
SEE	Single-Event Effect
SINDA	System Improved Numerical Differencing Analyzer
SMT	Surface Mount Technology
SOW	Statement of Work
STD	Standard
T	Test
TID	Total Ionizing Dose
TIM	Technical Interchange Meeting
TML	Total Mass Loss
TPL	Trended Parameters List
TQCM	Temperature-controlled Quartz Crystal Microbalance

Lunar Reconnaissance Orbiter Project

S-Band Telemetry, Tracking and Command Subsystem Deliverable Items List and Schedule

March 20, 2007



**National Aeronautics and
Space Administration**

**Goddard Space Flight Center
Greenbelt, Maryland**

TABLE OF CONTENTS

	<u>Page</u>
1.0 Introduction	1-1
1.1 Proprietary Data.....	1-1
1.2 Applicable Documents	1-1
2.0 Deliverable Documentation	2-1
2.1 Data Delivery Documentation and Schedule.....	2-2
Appendix A. Abbreviations and Acronyms	A-1

1.0 INTRODUCTION

This document is the Lunar Reconnaissance Orbiter (LRO) S-Band Telemetry, Tracking and Command (TT&C) Subsystem Deliverable Items List and Schedule (DILS). This document provides specific information on the hardware and data deliverables for the S-Band TT&C Subsystem.

1.1 PROPRIETARY DATA

Some of the content of documents may be of a proprietary nature to the document preparing/sending Party. In the event data is deemed to be proprietary, and for which protection is to be maintained, the sending Party shall mark the document with a notice to indicate that the data therein is proprietary and shall be used and disclosed by the receiving Party and its related entities (e.g., contractors and subcontractors) only for the purposes of fulfilling the receiving Party's responsibilities under the LRO Project, and that the identified and marked technical data shall not be disclosed or retransferred to any other entity without prior written permission of the document preparer.

1.2 APPLICABLE DOCUMENTS

431-SOW-000303	Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Statement of Work
431-SPEC-000121	Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Performance Specification
EEE-INST-002	Instructions for EEE Parts Selection, Screening, Qualification, and De-rating

2.0 DELIVERABLE DOCUMENTATION

This section provides a tabular listing of documentation deliverables, including the following information:

Description: This provides the Title of the deliverable item.

Reference: This provides the reference back to the pertinent document calling out the deliverable.

Category:

A = Approval: Documents in this category require approval from the National Aeronautics and Space Administration (NASA)/Goddard Space Flight Center (GSFC) Contracting Officer (CO). In general, documents shall be provided in contractor format as long as required content, as specified in the Lunar Reconnaissance Orbiter S-Band Telemetry, Tracking and Command Subsystem Statement of Work (431-SOW-000303), is addressed. The NASA/GSFC CO reserves the time-limited right of disapproval for each submission. The time-limited period is two weeks from receipt of documents.

R= Review: Documents in this category do not require formal NASA/GSFC CO approval. They must be received within a specified time period and are subject to evaluation.

I = Information: Documents in this category are informal and are for information only.

Quantity: This provides the required number of copies for the deliverable. All data is required to be submitted electronically. The number in the quantity column refers to the number of hard copies required.

Delivery Date: This provides the fixed or relative date or time that the deliverable is required.

