OMB Approval 2700-0042

AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1. CONTRACT ID CODE	PAGE	OF	PAGES
	1		3

2. AMENDMENT/MODIFICATION NO.	3. EFFECTIVE DATE	4. REQUISITION/PURCHASE REQ. NO.	5. PROJECT NO. (If applicable)
00042	See Block 16C	4200414985	

6. ISSUED BY CODE 210.S
NASA Goddard Space Flight Center
Procurement Operations Division

7. ADMINISTERED BY (If other than item 6) CODE 210.S
NASA/Goddard Space Flight Center
Space Sciences Procurement Office

8. NAME AND ADDRESS OF CONTRACTOR (No. Street, county, State and ZIP: Code)
LOCKHEED MARTIN CORP.
12257 STATE HWY
LITTLETON CO 80127-0000

CODE 04235 FACILITY CODE

(x) 9A. AMENDMENT OF SOLICITATION NO.

9B. DATED (SEE ITEM 11)

(x) 10A. MODIFICATION OF CONTRACT/ORDER NO. NNG09EK34C

10B. DATED (SEE ITEM 13) 04/02/09

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 one (1) copy 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 ACKNOWLEDGMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATA 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 data specified.

12. ACCOUNTING AND APPROPRIATION DATA (If required)

BNC: GJE PR: 4200414985 AMT: $3,000,000.00

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

( )	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 52.243-2 CHANGES – COST REIMBURSEMENT (AUG 1987)
(X)	D. OTHER (Specify type of modification and authority) NFS 1852.232-81 CONTRACT FUNDING (JUN 1990)

E. IMPORTANT: Contractor ☐ is not, ☒ is required to sign this document and return _1_ 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 incremental funding for continued contract performance, revises clauses G.1 and J.1, definitizes Contractor's cost proposal of May 6, 2011 (2011-SEP-CP-0179) for MAVEN Planetary Protection Support, and reflects action item MAVEN-CCR-0298 approved.

POC: Amy Aqueche. Email: amy.a.aqueche@nasa.gov

Continued....

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)	
Kyle Wille, Contracts Negotiator		Amy A. Aqueche	
15B. CONTRACTOR/OFFEROR	15C. DATE SIGNED	16B. UNITED STATES OF AMERICA	16C. DATE SIGNED
(Signature of person authorized to sign)	11/9/11	BY Amy A. Aqueche (Signature of Contracting Officer)	11/09/2011

1. Revise Clause B.1 – ESTIMATED COST AND AWARD FEE (1852.216-85) (SEPT 1993) as indicated below:

	FROM (CPAF)	B	FROM (CPAF)
Estimated Cost	[redacted]		
Maximum/Final Award Fee (Phase B)			
Base Fee (Phase CDE)			
Maximum Available Award Fee (Phase CDE)			
Maximum Positive Performance Incentive (Phase CDE)			
TOTAL CPAF (BCDE)	$245,800,678	$1,296,970	$247,097,648

2. SOW REVISION

Is Revised as Follows:

6.1.1 PHASE C and D SYSTEMS ENGINEERING ACTIVITIES

Planetary Protection Assaying requirements will be defined by the Planetary Protection Working Group. LM shall implement an assaying effort for the spacecraft, instruments, and overall observatory. LM shall provide assaying services at the instrument institutions for a minimum of two assays (during instrument fabrication and after assembly prior to delivery). A third assay is planned for either at the instrument institution or after delivery at LM. LM shall set up an assay lab and use common services for assays for data consistency between the spacecraft and instruments. GSFC and the instrument institutions will support LM in assaying activities at the institutions. After delivery to LM the assaying of the instruments will be the responsibility of LM as part of the overall observatory assaying activities. The level of assaying for MAVEN shall be similar to what was performed on MRO and has been agreed to by the Planetary Protection Working Group. LM shall integrate all the assaying results with the Burn up and Breakup analysis and generate the final Planetary Protection report prior to launch. The prelaunch planetary protection report will need to include the assay results from the instruments and the analysis of the Planetary Protection Equipment List (PPEL), which is described in the MAVEN planetary protection plan. LM shall manage and maintain the PPEL. GSFC shall support that effort and the generation of the final report. It is assumed that LM will subcontract the assaying effort. If so, LM shall maximize efficiencies with the instrument and spacecraft assaying subcontractor. The proposed assaying levels shall be coordinated with the PPWG prior to submittal.

The named revision is reflected within the SOW revision as updated and attached hereto

3. Revise Clause B.3 – CONTRACT FUNDING (1852.232-81) (JUN 1990) is revised to increase funds as set forth below:

	[redacted]
Estimated Cost	[redacted]
Base Fee	[redacted]
Award Fee	[redacted]
CPAF	[redacted]

*The allotment date is through December 9, 2011.

4. Clause G.1 1852.216-77 AWARD FEE FOR END ITEM CONTRACTS. (JUN 2000), paragraph (c) (1) is revised to read as follows:

(c) (1) Base fee, if applicable, will be paid in *monthly* installments based on the percent of completion of the work as determined by the Contracting Officer.

all other aspects of this clause remain unchanged and in full effect

5. Revise J.1, Item A-1, LIST OF ATTACHMENTS, to read as follows:

Attachment	Description	Date
A-2	Statement of Work (SOW) – Phase C/D/E Effort, REV E	September 15, 2011

- The updated SOW is hereby attached for reference.
- All other items listed in table J.1 remain unchanged and in full effect.

6. In consideration of this modification agreed to herein as complete equitable adjustment, 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.

7. All other terms and conditions remain unchanged and in full force and effect.

(END MODIFICATION)

MAVEN
Mars Atmosphere and Volatile Evolution Mission
CU/LASP • GSFC • UCB/SSL • LMI • JPL

Statement of Work (SOW) for the Mars Atmospheric and Volatile EvolutioN (MAVEN) Phase C/D/E Effort

MAVEN-PROC-SOW-0002
Revision E

Contract # NNG09EK34C

Effective Date: September 15, 2011
Expiration Date: September 15, 2016

Goddard Space Flight Center
Greenbelt, Maryland

National Aeronautics and Space Administration

CONFIGURATION MANAGEMENT (CM) FOREWORD

This document is a Mars Atmosphere and Volatile Evolution Mission (MAVEN) Project 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 MAVEN Configuration Management Office, 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:

MAVEN Configuration Management Office
Mail Stop 432
Goddard Space Flight Center
Greenbelt, Maryland 20771

REVIEW/APPROVAL PAGE

All project reviews and approvals are electronic via the MAVEN MIS at:

https://mavenmis.gsfc.nasa.gov

Statement of Work (SOW) for Phase C/D/E (Lockheed Martin)

DOCUMENT CHANGE RECORD

REVISION LEVEL	DESCRIPTION OF CHANGE	APPROVED BY	DATE APPROVED
Revision (-)	Baseline Release per CCR-0077	D. Mitchell	12/16/2009
Revision A	Changes to Section 6.2 per CCR-0089	D. Mitchell	12/22/2009
Revision B	Updates per MAVEN-CCR-0242.	D. Mitchell	11/16/2010
Revision C	Updates per CCR's 209, 213, 229, 240, 247, and 271.	D. Mitchell	3/10/2011 3/17/2011
Revision D	Updates per CCR's, 245, 252, 257, 258, 274, 276, 291, 292, 293, 296, 297, and 300.	D. Mitchell	08/11/2011
Revision E	Updates per CCR's 298, 357, 367	D. Mitchell	9/15/2011

Table of Contents

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1 INTRODUCTION

The Mars Atmospheric and Volatile EvolutioN (MAVEN) mission's primary goal is to provide a comprehensive picture of the Mars upper atmosphere, ionosphere, solar energetic drivers, and atmospheric losses. It will deliver definitive answers to long-standing questions about the climate history and habitability of Mars.

The MAVEN mission will gather this science through a single planetary orbiter at Mars. The orbiter delivers its science using three instrument packages: a stand-alone neutral gas and ion mass spectrometer (NGIMS), capable of measuring thermal neutrals and ions; a stand-alone imaging ultraviolet spectrometer (IUVS); and the Particles and Fields (P&F) package, consisting of six instruments (STATIC, SEP, SWEA, SWIA, LPW/EUV, MAG) measuring ionospheric properties, energetic ions, solar wind and solar energetic particles, magnetic fields, and solar EUV irradiance. In addition to these instrument packages, MAVEN will carry an Electra relay payload for the purposes of providing telecommunications relay services to other Mars missions including surface landers and rovers, spacecraft during Entry, Descent, and Landing (EDL) operations, and potential aerobot missions such as balloons and airplanes. Each instrument has significant relevant heritage. The instrument packages and the Electra relay payload will be delivered to LM as Government Furnished Equipment (GFE).

The NASA Goddard Space Flight Center (GSFC) manages the MAVEN project for the MAVEN Principal Investigator, Dr. Bruce Jakosky, University of Colorado at Boulder, Laboratory for Atmospheric and Space Physics (LASP) in Boulder, CO.

This Statement of Work (SOW) defines the work to be performed by Lockheed Martin Space Systems Company located in Denver, CO (herein referred to as LM) to design, develop and deliver a fully qualified flight spacecraft, integrate the instrument packages, qualify the orbiter (instruments/spacecraft), integrate the orbiter to the launch vehicle and launch the MAVEN orbiter, on a NASA provided launch vehicle, into a direct insertion orbit to Mars. This SOW also defines the work necessary for LM to design, develop and operate a Mission Support Area (MSA) that shall support the on-orbit mission operations of the MAVEN mission and support Science Operations Center at the LASP during Phase E. This SOW covers work done by LM during Phases C, D and E.

The Goddard Space Flight Center (GSFC) manages the MAVEN mission for NASA.

2 SCOPE OF WORK

LM shall provide the necessary personnel, facilities, services, and materials to design, fabricate, assemble, integrate (including integration of the NASA-supplied MAVEN scientific instruments) and test the MAVEN orbiter along with the necessary software, communications and ground support equipment to accomplish the MAVEN Mission scientific goals. This shall include the launch site processing, integration, and testing with an Atlas V launch vehicle in preparation for launch. LM shall deliver the orbiter to NASA in preparation for launching the MAVEN orbiter in a launch window opening on November 18, 2013 and closing on December 7, 2013. After launch, LM shall provide facilities and mission operations in support of the mission and science operations. The scope covers Phase C/D/E of the MAVEN Life Cycle. This work shall be performed in accordance with the requirements of this document and all attachments to the contract.

LM's scope of work shall include, but not be limited, to the following:

1. Manage the LM team through Phases C through E of the MAVEN mission.
2. Design, develop, fabricate, integrate, test, launch, and deliver a flight-qualified orbiter to meet the MAVEN science goals and objectives, and requirements flowed from the Mission Requirements Document (MRD).
3. Flow-down and implementation of the top-level mission requirements to the appropriate elements of the spacecraft and subsystems.
4. Design, development, fabrication, integration, testing and delivery of a flight qualified orbiter.
5. Receive the GFE instruments and related ground support equipment (GSE), then integrate them with the spacecraft bus and perform spacecraft level testing.
6. Provide all required spacecraft mechanical and electrical GSE.
7. Deliver and support integration, verification, and maintenance of ground system hardware and software.
8. Support combined spacecraft and ground system testing, and MAVEN end-to-end testing before launch.
9. Provide all services associated with the spacecraft/launch vehicle integration, launch site processing, launch site safety, launch site checkout and verification, and launch.
10. Provide all services associated with flight operations from the launch vehicle/spacecraft separation; cruise to Mars, Mars Orbit Insertion (MOI), on-orbit checkout, and Mars operations.
11. Support all services associated with the on-orbit spacecraft checkout and support associated with instrument checkout.