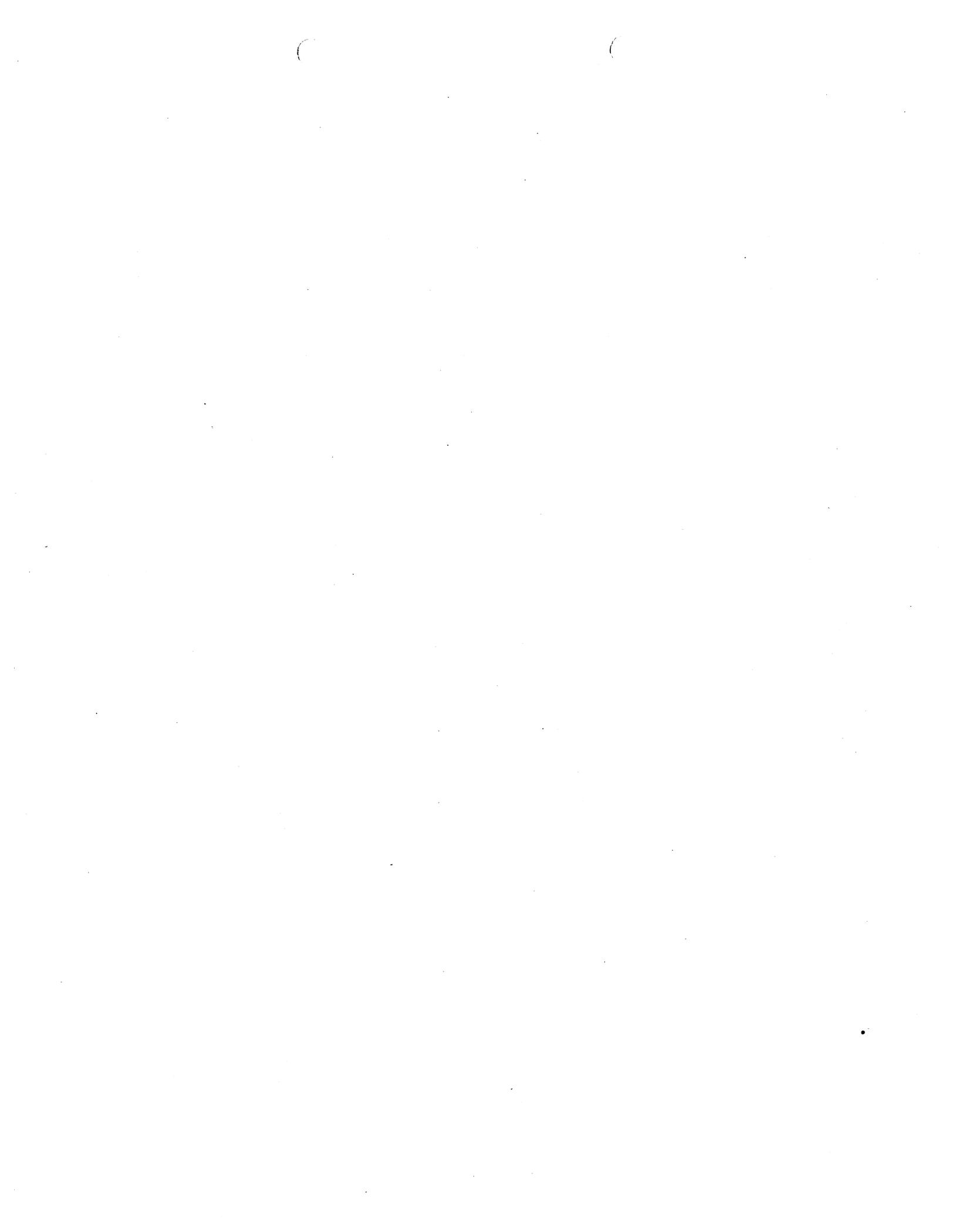
2.1 DATA DELIVERY DOCUMENTATION AND SCHEDULE

Item #	Description	Reference	Category	Quantity	Delivery Date
1	Monthly Status Report (MSR)	SOW Section 3.1	I	1	Ten (10) calendar days following the month being reported.
2	Preliminary Design Review (PDR)	SOW Section 3.3.1	R	1	Three (3) months after Award of Contract
3	Preliminary Design Review Report	SOW Section 3.3.1	A	1	Ten (10) calendar days after completion of PDR
4	Critical Design Review (CDR)	SOW Section 3.3.2	R	1	Three (3) months after PDR
5	Critical Design Review Report	SOW Section 3.3.2	A	1	Ten (10) calendar days after completion of Critical Design Review (CDR)
6	Pre-Environmental Review (PER)	SOW Section 3.3.3	A	1	Five (5) calendar days before start of environmental testing on Qualified Unit
7	Flight Unit Pre-Shipment Review (PSR)	SOW Sect 3.3.4	A	1	Five (5) calendar days prior to delivery of each Qualification and Flight Unit
8	Preliminary Interface Control Document (ICD)	SOW Sect 4.2.1	A	3	Fifteen (15) calendar days before PDR
9	Draft Interface Control Document (ICD)	SOW Sect 4.2.1	R	1	30 calendar days after contract award
10	ICD (Final)	SOW Sect 4.2.1	A	3	Fifteen (15) calendar days before CDR
11	Preliminary Drawing Package	SOW Sect 4.2.2	R	3	Fifteen (15) calendar days before PDR
12	Drawing Package (Final)	SOW Sect 4.2.2	A	3	Fifteen (15) calendar days before CDR
13	Preliminary Design Review Presentation Package	SOW Sect 4.2.3	I	5	Fifteen (15) calendar before PDR
14	Critical Design Review Presentation Package	SOW Sect 4.2.4	I	5	Fifteen (15) calendar before CDR
15	Flight Unit Data Delivery Package	SOW Sect 4.2.5	A	1	With each delivered Transponder
16	Preliminary Verification Test Plan	SOW Sect 4.2.6	R	3	Fifteen (15) calendar days before PDR
17	Verification Test Plan (Final)	SOW Sect 4.2.6	A	3	Fifteen (15) calendar days before CDR

Item #	Description	Reference	Category	Quantity	Delivery Date
18	Verification Test Procedures	SOW Sect 4.2.7	A	3	Thirty (30) calendar days before start of testing and as changes occur.
19	Preliminary Thermal Analysis	SOW Sect 4.3	R	2	Fifteen (15) calendar days before PDR
20	Thermal Analysis (Final)	SOW Sect 4.3	A	2	Fifteen (15) calendar days before CDR
21	Preliminary Reduced Thermal Model	SOW Sec. 4.3.1	R	2	Fifteen (15) calendar days before PDR
22	Final Reduced Thermal Model	SOW Sect. 4.3.1	A	2	Fifteen (15) calendar days before CDR
23	Final Detailed Thermal Model	SOW Sect. 4.3.1	A	2	Fifteen (15) calendar days before CDR
24	Preliminary Structural Analysis	SOW Sect 4.4	R	2	Fifteen (15) calendar days before PDR
25	Structural Analysis (Final)	SOW Sect 4.4	A	2	Fifteen (15) calendar days before CDR
26	Quality Assurance Plan	SOW Sect 6.1.1	A	3	Twenty-eight (28) calendar days after contract award
27	Class I Configuration Management (CM) Changes	SOW Sect 6.1.3	A	2	Five (5) calendar days after Contractor CM review
28	Class II CM Changes	SOW Sect 6.1.3	R	2	Five (5) calendar days after Contractor CM review
29	Anomaly Reports	SOW Sect 6.1.4	A	2	Five (5) calendar days after Contractor Anomaly Review Process determines disposition
30	Preliminary Flight Unit Failure Mode and Effects Analyses (FMEA)	SOW Sect 6.3.1	R	2	Fifteen (15) calendar days before PDR
31	Final Flight Unit Failure Mode and Effects Analyses (FMEA)	SOW Sect 6.3.1	A	2	Fifteen (15) calendar days before CDR
32	Parts Stress Analysis Criteria if different from EEE-INST-002	SOW Sect 6.3.2	A	2	Twenty-eight (28) calendar days after contract award
33	Preliminary Parts Stress Analysis	SOW Sect 6.3.2	R	2	Ten (10) calendar days before PDR
34	Parts Stress Analysis (Final)	SOW Sect 6.3.2	A	2	Ten (10) calendar days before CDR
35	Worst-Case Circuit Analysis (Preliminary)	SOW Sect 6.3.3	R	2	Fifteen (15) calendar days before PDR
36	Worst-Case Circuit Analysis (Final)	SOW Sect 6.3.3	A	2	Fifteen (15) calendar days before CDR