12. Provide spacecraft operator and engineering training for on-orbit operation.
13. Design, development, integration and testing of the Mission Support Area (MSA) as well as support the backup MSA at GSFC.
14. Operate and maintain the Mission Support Area (MSA) for the conduct of MAVEN flight operations post-launch.
15. Provide on-orbit engineering support for the MSA and spacecraft.
16. Implement an organized System Safety and Mission Assurance Program in accordance with the MAVEN Mission Assurance Requirements (MAR), MAVEN-PM-RQMT-0006, per the LM Mission Assurance Implementation Plan (MAIP), MAVEN-SC-PLAN-0029.
17. Provide engineering and I&T support to the instrument package providers
18. Conduct on-orbit operations, providing for the health and safety of the orbiter.
19. Establish and maintain the required International Traffic in Arms Regulations (ITAR) and Export Control documentation necessary for working with any international team members
20. Provide support of a MAVEN Education and Public Outreach (EPO) program that is being led by LASP and the NASA MAVEN Project Office.
21. Develop and deliver the Contract Data requirements identified in the MAVEN Contract Data Requirements List (CDRL) . MAVEN-PROC-LIST-0002

LM delivered spacecraft and associated efforts shall meet all the spacecraft requirements as flowed down from the Mission Requirements Document (MRD). These requirements are defined in the Spacecraft Specification, MAVEN-SC-SPEC-0002.

Level-of Effort Special Studies and Support

- Provide on a level-of-effort basis approx. 100 hours of engineering direct labor to support various flight system or mission operations special studies as directed in writing by the cognizant GSFC Contracting Officer during Phase C/D/E.

3 APPLICABLE DOCUMENTS

The documents listed in this section apply directly to the performance of the MAVEN contract. These documents establish detailed specifications, requirements, and interface information necessary for the performance of the contract. These documents are under configuration control at GSFC. The most recent version of the document takes precedence over the version listed. LM will be under contract to the configuration controlled version at the time the contract is negotiated. All CM controlled documentation for MAVEN is controlled in the Management Information System (MIS) https://mavenmis.gsfc.nasa.gov and all items marked with an (*) are controlled in the DOORS database hosted at LM. This document will be reviewed, approved and updated via procedures defined in the MAVEN Configuration Management Plan, MAVEN-PM-PLAN-0007. In the event of conflicting requirements, the requirements as specified in this SOW shall supersede requirements from the documents listed. LM shall immediately notify the GSFC Contracting Officer Technical Representative (COTR) of any conflicts among the applicable documents and this statement of work in order to resolve the conflict and revise the documents accordingly. Requirements of this document apply to all MAVEN hardware, at the component, subsystem and orbiter levels of integration, either supplied directly by GSFC, contractors or subcontractors. Requirements herein apply to engineering models (when used for qualification purposes or a potential flight spare), qualification models, flight, flight spare hardware, ground systems, and software.

DOCUMENT	DOCUMENT TITLE
MAVEN-SC-SPEC-0002*	MAVEN Spacecraft Specification (MRD Requirement subset)
MAVEN-PROC-LIST-0002	MAVEN Contract Data Requirements List (CDRL)
MAVEN-PM-RQMT-0005*	MAVEN Mission Requirements Document (MRD)
MAVEN-SYS-RQMT-0010*	MAVEN Environmental Requirements Document (ERD)
MAVEN-PM-RQMT-0006*	MAVEN Mission Assurance Requirements (MAR)
MAVEN-SYS-PLAN-0007	MAVEN Magnetic Cleanliness Controls
MAVEN-SYS-PLAN-0024	MAVEN Contamination Control Plan
MAVEN-SYS-PLAN-0020	MAVEN Software Management Plan (SMP)
MAVEN-PM-PLAN-0021	MAVEN Systems Review Plan (SRP)
MAVEN-ELECTRA-RQMT-0014	Mars Exploration Program Requirements for MAVEN Electra Relay Services
MAVEN-MOPS-RQMT-0002	Mission Operations System (MOS)/Ground Data System (GDS) Functional Requirements Document (FRD)

Attachment IV Phase B RFP	Mission Operations Requirements
MAVEN-LV-RQMT-0032	Launch Services Interface Requirements Document (LSIRD)
MAVEN-MDES-RQMT-0036	Technical Resource Allocation Specification (TRAS)

3.1 REFERENCE DOCUMENTS

The following are reference documents that contain detailed requirements that may be called out in the applicable documents identified in Sec. 3 or contain general requirements levied on the MAVEN project by NASA. They are to be considered as requirements to the overall contract, as applicable.

DOCUMENT	DOCUMENT TITLE
AFSCM 91-710	Range Safety User Requirements
ANSI/ESD S20.20	ESD Association Standard for the Development of an Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)
CR 5320.9	Payload and Experiment Failure Mode Effects Analysis and Critical Items List Ground Rules
FAP P-302-720	Performing a Failure Mode Effects Analysis
GIDEP S0300-BT-PRO-010	GIDEP Operations Manual
GP-1098	KSC Ground Operations Safety Plan, Volume 1
GSFC EEE-INST-002	Instructions for EEE Parts Selection, Screening, and Qualification and Derating
GSFC S-302-89-01	Failure Modes and Effects Analysis Procedures for Unmanned Spacecraft and Instruments
GFSC-STD-1000	Rules for Design, Development, Verification, and Operation of Flight Systems (aka Gold Rules)
GSFC-STD-7000	General Environmental Verification Standards (GEVS) for Flight Programs and Projects
GPR 1060.2	Management Review and Reporting for Programs and Projects

GPR 7120.4	Risk Management
GPR 8621.3	Mishap, Incident, Hazard, and Close Call Investigation
GPR 8700.4	Integrated Independent Reviews
GPR 8700.6B	Engineering Peer Reviews
IEEE 1413.1	Guide for Selecting and Using Reliability Predictions Based on IEEE 1413
IPC A-600	Acceptability of Printed Boards
IPC-A-610	Acceptability of Electronic Assemblies
IPC/EIA J-STD-001	Requirements for Soldered Electrical and Electronic Assemblies
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 Specifications for Printed Boards
IPC-6012	Qualification and Performance Specification for Rigid Printed Boards
IPC-6013	Qualification and Performance Specification for Flexible Printed Boards
IPC-6018	Microwave End Product Board Inspection and Test
K-ELV-11.2	Guide for Expendable Launch Vehicle Payload Processing at Kennedy Space Center and Cape Canaveral Air Force Station
KHB 1860.1	KSC Ionizing Radiation Protection Program
KHB 1860.2	KSC Non-Ionizing Radiation Protection Program
MAVEN-PM-PLAN-0008	MAVEN Project Management Plan
MAVEN-PM-PLAN-0007	MAVEN Configuration Management Plan
MAVEN-SYS-PLAN-0006	MAVEN Systems Engineering Management Plan (SEMP)
MAVEN-PM-PLAN-0004	MAVEN Risk Management Plan
MIL-STD 461C	Electromagnetic Emission and Susceptibility Requirements for the Control of Electromagnetic Interference

MIL-STD-461F	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
MIL-STD-462	Electromagnetic Interference Characteristics, Measurement of Radiated and Conducted EMI
NASA-HDBK-4001	Electrical Grounding Architecture for Unmanned Spacecraft
NASA-TP-2361	Surface Charging Avoidance
NASA-HDBK-4002	Avoiding Problems Caused by Spacecraft On-Orbit Internal Charging Effects
NASA-HDBK-7004B	Force Limited Vibration Testing Handbook
NASA-STD-7001	Payload Vibroacoustic Test Criteria
NASA-STD-7003	Pyroshock Test Criteria
NASA-STD-8719.13B	NASA Software Safety Technical Standard
NPD 7120.4	Program and Project Management
NPD8020.7G	Biological Contamination Control for Outbound and Inbound Planetary Spacecraft
NPD 8700.1	NASA Policy for Safety & Mission Success
NPD 8710.3	NASA Policy for Limiting Orbital Debris Generation
NPD 8720.1	NASA Reliability and Maintainability (R&M) Program Policy
NPD 8730.2	NASA Parts Policy
NPR 6000.1G	Requirements for Packaging, Handling, and Transportation for Aeronautical and Space Systems, Equipment and Associated Components
NPR 7120.5D	NASA Space Flight Program and Project Management Processes and Requirements
NPR 7123.1	Systems Engineering Processes and Requirements
NPR 7150.2	NASA Software Engineering Requirements
NPR 8000.4	Risk Management Procedural Requirements
NPR8020.12C	Planetary Protection Provisions for Robotic Extraterrestrial Missions

NPR 8621.1	NASA Procedures and Guidelines for Mishap Reporting, Investigating, and Record Keeping
NPR 8705.4	Risk Classification for NASA Payloads
NPR 8705.5	Probabilistic Risk Assessment (PRA) Procedures for NASA Programs and Projects
NPR 8715.3	NASA General Safety Program Requirements
NPR 8715.6A	NASA Procedural Requirements for Limiting Orbital Debris
NPR 8735.1	Procedures for Exchanging Parts, Materials, and Safety Problem Data Utilizing the Government-Industry Data Exchange Program and NASA Advisories
NPR 9501.2D	NASA Contractor Financial Management Reporting
NSS 1740.12	Safety Standard for Explosives, Propellants, and Pyrotechnics
NSS 1740.14	Guidelines and Assessment Procedures for Limiting Orbital Debris
RADC-TR-85-229	Reliability Prediction for Spacecraft
SAE AS9100	Quality Management System, Aerospace Requirements
541-PG-8072.1.2	GSFC Fastener Integrity Requirements

4 PERIOD OF PERFORMANCE

The period of performance for the work specified in this SOW will be for phases C, D and E.

The following table contains the current projected start dates for each phase of the mission:

Table 4-1 – MAVEN Mission Phases Dates

Phase	Date
Phase C - START	Nov. 1, 2010
Phase D - START	August 2012
LAUNCH Readiness Date	**November 18, 2013**
Phase E - START	[L+30 days]
Phase E - END	Mapping Phase Start + 365 days + 6 months of final data analysis/archiving

Phase F – "Decommissioning Phase" – Contract closeout and property disposition will be handled either in Phase F or as a contract change to Phase E when the requirements and costs are better understood.

5 PROGRAMMATIC REQUIREMENTS

5.1 PROJECT MANAGEMENT

LM shall designate, by name, a LM MAVEN Project Manager (PM). The PM shall be responsible for leading the LM team through these phases of the project and manage the contract to ensure that all performance, schedule, costs and quality objectives are met. The PM will be the primary point of contact and shall provide full visibility to NASA/GSFC on all aspects of performance covered by this SOW and immediately disclose existing or potential problems and planned resolutions. The PM shall maintain a liaison with the GSFC/MAVEN COTR and GSFC MAVEN Project Office to ensure adherence to all requirements. The PM will be the technical focal point and direct and administer the MAVEN orbiter development, mission integration and mission operations. The PM shall coordinate LM efforts with that of its subcontractors, the MAVEN Instrument Investigators, and NASA.