Item #	Description	Reference	Category	Quantity	Delivery Date
37	Preliminary Reliability Prediction	SOW Sect. 6.3.4	I	2	Fifteen (15) calendar days before PDR
38	Reliability Prediction (Final)	SOW Sect. 6.3.4	A	2	Fifteen (15) calendar days before CDR
39	Trend Parameter List	SOW Sect 6.5.2	R	3	Five (5) calendar days prior to PER
40	Test and Trend Analysis Reports	SOW Sect 6.5.2	I	1	Delivered at PSR
41	Printed Wiring Board (PWB) Coupons	SOW Sect 6.6.5.1	A	1 Coupon per board	Deliver Twenty-one (21) calendar days before start of PWB assembly
42	Advanced Packaging Technology Requirements Documentation	SOW Sect 6.6.5.3	A	2	Twenty-eight (28) calendar days after contract award
43	Parts Identification List (Preliminary)	SOW Sect 6.7.1	R	5	Fifteen (15) calendar days before PDR
44	Parts Identification List (Final)	SOW Sect 6.7.1	A	5	Fifteen (15) calendar days before CDR
45	Documentation on Custom Devices	SOW Sect 6.7.2	A	2	Twenty-eight (28) calendar days after contract award
46	Plastic Encapsulated Microcircuit (PEM) Specification Documents	SOW Sect 6.7.3	A	2	Twenty-eight (28) calendar days after contract award
47	Radiation Test Plans (If Applicable)	SOW Sect 6.7.4	R	2	Plans submitted thirty (30) calendar days prior to test. Returned with comments within fifteen (15) calendar days.
48	Radiation Test Reports	SOW Sect 6.7.4	A	2	Ten (10) calendar days after test
49	Recertification Plans for Parts >5Yrs (If Applicable)	SOW Sect 6.7.5	A	2	Fifteen (15) calendar days before CDR
50	As-Built Parts List	SOW Sect 4.2.5	R	1	Due at PSR
51	Alert/Advisory Disposition and Preparation	SOW Sect 6.7.6	R	2	Due 3 working days after Contractor disposition
52	Preliminary Materials Identification List	SOW Sect 6.8.1	A	5	Fifteen (15) calendar days before PDR
53	Materials Identification List (Final)	SOW Sect 6.8.1	A	5	Fifteen (15) calendar days before CDR
54	As-Built Materials List	SOW Sect 6.8.1	R	1	Due at Five (5) calendar days prior to PSR
55	Preliminary Materials Usage Agreement	SOW Sect 6.8.2	R	2	Fifteen (15) calendar days before PDR

Item #	Description	Reference	Category	Quantity	Delivery Date
56	Materials Usage Agreement (Final)	SOW Sect 6.8.2	A	2	Fifteen (15) calendar days before CDR
57	Limited-Life Items List	SOW Sect 6.3.4	A	2	Fifteen (15) calendar days before PDR
58	Close Out Photos	SOW Sect. 4.2.5	R	1	Due at PSR



Appendix A. Abbreviations and Acronyms

Abbreviation/ Acronym	DEFINITION
CCB	Configuration Control Board
CCR	Configuration Change Request
CDR	Critical Design Review
CM	Configuration Management
CMO	Configuration Management Office
CO	Contracting Officer
DILS	Deliverable Items List and Schedule
EEE	Electrical, Electronic, and Electromechanical
ESD	Electro Static Discharge
FMEA	Failure Mode and Effect Analyses
GSFC	Goddard Space Flight Center
INST	Instrument
LRO	Lunar Reconnaissance Orbiter
MSR	Monthly Status Review
NASA	National Aeronautics and Space Administration
PDR	Preliminary Design Review
PEM	Plastic Encapsulated Microcircuit
PER	Pre-Environmental Review
PSR	Pre-Shipment Review
PWB	Printed Wiring Board
SOW	Statement of Work
SPEC	Specification
TBD	To be Determined
TBR	To be Reviewed/Resolved