LM shall establish, implement and maintain a management system that integrates management disciplines, functions, and systems into an overall activity to achieve cost-effective planning, organizing, controlling, and reporting of the contract objectives. The day-to-day management and administration of the specified work are the prime objectives of this SOW element. As part of this effort, LM shall provide traceability of cost, schedule and technical progress data for work being performed by LM and all of its suppliers and subcontractors in support of this contract, as well as provide the necessary leadership and technical coordination of the activities to ensure schedules and technical progress are consistent with the contract objectives.

5.2 CONTRACTUAL/TECHNICAL DIRECTION

LM performance to the requirements of this contract is under the administrative direction of the NASA GSFC Contracting Officer (CO). Administrative direction includes guidance and approvals that establish all understandings and agreements between LM and NASA. Sole authority to make changes, revisions, or amendments, to the contract, on behalf of NASA and to effect deviations (by way of additions or deletions) from the work described herein rests with the authorized CO.

The CO designates the COTR as the principal technical interface to LM who will monitor LM's technical performance and progress. All technical changes to the contract, addition of tasks must be previously coordinated with the COTR as the MAVEN project representative. The COTR will coordinate with the CO any official changes to the contract. Any deletions, additions, changes or amendments to this SOW, or other exhibits or documents referenced herein, are not considered technical guidance and shall be implemented by LM only if expressly authorized in writing by the CO.

Acceptance of direction from anyone other than the COTR and/or CO will not be considered as a basis for claim against the government.

5.3 COMMUNICATIONS

LM shall provide regular communications and meetings with NASA/GSFC either via teleconferences or face-to-face to discuss programmatic, financial data, contracts, and technical status and issues. Periodic meetings (weekly, monthly, and quarterly) shall be established. In addition to the periodic meetings, special meetings such as Technical Interchange Meetings (TIMs) shall be set up for detailed technical or programmatic interchange as needed.

5.3.1 WEEKLY MEETINGS

LM shall report technical and programmatic progress in weekly informal teleconferences with the MAVEN Project Office.

LM shall conduct status meetings with the COTR on a weekly basis and generate a brief email status to be sent to the COTR.

5.3.2 MONTHLY/QUARTERLY MEETINGS

LM shall conduct a Monthly Management Review (MMR) at the LM Denver facility. LM shall prepare a MAVEN Spacecraft Monthly Technical Progress Review data package (see Section 5.3.8.1) and present this data package to NASA –on an agreed upon date around the 15th of each month held at LM's facility except when combined as a quarterly project review. The quarterlies will rotate between Lockheed Martin (LM), the Laboratory for Atmospheric and Space Physics (LASP), the Goddard Space Flight Center (GSFC), the Jet Propulsion Laboratory (JPL), and the University of California, Berkeley, Space Sciences Lab (SSL). LM is to prepare the same review package for the project, but will likely present a reduced package at the quarterly. A separate LM Quarterly with GSFC management may be required. The monthly Technical Progress Reviews shall be held unless the NASA COTR and LM PM agree to an alternate briefing. A separate financial splinter meeting will be held to address financial and contract data.

5.3.3 TECHNICAL INTERCHANGE MEETINGS

LM shall support/conduct miscellaneous Technical Interchange Meetings (TIMs) as needed to resolve and work out detailed technical issues (e.g. interfaces). These will be held via teleconferences or via face-to-face meetings. The location of these TIMs will likely vary between GSFC. LASP, University of California at Berkeley, JPL, LM, and the launch vehicle provider. Attendance to these TIMs will depend on the topic to be discussed and should be limited to the appropriate personnel. Some examples of specific TIMs that are required are:

- Technical and Project team telecoms and working meetings, such as mission assurance, software, integration and test, fault protection, subsystems, mission sequence and operations.
- Telecons and working meetings for interfaces and integration with the payloads, telecom equipment, launch vehicle and the ground system.
- Flight System Design Team meetings with GSFC participation via telecon.
- Engineering Change Boards

- Mission Assurance Working Groups
- Spacecraft
- EMI Working Group
- ICD Working Groups
- Payload Working Group

5.3.4 OFFSITE TEAM BUILDING

LM shall support a series of offsite management and leadership team building exercises at key points in the MAVEN project cycle. These will most likely be at the start of Phase C, the start of ATLO, start of System Level Environmental Testing, and start of Launch Site Operations. These will nominally be a 1-day event, likely tied in with the Quarterly Management Reviews. They will focus on establishing a quality and open working relationship between key members of the MAVEN team.

5.3.5 REVIEWS

LM shall conduct and/or support various subsystem, spacecraft, and mission level reviews during Phases C through E. The MAVEN Life Cycle reviews are shown in Figure 5-1. The current planned MAVEN reviews are defined in Appendix A of the System Review Plan, MAVEN-PM-PLAN-021 and are summarized in Figure 5-2. The MAVEN Review Schedule is reflected in the MAVEN Integrated Master Schedule. Finalization of the review dates shall be coordinated during regular/monthly schedule meetings with the MAVEN Project Office at GSFC. (CDRL PM-13)

5.3.5.1 INDEPENDENT REVIEWS

LM shall provide support for a formal review program chaired by GSFC and/or an independent representative identified by NASA Headquarters that meets the requirements of the MAVEN Mission Assurance review program. The reviews shall:

- Assure that the spacecraft, instrument(s) and supporting designs are consistent with the MAVEN Mission Requirements Document;
- Assure that the characteristics of the systems are carefully examined to develop the best approach consistent with existing constraints and available resources;
- Provide a means of periodic evaluation of the hardware, software, and ground support development;
- Assure that end-item deliverables (systems and subsystems) meet the MAVEN requirements for performance, schedule and cost.

Independent life-cycle reviews are formal reviews that will be conducted by the Standing Review Board (SRB) team as defined in NPR 7120.5D (NASA Space Flight Program and Project Management Requirements) and in the Terms of Reference for Independent Life Cycle Reviews of the MAVEN Project dated March 15, 2010. The SRB will chair the following reviews during Phases C/D/E:

- **Mission Critical Design Review (CDR)**
- **System Integration Review (SIR)/ATLO Readiness Review (ARR)**
- **Operations Readiness Review (ORR)**
- **Observatory Pre-Ship Review (PSR)**
- **Post Launch Assessment Review (PLAR)**
- **Critical Events Readiness Reviews (CERR)**
- **Decommissioning Review (DR)**

  - LM shall prepare and submit a MAVEN **Mission Critical Design Review (CDR)** Data Package. This review typically occurs after the design has been completed but prior to the start of manufacturing flight components or the coding of software. Scheduling of the review will be coordinated with the MAVEN Project Office, F***light component procurement, if required prior to the MAVEN Confirmation Review with NASA HQ, shall require approval by the MAVEN Project Office,*** LM shall emphasize implementations of design approaches as well as test plans for flight systems including the results of engineering model testing. LM shall present the MAVEN Mission CDR Data Package to the Systems Review team at the Critical Design Review.

  - LM shall prepare and submit a MAVEN **Systems Integration Review/ATLO Readiness Review (SIR/ARR)** data package. LM shall conduct the ARR and present the **ATLO Readiness Review (ARR)** data package to the Systems Review team at LM's facility.

    LM shall prepare and submit a MAVEN **Operational Readiness Review (ORR)** Data Package. The ORR examines the actual system characteristics and the procedures used in the system's or product's operation and ensures that all system and support (flight and ground) hardware, software, personnel, and procedures are ready for operations and that user documentation accurately reflects the deployed state of the system. This review will be conducted at the LM facility, roughly 4 months prior to launch, to verify overall readiness of the Mission Operations Center and Science Operations Center resources to achieve the mission flight objectives.

  - LM shall prepare and submit a MAVEN **Observatory Pre-Ship Review (PSR) Data Package.** This review shall take place prior to shipment of the orbiter to the launch site. LM shall present evidence to show that testing has been completed with no unacceptable open issues and will evaluate the readiness of the hardware and software

for flight. LM shall address the testing on flight hardware and software, verification and documentation of the hardware and software configuration, identification of outstanding safety risks, disposition of waivers/deviations/open issues, compatibility of spacecraft and ground support equipment, and orbital operations plans. LM shall present a MAVEN Orbiter Pre-Ship Review Data Packages to the Systems Review team at the Pre-Ship Review.

- LM shall prepare and submit a MAVEN **Post Launch Assessment Review (PLAR)** Data Package. This review will be conducted at LM's facility and will address post launch events, anomalies, trend data, and overall MAVEN health and status.

- LM shall prepare and submit a MAVEN **Critical Events Readiness Review (CERR)** Data Package. This review will be conducted at LM's facility and will address critical events such as Mars Orbit Insertion (MOI) and Apoapsis Lowering.

- LM shall prepare and submit a MAVEN **Decommissioning Review (DR)** Data Package. This review will be conducted at LM's facility to address decommissioning MAVEN after all mission flight objectives have been achieved or directed by NASA HQ.

Two reviews that are chaired by the Kennedy Space Center (KSC) with SRB support are:

- **Flight Readiness Review (FRR)**
- **Launch Readiness Review (LRR)**

  - LM shall prepare and submit a MAVEN **Flight Readiness Review (FRR)** Data Package. This review will be conducted at the launch facility to verify overall readiness of flight hardware and software, and ground and launch support resources to achieve the mission flight objectives. LM shall support the Flight Readiness Review.

  - LM shall prepare and submit a MAVEN **Launch Readiness Review (LRR)** Data Package. This review will be conducted at the launch facility to verify overall readiness of flight hardware and software, and ground and launch support resources to achieve the mission flight objectives. LM shall support the Launch Readiness Review.

There are also independent reviews conducted by the Safety and Mission Assurance organization, NASA HQ, and GSFC Director Office. They include, but are not limited to:

- **Safety and Mission Success Review (SMSR)** at NASA Headquarters. LM shall support the development and presentation for the SMSR.

- **Mission Readiness Review (MRR)**, which is a GSFC management review..

- Other reviews as required.

There are reviews that will be chaired by the Goddard Space Flight Center (GSFC) Integrated Independent Review Team (IRT), an independent GSFC authority. The review requirements are defined in *GPR 8700.4 Integrated Independent Reviews* and in the MAVEN MAR (MAVEN-PM-RQMT-0006) Section 8.0. These reviews shall include:

- **Spacecraft Critical Design Review (CDR)**
- **Spacecraft Pre-Environmental Review (PER)**
- **MOS/GDS PDR**
- **MOS/GDS CDR**
- **Mission Operations Review (MOR)**

  - LM shall prepare and submit a MAVEN **Spacecraft Critical Design Review (CDR)** Data Package. This review occurs after the design has been completed but prior to the start of manufacturing flight components or the coding of software. LM shall emphasize implementations of design approaches as well as test plans for flight systems including the results of engineering model testing. LM shall present the MAVEN Spacecraft CDR Data Package to the Systems Review team at the Critical Design Review.

  - LM shall prepare and submit a MAVEN **Orbiter Pre-Environmental Review (PER)** Data Package. This review occurs prior to the start of environmental testing of the flight instrument. LM shall emphasize the readiness of the flight hardware and software, and facilities for system level test and evaluate the environmental test plans. LM shall present the MAVEN Orbiter PER Data Package to the Systems Review team Pre-Environmental Review.

  - LM shall prepare and submit a MAVEN **Mission Operations/Ground Data System (MOS/GDS) Preliminary Design Review (PDR)** Data Package. This review will be conducted at LM's facility and will address Phase E Operations. It will occur roughly 6 months after Mission PDR and cover the end-to-end GDS and interfaces for MAVEN, and the interactions between GDS facilities and how operations will be performed.

  - LM shall prepare and submit a MAVEN **Mission Operations/Ground Data System (MOS/GDS) Critical Design Review (CDR)** Data Package. This review will be conducted at LM's facility and will address Phase E Operations. It will occur roughly 2 years before launch and covers in greater detail the mature design of the end-to-end GDS and interfaces for MAVEN, and the interactions between GDS facilities and how operations will be performed.

- LM shall prepare and submit a MAVEN **Mission Operations Review (MOR)** Data Package. This Mission-oriented review occurs roughly 12 months before launch. The MOR would build on the operations portion of the MOS-GDS PDR and CDR (more focus on operations plans and procedures and less on GDS). LM shall present the status of the system components, including the ground system, network-operations, the operational interfaces with the flight system, and orbital operations plans.

Finally there are lower-level informal engineering peer reviews, tabletops, and subsystem Critical Design reviews (CDRs). Engineering peer reviews of subsystem hardware/software chaired by LM shall occur during the project life cycle. These reviews are expected to cover the most detailed designs of the MAVEN reviews. It is the intent of the peer reviews that participants generate a detailed understanding of the component and subsystem designs' ability to meet higher-level system and mission requirements. Effective peer reviews will enable significant streamlining of the content of higher-level formal reviews. To promote continuity of the whole review program, LM shall notify the COTR of the lower-level review schedule to allow participation by the GSFC independent review team members and the GSFC MAVEN Project technical engineering support staff.

LM shall provide the necessary resources to prepare technical and programmatic handouts and drawings/schematics/schedules for distribution at the reviews, as well as present the data when required.

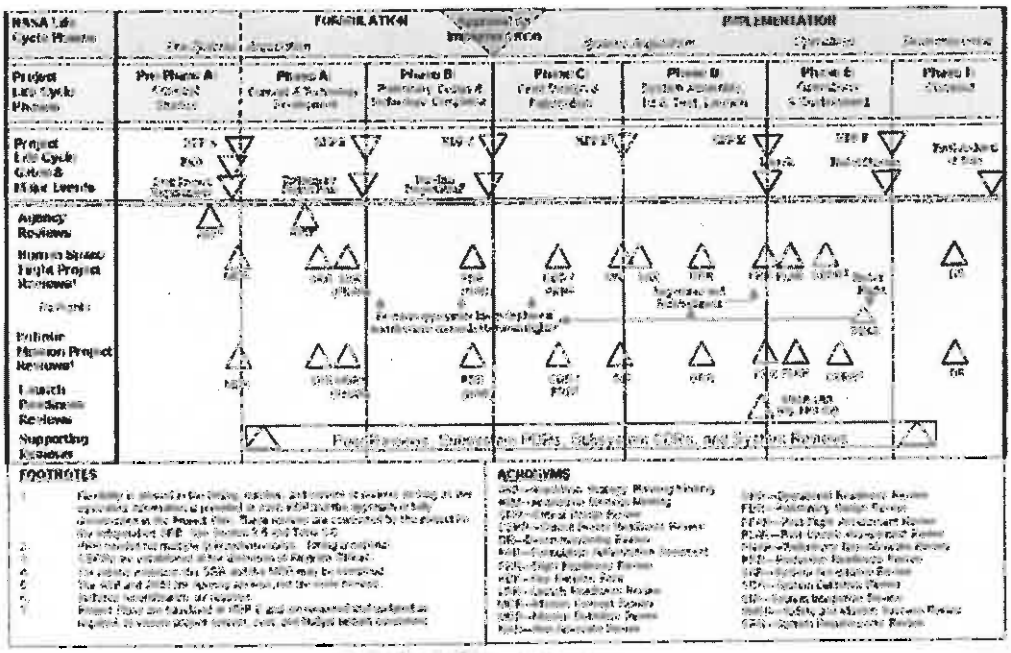
LM shall have available for NASA access and review, the minutes of the peer reviews (including action items if any) within ten (10) working days after a review has been conducted.

LM shall implement a system for tracking the status and resolution of Action Items initiated during peer and formal reviews whose status shall be reported at the formal reviews.

Wherever possible, these peer reviews should be conducted in accordance with *GPR 8700.6B, Engineering Peer Reviews*

Some of the Peer Reviews and Subsystem Reviews required are:

- Lower Level Peer Reviews of hardware and software designs, analyses, and procedures where deemed necessary prior to higher-level reviews.
- Informal Test Readiness Reviews (TRRs) at the assembly/ subsystem level prior to the start of environmental testing.
- Pre-delivery reviews for subsystems, individually delivered assemblies, software and support equipment.
- Subsystem Critical Design Reviews (CDRs).
- Flight Parameter Reviews (FPR) at the LM's facility.



MAVEN Life Cycle Reviews
Figure 5-1

Reviews	Date	Days	Chairing Authority	Location/Comments
Mission-level Reviews				
Systems Requirements Assessment	Complete		SRB	GSFC
PDR	Complete		SRB	GSFC
CDR	*	*	SRB	GSFC
SIR	*	*	SRB	LM-Denver
PER	*	*	IIRT	LM-Denver
PSR	*	*	SRB	LM-Denver
FRR	*	*	KSC	KSC
LRR/LVFRR	*	*	KSC	KSC
PLAR	*	*	SRB	LM-Denver
CERR	*	*	SRB	LM-Denver
DR	*	*	SRB	LM-Denver
MRR	*	*	GSFC CD	GSFC
SMSR	*	*	HQ/OSMA & Chief Eng	NASA HQ
MRB	*	*	SMD AA	NASA HQ
S/C &Ground Segment Reviews				
S/C PDR	*	*	IIRT	LM-Denver
MOS/GDS PDR	*	*	IIRT	LM-Denver
S/C CDR	*	*	IIRT	LM-Denver
MOS/GDS CDR	*	*	IIRT	LM-Denver
MOR	*	*	IIRT	LM-Denver
ORR	*	*	IIRT	LM-Denver
P&F Package Reviews				
PDR	*	*	IIRT	UCB
CDR	*	*	IIRT	UCB
PER	*	*	IIRT	UCB
PSR	*	*	IIRT	UCB
RS Package Reviews				
PDR	*	*	IIRT	LASP
CDR	*	*	IIRT	LASP
PER	*	*	IIRT	LASP
PSR	*	*	IIRT	LASP
NGIMS Instrument Reviews				
PDR	*	*	IIRT	GSFC
CDR	*	*	IIRT	GSFC
PER	*	*	IIRT	GSFC
PSR	*	*	IIRT	GSFC

*See MAVEN-PM-PLAN-0021 MAVEN Systems Review Plan App. A for dates and durations.

MAVEN Review Summary
Figure 5-2

5.3.5.2 SAFETY REVIEWS

LM shall support and develop data packages as required to support GSFC PDRs, CDRs and PSRs Reviews. LM shall support the KSC Safety Reviews, Delta Safety Reviews, and Safety TIMs, as required.

5.3.5.3 PLANETARY PROTECTION REVIEWS

MAVEN has been given a classification as a Category III (orbiter, flyby) mission. LM shall support and develop data packages as required for the following required (per NPR 8020.12C) planetary protection reviews:

- Pre-Launch Planetary Protection Review (120 to 90 days prior to November 18, 2013)
- Launch Readiness Review (as an agenda item on the project LRR)

5.3.6 RESOURCE MANAGEMENT

LM shall establish, implement, and maintain a comprehensive resource management system for planning, authorizing, and controlling the total resources effort for each task and for providing timely and adequate visibility into manpower and schedule performance. The system shall be consistent with the spacecraft contractor's standards.

LM shall provide facilities required for component, subsystem, and spacecraft development and testing, such as: clean rooms, thermal vacuum chambers, thermal cycle chambers, vibration facilities, and spacecraft storage facilities.

LM shall establish, implement, and maintain an integrated scheduling system consistent with their corporate procedures. The spacecraft contractor shall provide a master program phasing schedule, spacecraft schedules, and detailed subsystem schedules in accordance with (CDRL PM-11).

LM shall provide the necessary resources for monitoring, controlling, executing, and administering the MAVEN contract and subcontracts to ensure compliance with all contractual requirements.

5.3.7 SITE ACCESS

NASA shall be granted access to the LM and subcontractor facilities. Procedures for visit requests, contacts and authorizations will be coordinated with the LM MAVEN PM.

LM shall provide office space, telephones, and high-speed internet access, with provisions to get through Contractor firewalls to GSFC, for use by four (4) GSFC representatives during the performance of this Contract. The facility and network shall meet GSFC flight operations security requirements and NASA IT security requirements.

5.3.8 REPORTS

LM shall provide various programmatic reports during the Phase C through Phase E period. This section will outline the various periodic reports that will be needed. LM shall develop and deliver all documentation in according with the Contract Deliverables Requirements List (CDRL). LM shall make available to the MAVEN project in a timely manner when requested, any spacecraft/orbiter related plans, reports, technical memoranda, procedures, and analyses that are contractor or subcontractor generated under this contract for the MAVEN mission, but not listed in the CDRL.

LM shall prepare and submit a final summary letter/report, upon completion of Phase D and Phase E, stating which deliverables were met per the contract and whether or not all electronic deliverables and data were captured in the MIS system database. The summary shall identify specific idiosyncrasies or "features' of the MAVEN orbiter.

5.3.8.1 MONTHLY TECHNICAL PROGRESS REPORT

LM will generate a written monthly report/presentation regardless of whether the review takes place or not. These reports shall then be submitted in electronic format. General guidance for content is identified, but not limited to what is addressed in CDRL PM-02.

5.3.8.2 SCHEDULE REPORTS

LM shall develop and maintain a project schedule by logically networking detailed program activities from contract award to the completion of the contract. Reports are as identified in CDRL PM-11.

5.3.8.3 MONTHLY and QUARTERLY FINANCIAL REPORTS

The Contractor shall integrate projected and actual cost data from all cost centers and shall submit monthly and quarterly financial management reports per CDRL PM-03 and CDRL PM-04.

5.3.8.4 EARNED VALUE REPORTING

LM shall use and maintain in performance of this contract an Earned Value Management System (EVMS). Reports shall be delivered per CDRL's PM-07, PM-08, PM-11.

5.3.8.4.1 EARNED VALUE MANAGEMENT SYSTEM REVIEWS

The MAVEN Project Office will assess the compliance of LM's EVMS and Performance Management Baseline by conducting Integrated Baseline Reviews (IBRs) and EVMS Assurance Reviews CDRL PM-10.

5.3.9 RISK MANAGEMENT

LM shall implement a risk management program in compliance with NPR 8000.4, *NASA Risk Management Procedural Requirements*. As part of their risk management program, LM shall prepare and submit a Risk Management Plan per CDRL PM-28.

5.3.10 CONFIGURATION MANAGEMENT

Configuration Management (CM) shall be performed in support of the MAVEN Project. The configuration of deliverable items shall be maintained throughout all phases of assembly and test. Configuration verification shall be performed and documented as assemblies are incorporated into higher-level assemblies and at major project milestones (i.e. pre-environmental test, pre-ship, pre-launch, etc). LM shall deliver a Configuration Management Plan per CDRL PM-12 that documents the CM process for MAVEN.

LM shall provide documentary Electronic Images of the MAVEN Orbiter during all phases of fabrication and ATLO. This imagery will be used to document the construction of the MAVEN Observatory. It shall include receiving and inspection photos of the instruments and subsystem deliveries. The electronic images shall be delivered per CDRL PM-02.

5.3.11 SUBCONTRACT MANAGEMENT

LM shall negotiate and award all subcontracts that are necessary for the development of the spacecraft, the Mission Support Area (MSA), instrument support, and support of the SOC. LM shall flow-down mission assurance requirements contained in the MAVEN MAR, MAVEN-PM-RQMT-0006, document to all subcontracts as defined in the MAVEN Mission Assurance Implementation Plan (MAIP), MAVEN-SC-PLAN-0029. LM shall provide technical and programmatic oversight of the subcontract and report their progress and performance in the monthly reports. For all subcontracts already in place, LM shall update and negotiate these subcontracts to cover phases C through E of the mission if required. Also, all subcontracts with a non-United States participant must meet all approved NASA procurement policies. The NASA FAR Supplement (NFS) subpart 1825 addresses foreign acquisitions.

5.3.12 EXPORT CONTROL

LM shall prepare, submit, and update as necessary any International Traffic in Arms Regulations (ITAR) and Export Control documentation required. LM shall comply with the provisions of 22 CFR 120-130, International Traffic in Arms Regulations (ITAR); 15 CFR 730-774, Export Administration Regulations; and NASA FAR Supplement 1852.225-70, Export Licenses.

6 TECHNICAL REQUIREMENTS

6.1 SYSTEMS ENGINEERING

LM shall provide systems engineering for the spacecraft, orbiter, and mission level. The systems engineers shall be responsible for the overall technical coordination of the technical team in order to produce a design and a system that meets all of its requirements.

Included in the systems engineer's responsibility is the proper flow-down of top-level requirements to the spacecraft, spacecraft subsystems, and component levels and the tracking and verification of all these requirements. The spacecraft team shall use the DOORS® requirement management tool to help manage the requirements effort. The Mission Requirements Document, the Spacecraft Specification, and all spacecraft specific Interface Control Drawings (ICDs) shall be entered in the DOORS® database. Requirements links shall be established between the spacecraft level documents and also higher level mission documents. As the design matures, the documents in DOORS® (and the DOORS® database) shall be updated and maintained as necessary. The systems engineers shall be responsible for ensuring that all requirements are verified and should use the DOORS® tool to document the results, create and update the verification matrices for each subsystem and the overall spacecraft/orbiter, and produce verification reports as necessary.

The systems engineers shall also lead the effort to identify and document all technical interface information within the spacecraft via ICDs. They shall also be intimately involved with the top-level ICDs (e.g.: Spacecraft to Instrument Suite ICDs) generated by other MAVEN mission elements that involve the instrument packages.

Another important function of the systems engineer shall be to budget and allocate the important technical resources (e.g.: mass, power, data rates, etc.) of the spacecraft. During the design, development and test effort, the systems engineer shall track these resources and report them on a monthly basis.

The systems engineering team shall use as a guide the following documents: 1) NASA Systems Engineering Processes and Requirements (NPR 7123.1A); 2) NASA Systems Engineering Handbook (SP-2007-6105) and, 3) the Goddard Procedural Requirement on Systems Engineering (GPR 7120.5A).

The following sections contain some systems engineering activities that shall be performed in Phases C through E.

6.1.1 PHASE C and D SYSTEMS ENGINEERING ACTIVITIES

During Phases C and D, the systems engineering activities shall include, but not be limited, to the following tasks:

- Perform Requirements traceability, update verification matrices. Establish flight system verification plan.
- Develop Spacecraft Specification document
- Generate Baseline Drawing trees and Indentured Parts Lists, or equivalents

- Generate Baseline Block Diagrams
- Maintain Interface Control Documents (ICDs)
- Manage and trend technical resources (power, mass, etc.)
- Provide Baseline inputs to other mission element ICDs
- Support the MAVEN mission systems engineering activities
- LM shall generate a Gold Rules Compliance Matrix.
- LM shall generate a list of exceptions to test-as-you-fly.
- LM shall input to the list of incompressible tests.
- Engineering Layout Drawings of the MAVEN Orbiter, Electrical Schematic Drawings of the MAVEN Orbiter and any design documentation related to the MAVEN Orbiter shall be available for NASA access and review including hard copies at the request of the COTR.
- LM shall develop a MAVEN Thermal Analytical Model of the MAVEN Orbiter.
- LM shall develop a MAVEN Structural Analytical Model of the MAVEN Orbiter.
- LM shall provide input to the MAVEN Contamination Analytical Model of the MAVEN Orbiter. LM shall document the results of these models covering techniques used, assumptions made and results.
- LM shall develop MAVEN Radiation Exposure Analytical Models of the MAVEN Orbiter. LM shall document the results of these models covering techniques used, assumptions made and results.
- LM shall formulate inputs to NASA and support the development of the MAVEN Environmental Requirements Document (ERD) and Orbiter, Component, and Instrument Test Requirements Documents. These requirements specification will define the environment that the MAVEN Orbiter and the individual instruments will encounter in terms of EMC, thermal, thermal vacuum, vibration, static load, shock etc.
- LM shall prepare and submit to NASA, as requested, MAVEN Spacecraft Subsystem Block Diagrams for each spacecraft subsystem.
- The activities at LM and spacecraft design shall meet the contamination control requirements as defined in the MAVEN Contamination Control Plan, MAVEN-SC-PLAN-0024 (LM document MAV-PN-09-002). (Phase B CDRL MA 13-1)
- LM shall support and participate in the MAVEN Science Working Group (SWG). The SWG meets once every three-months. LM shall attend and provide information such as status of the spacecraft to the SWG.

- LM shall provide Flight Segment inputs to the project level orbit determination performance analysis and orbit determination documentation.
- LM shall provide inputs to the Trajectory and Maneuvering Planning documentation and analysis.
- LM shall support the Planetary Protection Working Group and provide the necessary analysis/help develop any Planetary Protection documentation. LM shall support planetary protection, reviews as required. Mission and spacecraft design shall meet the requirements of a Category III (orbiter, flyby) spacecraft per NPR 8020.12C
- Breakup and Burnup analysis will be provided at CDR identifying items that are likely to not need planetary protection cleaning. Additional analysis will be requested via RFP.
- Planetary Protection Assaying requirements will be defined by the Planetary Protection Working Group. LM shall implement an assaying effort for the spacecraft, instruments, and overall observatory. LM shall provide assaying services at the instrument institutions for a minimum of two assays (during instrument fabrication and after assembly prior to delivery). A third assay is planned for either at the instrument institution or after delivery at LM. LM shall set up an assay lab and use common services for assays for data consistency between the spacecraft and instruments. GSFC and the instrument institutions will support LM in assaying activities at the institutions. After delivery to LM the assaying of the instruments will be the responsibility of LM as part of the overall observatory assaying activities. The level of assaying for MAVEN shall be similar to what was performed on MRO and has been agreed to by the Planetary Protection Working Group. LM shall integrate all the assaying results with the Burn up and Breakup analysis and generate the final Planetary Protection report prior to launch. The prelaunch planetary protection report will need to include the assay results from the instruments and the analysis of the Planetary Protection Equipment List (PPEL), which is described in the MAVEN planetary protection plan. LM shall manage and maintain the PPEL. GSFC shall support that effort and the generation of the final report. It is assumed that LM will subcontract the assaying effort. If so, LM shall maximize efficiencies with the instrument and spacecraft assaying subcontractor. The proposed assaying levels shall be coordinated with the PPWG prior to submittal.

Comment [01]: CCR 298

Mission Assurance/Systems Related Requirements:

- The FMEA shall be performed in accordance with GSFC S-302-89-01 "Failure Modes and Effects Analysis Procedures for Unmanned Spacecraft and Instruments" or a developer(s) procedure that has been approved by the GSFC MAVEN COTR.

- All part applications that do not meet the derating criteria shall be documented in a formal LM memorandum and approved by the MAVEN Parts Control Board (PCB) for flight. The analyses and updates shall be made available for NASA access and review.

- LM shall perform trend analyses to the component level to track measurable parameters that relate to performance stability. Selected parameters shall be monitored for trends starting at component acceptance testing and continuing during the system integration and test phases. The monitoring shall be accomplished within the normal test framework (i.e., during functional tests, environmental tests, etc). LM shall establish a system for recording and analyzing the parameters as well as any changes from the first observed value even if the levels are within specified limits. A list of parameters to be monitored and the trend analysis reports shall be available for NASA access and review. Trend analysis data shall be reviewed with the mission operational personnel prior to launch, and the mission operational personnel shall continue recording trends throughout mission life for early detection of possible mission failure tendencies.

- LM shall meet the Mission Assurance requirements identified in the MAR regarding Printed Wiring Board (PWB) Coupons. The exception noted here is that while GSFC will return coupon analysis results within 2 weeks, LM may proceed prior to receiving GSFC results if LM coupon analysis is acceptable. The project will assume the cost/schedule risk in this specific instance. Upon first indication that GSFC results indicate coupon deficiencies, LM will convene with the GSFC CSO and COTR and establish a resolution plan before proceeding further with that PWB vendor.

In general, Mission Assurance requirements are identified in Section 7.

6.2 FLIGHT SYSTEM

LM shall design, fabricate, calibrate, integrate, test and deliver a fully qualified flight system integrated, tested, and qualified with the instrument packages. The flight system shall be designed and tested to fulfill the mission science requirements for measurement accuracy and precision. As part of the development of the flight hardware, the spacecraft team should use a combination of Prototype Units (PUs), Engineering Models (EMs), and Qualification Models (QMs) as applicable, depending on the heritage and maturity of each of the subsystem designs. This shall lead into the development of the flight units for each subsystem. Each flight subsystem or component shall be fully qualified prior to its delivery to spacecraft ATLO. LM shall provide

the necessary spacecraft spares, and necessary ground software/support equipment and special tooling.

6.2.1 DESIGN AND DEVELOPMENT

Complete the design efforts initiated under Phase B and finalize the Flight System design, requirements definition, payload accommodations and interfaces, and to finalize the manufacturing, integration, test, verification, and launch operations plans.

Develop, verify, certify, operate and maintain testbeds, in accordance with GSFC approved Testbed Plans , to verify flight software functions, subsystem and payload interface functions, timing interactions, flight/ground interface testing, command sequence testing, integrated flight/ground development, and fault identification and response routines.

Support the development, verification and validation of critical mission sequences, significant mission sequences, and mission scenarios during the ATLO phase.

6.2.2 MANUFACTURING, ASSEMBLY, INTEGRATION, AND TEST

LM shall provide the appropriate manufacturing, assembly, integration, and test resources necessary to deliver a qualified Flight System, which consists of the integrated spacecraft and science payloads that will support the launch and mission operations.

LM shall manufacture, assemble, integrate and test the MAVEN spacecraft, in accordance with Contractor-developed fabrication, assembly, integration, test, verification and calibration documentation including GSFC-approved plans, specifications, procedures, drawings and analyses.

LM shall integrate and test the Science and Relay Payloads with the spacecraft in accordance with LM-developed integration and test plans, procedures, drawings and specifications.

LM shall provide ground support equipment (including test and control instrumentation, software, ground handling and lift fixtures, special tooling, special test equipment and shipping containers) required to manufacture, integrate, test, calibrate ship and prepare the Flight System for launch.

LM shall demonstrate compatibility of the Flight System Telemetry and Command (T&C) systems, Planning and Scheduling systems, and command sequencing systems in the Mission Support Area (MSA) located at LM

LM shall demonstrate compatibility of the Flight System with data products of the Science Operations Center (SOC).

LM shall demonstrate compatibility of the Flight System with data products of the Instrument Team institutions (SSL, LASP, GSFC).

LM shall demonstrate compatibility of the Flight System with data products of the Navigation element located at JPL.

LM shall demonstrate commanding and data flow including end-to-end sequence testing.

6.2.2.1 SUBSYSTEMS

During Phase C and D, the subsystem hardware development activities shall include, but not be limited, to the following tasks:

a. Generate Specification documents
b. Complete design, schematics, drawings
c. Update As-Designed Parts Lists
d. Order remaining non-flight and flight long-lead parts
e. Fabricate and test EM units where applicable
f. Perform Baseline Mechanical Structural Models/Analyses
g. Perform Baseline Thermal Models/Analyses
h. Generate Baseline Manufacturing Plan
i. Generate Baseline Spacecraft Grounding Diagram
j. Conduct Peer Reviews of the Subsystem Designs
k. Present design at mission-level CDRs
l. Conduct ATLO Readiness Reviews for each of the subsystem flight hardware.
m. Present Environmental and Integration and Test Plans

GSFC considers the EMI/EMC testing as a workmanship test whereas Lockheed and some of their subsystem vendors consider the testing to put the flight hardware at risk. As a result, exceptions to the Subsystem EMI/EMC test program have been identified. LM shall implement the following in addition to the baseline:

Additonal EMI/EMC testing

1. Command & Data Handling C&DH2
2. Two Axis Motor Electronics (TAME)
3. Transponder SDST2
4. Traveling Tube Wave Amplifier (TWTA2)

Reduction/Elimination in EMI/EMC testing

1. Reaction Wheels/Electronics (RWA2,3, and 4)
2. Inertial Measurement Unit (IMU2)
3. Reduction in Susceptibility testing for Reaction Wheel #1, IMU1, and Star Tracker (ST1)

n. LM shall perform, as agreed upon, Orbiter level Deployment tests to confirm that the final spacecraft, as built, has sufficient margin and clearance to deploy the

appendages. These tests shall encompass the Solar Arrays and Spacecraft-Provided Instrument Booms and be performed post Environmental Testing.

o. LM shall perform early testing of the EPS High Efficiency Power Supply (HEPS) card to mitigate risk regarding its single point failure and excessive white wire configuration. LM shall also perform a minimum of 4 Thermal Vacuum cycle tests at the Power and Data Distribution Unit (PDDU) box level as part of the risk mitigation as well as GSFC mandatory quality assurance inspections.

6.2.2.1.1 PROPULSION

LM shall supply all labor, materials (excluding GFE), and ground support equipment (excluding GFE) necessary for all referee fluid loading and off-loading and drying of the MAVEN spacecraft during environmental testing and all fueling and off-fueling, if necessary, of the MAVEN spacecraft in preparation for flight. All work shall be in compliance with LM, GSFC, Kennedy Space Center and Cape Canaveral Air Station safety requirements.

LM shall procure a 1/2" Latch Valve and spare to replace the 3/4" Latch Valve design.

LM shall implement the Mars Orbit Insertion Thruster (MOIT) Rocket Engine Assembly (REA) design "opportunity" that uses a 35:1 extended nozzle ratio. This design improves propellant margin and performance while providing an opportunity for extended science and/or relay mission operations.

6.2.2.1.2 THERMAL

LM shall supply the material and labor for the fabrication of the instrument thermal blankets for all instrument Flight Models as defined in the payload receivables/deliverables (REC/DEL) list.

LM shall perform the design, analysis, and fabrication of the instrument thermal blankets (as defined by the payload REC/DEL list), all spacecraft to instrument passive mounting interfaces and all spacecraft to instrument power/telemetry harnessing. The instrument institutions will provide a simplified thermal model (using Thermal Desktop Version 5.3 with no more than 50 nodes) for LM to incorporate into an integrated system thermal model. LM will use these simplified thermal models to calculate the bounding thermal environments for the instruments.

LM shall supply the material and labor for the fabrication of the instrument thermal blankets for all engineering models (EM) as defined in the payload REC/DEL list. Models for thermal blanket fabrication, and mock-ups of the instruments will be provided by the instrument package teams.

LM shall have available for NASA access and review, a MAVEN Orbiter Thermal Analysis.

6.2.2.1.3 SOFTWARE

During all phases of the project the contractor shall comply with all software management requirements documented in the MAVEN Software Management Plan (SMP), MAVEN-SYS-PLAN-0020.

- LM shall design the MAVEN flight software so that it can be modified on orbit per ground commands as defined in the MRD.

- LM shall design the MAVEN workstation based, spacecraft Software Simulator (Soft-Sim) in place at the Subcontractor's facility. LM shall maintain the simulator software with the current flight software and simulation models build.

- Support flight software Independent Verification and Validation (IV&V) at GSFC and at the NASA IV&V facility to assess adequacy of specifications and software design compliance and verification approach.

- LM shall comply with the Software Safety requirements for the spacecraft and verify all safety-critical software on flight or flight-like hardware as defined in the NASA-STD-8719.13B; NASA Software Safety Technical Standard

6.2.2.1.4 SOLAR ARRAYS/MAGNETIC CLEANLINESS

LM Shall design the Solar Arrays to meet the MAG instrument magnetic cleanliness requirements. The design shall implement a solar array string layout in a U-string configuration.

6.2.2.2 SPARES

LM shall work with the GSFC project office in the development of a flight and ground systems spares program. GSFC will coordinate the spares risk posture with LM. Disposition of spares will approved by the GSFC MAVEN project office.

Spare flight hardware may be available per agreements with the Jet Propulsion Laboratory and identified in the following Memorandum of Understanding's:

1. FHLP-08-013, Agreement to Transfer JPL Hardware to GSFC for the MAVEN Project, dtd April 2008
2. FHLP-10-009, Agreement to Transfer JPL Hardware to GSFC for the MAVEN Project, dtd 2-23-10
3. FHLP-11-010, Agreement to Transfer JPL Hardware to GSFC for the MAVEN Project, dtd 11-17-10

4. FHLP-11-027, Agreement for the Allocation of Pyro Valves and PCAs between the SMAP Project and the MAVEN (GSFC) Project, 3-9-11

LM shall procure the following spare flight hardware and test hardware

1. Spare Small Deep Space Transponder (SDST)
2. SDST Special Test Equipment (STE)
3. Spare Adcole Sunsensor,
4. Spare Propulsion High and Low Pressure Service Valves and High Pressure and Bi-Prop Filters
5. Spare SFC (BAE Rad-750 flight computer card)
6. Spare CPS-J card (SEAKR Power supply card)
7. Spare Reaction Wheel Assembly (RWA)
8. Spare EEE parts for EPS and C&DH.
9. Procure a spare Engineering Development Unit (EDU) C&DH Space Flight Computer (Rad750) from BAE Systems and a CPS-J Power Supply from SEAKR

Comment [M2]: CCR 367

LM shall procure 3/8" spare latch valve due to lack of flight spare available as GFE..

LM shall procure a 1/2" Latch Valve and spare to replace the 3/4" Latch Valve design.

6.2.3 ATLO

LM shall execute a robust ATLO program as documented in the Integration, Assembly and Test Plan. (CDRL IT-02) This plan shall provide details on the Integration, Assembly and Test flow starting with spacecraft subsystem level integration and ending with shipment to the launch facility. The plan shall also describe aliveness, functional and performance testing throughout the test flow.

LM shall perform specific testing to verify the magnetic environment for the MAG instrument. They shall include

1. Orbiter Magnetic Moment Test
2. Magnetic Compatibility Test.
3. Solar Array Electrical Configuration Test
4. Solar Array String Magnetic Characterization

LM shall conduct an environmental test program in accordance with the requirements for an ATLAS-V launch vehicle as identified in the *GEVS for STS and ELV Payloads, Subsystems, and Components, GSFC-STD-7000*, for flight hardware sufficient to demonstrate design qualification, acceptance, and to test for workmanship. The test program tailored for MAVEN is

documented in the MAVEN Environmental Requirements Document (ERD), MAVEN-SYS-RQMT-0010.

Functional testing shall be performed before, during, and after environmental tests, as appropriate. LM's environmental test plans shall define the specific parameters associated with the planned environmental tests.

The following environmental exposures are required as a baseline for the MAVEN orbiter: Modal Survey, Sine Vibration, Acoustics, Mechanical Shock, EMI/EMC, Thermal Vacuum/Thermal Balance, Mass Properties, and Deployments shall be performed.

Repeated functional tests should be used to demonstrate the growing maturity of spacecraft subsystems, perform trending analysis, and to baseline performance status before each environmental test. Comprehensive Tests shall be performed to verify full mission hardware compliance, compatibility, and operability; and to perform trending analysis. The comprehensive test program shall establish a baseline pre and post environmental testing to identify anomalies and/or potential trends. LM shall develop the orbiter test procedures and integrating the instrument test procedures into the orbiter test program. LM shall convert the instrument functional procedures into the appropriate format(s) for use in system testing.

Prior to the PSR, LM shall perform an end-to-end compatibility test to demonstrate the Mission Support Area (MSA) capability to communicate with the MAVEN orbiter (up-link and downlink) via the DSN. Simulated normal orbital mission scenarios encompassing launch, subsystems and instrument activation, housekeeping, command/control, and stabilization/pointing shall be demonstrated, including the collecting, processing, and archiving of science data. Orbiter immunity to erroneous commands, autonomous safe-hold, and simulated anomaly recovery operations shall also be demonstrated.

LM shall report flight hardware failures to the MAVEN Project at GSFC beginning with acceptance testing of flight hardware. A failure is defined as any departure, or suspected departure, from design, performance, testing, or handling requirements that affects the function of flight equipment shall be immediately documented. Reporting documentation shall include as a minimum the date and time of occurrence, anomaly description, and root cause and corrective action. Developer review/disposition/approval of failure reports shall be described in applicable procedure(s) included or referenced in the MAIP. Failures in ground support equipment that interfaces with flight equipment shall also be immediately documented. LM shall report failures within 24 hours of occurrence. A Problem/Failure Report documenting the failure and investigation shall be supplied to the MAVEN COTR within 5 days of the occurrence beginning with orbiter integration.

Reporting shall continue through successful closure with the Failure Review Board (FRB). The FRB shall be comprised of the following:

1. Systems Engineer (chairperson);
2. Developer quality or reliability representative;
3. Developer project manager or representative;
4. NASA/GSFC MAVEN Systems Engineer or Designee;
5. NASA/GSFC MAVEN CSO or Designee;
6. NASA/GSFC MAVEN COTR or Designee;
7. Developer engineering representative responsible for the failed unit.

GSFC has final approval of all Orbiter PFR dispositions starting with the first instrument integration with the spacecraft. Prior to that the Task Manager will be given access to all failure reports. In addition, GSFC reserves disapproval rights within two working days on PFR dispositions prior to Orbiter I&T. The GSFC CSO, or his delegated representative, shall be kept informed of FRB meeting schedules and agenda with sufficient advance notice to permit GSFC participation, if desired. LM shall provide GSFC access to their MAVEN failure-reporting database.

The developer shall operate a closed looped nonconformance control system to disposition discrepant hardware. The developer shall identify each nonconformance in an MRB Report (or developer compatible form). LM shall provide GSFC access to their MRB database.

LM shall provide a site, all supervision, labor, equipment, parts and supplies to support the MAVEN Spacecraft Assembly, Integration, and Verification (AIV).

LM shall provide a site, all supervision, labor, equipment, parts and supplies to support the MAVEN Instruments Assembly, Integration, and Verification (AIV) onto the MAVEN spacecraft.

LM shall prepare and submit to NASA an Orbiter Mass Properties Report as part of the Monthly Status Reviews. This will typically be a mass summary at the monthly review. A detailed breakdown of the mass properties shall be maintained and available for review.

LM shall have available for NASA access and review a MAVEN Orbiter Structural Analysis.

LM have available for NASA access and review an Orbiter Modal Correlation Post-Test Results.

All test data from the start of ATLO thru Phase E shall be archived. Access to spacecraft level (including integrated instrument) raw test data shall be provided to government and authorized contractor personnel.

6.2.4 TESTBEDS

Specify, develop, verify and maintain one (1) Flight System single sided testbed and two (2) flight software simulator (Soft-Sim), including all required support equipment, for use with GSFC and LM Mission Operations System.

Maintain and update as necessary Contractor provided hardware and software, including operation and maintenance of the Flight System testbed to reflect actual Flight System performance/capabilities during Phase E.

6.2.5 GROUND SUPPORT EQUIPMENT

LM shall provide Mechanical Ground Support Equipment (MGSE) for the handling of the Spacecraft and Orbiter during instrument build-up and test, shipping, and installation operations at the spacecraft LM. The instruments will provide instrument lifting fixtures if required.

LM shall provide for Electrical Ground Support Equipment (EGSE) for the control and operation of the Spacecraft during instrument build-up and test, performance evaluation, test, simulation and stimulation of the flight Spacecraft. EGSE directly interfacing with the flight hardware shall use flight quality connectors or connector savers to interface with flight hardware to minimize the number of flight connector mate/demates during ground testing, or perform a GSE Failure Modes and Effects Analysis (FMEA) along with mate/demate logs to ensure flight connector integrity. The instruments will provide instrument-specific EGSE, if required.

LM shall provide a 2nd set of C&DH EGSE to help with parallel testing of the C&DH flight systems and support other system or instrument tests as required.

6.2.6 PAYLOAD ACCOMMODATIONS AND SUPPORT

Incorporate payload-provided mechanical configuration, structural and thermal math models with flight system models and provide relevant integrated model results to payload providers.

Conduct planning and coordination with payload providers and GSFC to establish payload and spacecraft interface design verification, test plans and requirements for ATLO.

Provide suitable facilities, and handling and transportation support for storage, pre-integration checkout, testing, and integration of individual payloads.

Interface details will be defined in the applicable ICDs and payloads receivable/deliverable list.

Provide purge gases and control cart as required.

Integrate Engineering Model (EM) payloads in accordance with spacecraft-payload Interface Control Documents (ICDs), with testbed(s) to verify and evaluate spacecraft-payload electrical interfaces, command and telemetry performance.

LM shall fabricate and provide MAG Engineering Model non-flight test harnesses and pigtail materials for MAG testing at GSFC.

LM shall accommodate MAG Calibration Roll operational events.

LM shall design the mission to accommodate IUVS Fly "Y" nod articulation.

LM shall provide redundant isolated primary power services to the single string Electra Payload.

Comment [M3]: CCR 357

6.2.6.1 PAYLOAD PROVIDED DELIVERIES

Agreements for payload deliveries will be captured in the Payload Receivables/Deliverables List and will be attached as part of the Phase C/D/E RFP.

Payload providers will:

- Provide a fit check template for each payload.
- Support preparation of the interface control documentation.
- Identify what type and quantity of external payload connectors are required.
- Provide a payload engineering model (EM) or simulator, which simulates the signal interface behavior of the flight unit. The EM or simulator will provide an interface that is electrically and functionally equivalent to the flight unit. The EM or simulator will reproduce timing, signal levels, polarity, bit ordering, and data format of the flight unit.
- Provide a set of EM or simulator Ground Support Equipment (GSE) as required to operate/assess the EM/simulator in the flight system test bed.
- Provide a payload mass model if the payload cannot be simulated as a rigid body with modes greater than 100 Hz and/or it uses kinematic mounts.
- Deliver Flight Payload and GSE.
- Provide thermal and structural math models, or equivalent.
- Provide payload installation procedures and handling and/or operating constraints.
- Provide payload-mounted alignment cubes, if required, for alignment characterization.
- Provide an end-item data package and Hardware Requirements Certification Review.

6.2.6.2 FACILITIES

Provide suitable Class 100,000 access-limited, clean room facilities, including high-speed Internet connections, for post-delivery processing of payload hardware and GSE by payload provider personnel. The facility shall be operated in line with the MAVEN Contamination Control Plan. Provide "contingency" capability of a Class 10,000 clean bench/tent if required for offline instrument processing/testing.

ATLO facilities shall meet payload contamination requirements.

6.3 GROUND SYSTEM

6.3.1 GROUND SYSTEMS DEVELOPMENT

LM shall:

Derive detailed requirements for MAVEN ground system software and hardware to support MAVEN flight operations in the MSA, based on Level 2/3 Mission Operations System-Ground Data System (MOS-GDS) requirements.

Prepare Flight System inputs to the Operations Plan, define requirements, and coordinate with GSFC Ground System personnel to establish detailed interface specifications and agreements.

Work with elements of the distributed MOS-GDS architecture to produce a Ground System Interface Control Document (ICD) and Operations Interface Agreements (OIA)

Prepare a multi-volume Mission Operations Plan

Submit inputs to and provide review support for development of the Project-level Mission Plan document

Provide a real-time Telemetry and Command (T&C) system for command and control of the MAVEN orbiter.

Provide a Planning and Scheduling / command sequence generation system to support mission planning, command sequence generation, uplink table generation, and flight rule / constraint checking for commands

Provide a long-term trending and plotting system for subsystem performance characterization and analysis

Provide and maintain standalone software tools in the MSA for support of MAVEN operations

Derive detailed requirements for MAVEN ground system software and hardware to support MAVEN telemetry monitoring and emergency orbiter commanding from a backup Mission Support area (bMSA) to be located at GSFC.

Provide software for deployment at GSFC to support development of the back-up Mission Support Area (bMSA)

Provide a "controlled repository" to hold a current image of all operational data to allow the back-up Mission Support Area (bMSA) at GSFC to assume responsibility for operations

Provide a system to support development of the master C&T database resident at LM

Support electronic data interfaces between the MSA and external elements of the distributed MAVEN MOS-GDS architecture including the DSN, SOC, Instrument Teams, GSFC bMSA, and Navigation element at JPL

Provide the capability (via the JPL Incident, Surprise, and Anomaly [ISA] system, or other system) to document and track the status of anomalous events during the MAVEN mission

Provide Personnel to participate with the LASP and GSFC Ground System teams in all operations planning and preparation activities, including:

- Ground System Scenario development and detailed Operations Concepts development.
- Ground System operations procedures and contingency procedures development
- Operations interface specifications and software interface specifications.
- Ground System testing, training and rehearsals.
- Development of operations handbook and training materials.

7 SAFETY AND MISSION ASSURANCE

During all phases of the project the contractor shall comply with all safety and mission assurance requirements documented in the MAVEN Mission Assurance Requirements, MAVEN-PM-RQMT-0006, which is included as an attachment to this contract. The contractor's plan for compliance with the MAR shall be documented in the MAIP, MAVEN-SC-PLAN-0029LM shall allow for support, at GSFC's discretion, Systems, Quality and Reliability Assurance engineers to reside at the Contractor's facility to support Phases C/D and E activities.

7.1 SAFETY

LM shall comply with safety requirements for the spacecraft as documented in the MAVEN Mission Assurance Requirements, MAVEN-PM-RQMT-0006 and AFSCM 91-710, Range Safety User Requirements Manual.

8 LAUNCH OPERATIONS

Conduct launch site operations for the spacecraft and payloads at Kennedy Space Center (KSC) including monitoring Flight System health, and performing required spacecraft fueling/defueling and maintenance operations before encapsulation and stacking. Support pre-launch Flight System operations during encapsulation and stacking, monitoring and reporting Flight System launch readiness/health before liftoff and during launch.
Participate in launch site operations planning activities and prepare Flight System inputs for launch preparation plans, procedures and sequences as well as other required launch vehicle and ATLO documentation.

LM shall develop Launch Site Operating Procedures for the MAVEN Mission.

LM shall develop Orbiter Launch Procedures for the MAVEN Mission.

LM shall provide technical support, maintenance, repair and recalibration of the MAVEN Spacecraft. This shall include support of launch operations at the launch site and on-orbit checkout of the MAVEN Spacecraft for a period of 30 days after launch.

LM shall develop Target Specification and Launch Window Specifications for preliminary Mission Analysis and Detailed Test Objectives.

LM shall support mission operations and anomaly response team activities through the Post-Launch Assessment Review (PLAR).

8.1 LAUNCH VEHICLE INTEGRATION

Support the development of the detailed Launch Services Interface Requirements Document (LSIRD), (MAVEN-LV-RQMT-0032). Provide any analyses and data and support GSFC and the launch vehicle provider to complete all required launch vehicle analyses, studies, reports, procedures, plans sequences and related interface documentation. Provide support to the United Launch Alliance (ULA) in preparing the Launch Vehicle Interface Control Document (LV-ICD); act as a signatory on the LV-ICD; and provide necessary support and test results to verify LV-ICD requirements.

8.2 LAUNCH SITE PROCESSING

LM shall work with KSC to prepare a Launch Site Support Plan.

Deliver the Flight System to KSC in accordance with Contractor-prepared shipping plans.

Perform post-shipment Flight System verification testing and support the integration of the Flight System with the launch vehicle at the launch site.

LM shall meet the requirements specified in "Table B-1. Customer Requirements Index for ELV Spacecraft" contained in *Guide for Expendable Launch Vehicle Payload Processing at Kennedy Space Center and Cape Canaveral Air Force*.

9 LOGISTICS

LM shall plan and coordinate all spacecraft move/transportation operations.

LM shall comply with *NASA NPG 6000.1E Requirements for Packaging, Handling and Transportation for Aeronautical and Space Systems, Equipment and Associated Components* and the *International Traffic in Arms Regulations* when handling and transporting hardware, documentation, software and Ground Support Equipment among, test facilities, Goddard Space Flight Center (GSFC), and the Kennedy Space Center (KSC).

LM shall execute all foreign shipments under a Government Bill of Lading provided by NASA.

10 EDUCATION AND PUBLIC OUTREACH

LM shall provide support to an integrated Education and Public Outreach (EPO) effort for the MAVEN mission. The EPO program will combine new initiatives with proven techniques to communicate MAVEN mission results to the public and incorporate MAVEN science in learning activities on various educational levels for phases C through E of the mission. LM shall fully coordinate EPO activities with the overall MAVEN project EPO lead.

Status of LM's E/PO program support shall be included as an integral element of major Mission reviews.

11 GOVERNMENT FURNISHED EQUIPMENT/SERVICES

The Government Furnished Equipment (GFE) list is provided as Attachment K to the Phase CDE contract. GFE listed as non-committal will be negotiated on a case by case basis.

NASA will provide Deep Space Network (DSN) tracking, data recovery, and Compatibility Test Trailer support.

NASA will provide the ATLAS-V launch vehicle and associated launch services such as vehicle production, launch site assembly, Orbiter propellant, purge, temperature and humidity control, contamination control, checkout, launch countdown and range support as well as Orbiter/launch vehicle integration, analysis, and post-flight mission data evaluation.

NASA will provide the Test Payload Adapter Fitting (TPAF) for the orbiter system level sine vibration test.

NASA/GSFC will provide the MAVEN Instrument (STATIC, SEP, SWEA, SWIA, LPW/EUV, MAG, IUVS, NGIMS, and Electra) management and oversight, flight hardware and software, ground support hardware and software, and Instrument Team participation, such as design reviews, ICDs, Orbiter integration, assembly and test, Orbiter Environmental test, launch support, Instrument commissioning, and mission support. Instrument Delivery Dates are as reflected in the MAVEN Integrated Master Schedule (IMS).

Licensing for Software and Ground Systems as required

12 GSFC SUPPORT

The GSFC MAVEN project will at a minimum:

- Review and approve or disapprove within 20 working days after receipt at GSFC (unless otherwise specified) documents submitted by the Contractor in response to project requirements, other than problem/failure reports.
- Attend and participate, as appropriate, in Contractor and lower-tier Contractor reviews, and critical technical discussions.
- Identify the selected launch services provider and provide launch vehicle environments.
- Perform Quality/Safety Assurance surveys and evaluations at Contractor facilities.
- Provide engineering support, as mutually agreed upon, to the Contractor's design, interface definition and integrated product teams.
- Provide EELV test Payload Attach Fitting for orbiter test program
- Review test results for GFE items on the spacecraft and provide concurrence before breaking major spacecraft configurations.
- Negotiate and provide the support of the JPL/ NASA Compatibility Test Van (CTV) for End to End testing.
- Negotiate with the United States Air Force for the C-17 airlift transportation and delivery to the launch site as required.

13 RECORD KEEPING

13.1 PROGRAM PLANS AND DATA

LM shall prepare and submit the plans and documents as specified in the CDRLs. Those not shown, as deliverables shall be made available if required. LM shall maintain as-built documentation thru the life of this contract.

13.2 INFORMATION, DATA, RECORDS AND STORAGE

Establish a method to provide access by Internet to authorized MAVEN Project personnel for working data products in accordance with CDRL PM-001. A GSFC or Contractor electronic database system or combination of both can be used. If a Contractor database is used, maintain access protection for the system, including an access control list for all authorized MAVEN Project personnel.

All test data from the start of ATLO thru Phase E shall be archived.

14 PHASE E / MISSION OPERATIONS

LM shall provide the resources necessary to support the GSFC mission operations team from the completion of the Post-Launch Assessment Review (PLAR) through Phase E and an option for Phase F decommissioning support to operate the MAVEN Flight System.

14.1 PHASE E ACTIVITIES TO BE DEVELOPED DURING PHASE C/D

LM shall support GSFC MAVEN Project work with the Mission Ground Support Systems MGSS) office point of contact at JPL to prepare Project Service Level Agreements (PSLA).

LM shall support the GSFC MAVEN Project in the development of the DSN Services Agreement (DSA) with the DSN Plans and Commitments Office at JPL

14.2 PHASE E

14.2.1 OPERATIONS

LM shall provide operations and technical support for the MAVEN Spacecraft during the mission operations phase of the project for a period starting at launch, thru Cruise Phase, and for 1 Earth-year after start of the Mars Mapping Phase.

LM shall be responsible for operation and control of the MAVEN Spacecraft and shall process and distribute data to the MAVEN Principal Investigators and the MAVEN Science Operations Center.

Perform engineering monitoring, tracking and analyses of all spacecraft functions and performance

- Summarize results in reports.
- Notify GSFC in response to unexpected off-nominal spacecraft conditions.

Perform analyses and ground tests as necessary to verify in-flight anomalous behavior and performance, and to determine and verify corrective actions. Use an Incident, Surprise, Anomaly (ISA) process to document in-flight anomalies and the evaluation and corrective actions.

Provide support to the LASP Science Operations System team to develop and verify Flight System command sequences.

Support the LASP and GSFC Ground System teams to develop plans, procedures, timelines, rehearsals, sequences and contingencies.

Maintain and update as necessary Contractor provided hardware and software, including operation and maintenance of the Flight System.

Use the Flight System testbeds to test first-time and critical command sequences, for anomaly resolution and recovery and for flight software maintenance and upgrades.

Maintain and modify in-flight, as needed, the flight software, for enhancements, or anomaly resolution.

Complete other activities in support of Mission.

Provide level-of-effort engineering support for various flight system or mission operations special studies as directed in writing by the Cognizant GSFC Contract Officer.

LM shall modify the spacecraft operations and planning to increase the time to perform the Transition to the Science Mission Phase from 3 weeks to 5 weeks.

LM shall shall support the arrival of MAVEN at Mars on any day between the periods September 22, 2014 through September 28, 2014 to elimination occultation at the end of MOI.

LM shall provide sufficient Phase E operations and planning that support the increased science and mission operations defined at the Science Operation Technical Interchange Meeting (TIM) on August 26-27 at LASP, Boulder CO

14.2.2 PROGRAM MANAGEMENT AND REPORTING

Establish a management system and organization to support the requirements of this Contract

Assign a Flight System Operations Manager who is responsible for all Contractor effort and shall have authority commensurate with that responsibility

Continue to implement a reporting program as established during Phases B/C/D.

Update and maintain a listing of program risk items including technical, schedule and cost risks, and provide mitigation options and cutoff.

Grant specific GSFC personnel non-escort privileges to all areas of the Contractor's facility where work is being performed under this Contract.

Accept "in-scope" technical direction only from the GSFC COTR. Direction will be in written form, such as a Technical Direction Memorandum (TDM).

Maintain technical liaison between MAVEN Project personnel, and the Contractor's equivalent personnel to permit the timely involvement in relevant technical issues.

14.2.3 MEETINGS AND REVIEWS

Participate in and support GSFC Project and NASA meetings and reviews, in accordance with GSFC approved Review plan, including but not limited to:

- Engineering and Management status and working meetings and telecons.
- Quarterly Reviews at GSFC as requested

- Critical Event Readiness Reviews at GSFC for all mission operations critical events.
- Sequencing and real-time command meetings and reviews
- Other meetings and reviews as requested by GSFC
- Post-Launch Assessment Review (PLAR) at the contractor's facility.

14.2.4 PROGRAM PLANS AND DATA

Generate a Program Plan and maintain as-built documentation.

14.2.5 INFORMATION, DATA, RECORDS AND STORAGE

Transfer all deliverable documentation to a GSFC database system, which is Internet accessible and is configuration-controlled, released documents.

Establish a method to provide access by Internet to authorized MAVEN Project personnel for working data products. A GSFC or Contractor electronic database system or combination of both can be used. If a Contractor database is used, maintain access protection for the system, including an access control list for all authorized MAVEN Project personnel.

15 POST-LAUNCH RESIDUAL HARDWARE DELIVERY

Disposition per GSFC direction, all residual flight spare hardware, including flight electronic parts, and ground support equipment, including test and control instrumentation, software, ground handling and lift fixtures, special tooling, special test equipment and shipping containers. Delivery to include all appropriate documentation to allow for future usage.

Property disposition will be handled either in Phase F or as a contract change to Phase E when the requirements and costs are better understood.

16 INSPECTIONS AND ACCEPTANCE

The Flight System and any deliverable flight spares and/or rapid repair kits fabricated and assembled under this Contract shall be inspected at the Contractor's facility and verified for compliance with the requirements set forth in this Contract, using Contractor-prepared test plans

Flight System final checkout shall be performed at the launch site, using Contractor prepared test plans

Final inspection and acceptance of all ground support equipment shall be at the Contractor's facility.

Final acceptance of any Ground System hardware, software, procedures, and trained personnel needed for performance analysis of the flight system shall be at the Contractor's facility.

Final acceptance of the Flight System shall be at liftoff.

Acceptance of the Flight System will be documented on a Letter of Completion (LOC), as indicated by the GSFC Contractor Manager's signature or assigned delegate's signature.

16.1 DELIVERY INSTRUCTIONS

Except as otherwise provided in this Contract, the point of inspection, acceptance and delivery of all CDRL items deliverable under this Contract shall be the NASA Goddard Space Flight Center, Greenbelt, Maryland 20771. All such deliverables shall be packaged, packed, boxed or crated in such a manner to ensure safe delivery and shall be shipped prepaid and at the Contractor's expense to the point of delivery.

- The Flight System shall be shipped from LM directly to KSC, Florida for launch site processing and launch vehicle integration. The point of delivery for the Flight System shall be at KSC, Florida
- LM shall provide the transportation and delivery to the launch site. NASA GSFC will coordinate the airlift transport via C-17 as required.
- Residual flight hardware and ground support equipment, software, ground handling and lift fixtures, special tooling, special test equipment and shipping containers shall be delivered in place at LM Denver, CO.

LM shall provide the CO the annual and final reports of reportable items described in the article entitled "New Technology." Copies of transmittal letters for those reports shall be sent to the GSFC Intellectual Property Office Technology (IPO) and to the cognizant GSFC negotiator.

17 APPENDIX – UPDATES TO THE STATEMENT OF WORK

The following updates are changes to the SOW that

	CCR #	SOW	GFE or Rec/Del List Mod
1.	209	Replace 3/4" Latch Valve design with 1/2" Latch Valve and procurement of spare.	N
2.	271	Procure 3/8" spare latch valve due to lack of flight spare available as GFE.	N
3.	213	Update the solar array string layout to U-string configuration. U-String Solar Array Layout is necessary to meet MAG Cleanliness requirements and increase Outer Solar Panel Size to 77.5" in length.	N
4.	229	Respin the GIF card and implement Mode Register Refresh changes to help mitigate the Single Event Upset (SEU) Susceptibility Requirements. This is to meet MRD requirement governing Science Collection during Solar Flare Activity.	N
5.	240	Increase Transition Phase duration from 3 weeks to 5 weeks. This extra time is required to complete all of the orbit maneuvers and payload checkouts needed to prepare the spacecraft for the Science Phase.	N
6.	247	Addition of MAG test harnesses.	Y - Rec/Del update
7.	291	Procure 3 spacecraft models. Reference Proposal (SEP-CP-0116)	N
8.	292	Addition of the following Spares: Small Deep Space Transponder (SDST), SDST Special Test Equipment (STE). Adcole Sunsensor, Propulsion Valves and Filters, BAE Rad-750 card, CPS-J card, and SPC cards. The pyrovalves are the only items affecting the GFE list. Reference Proposal (SEP-CP-0083)	Y
9.	258/293	Modification of the EMI/EMC test program for the subsystem 2nd flight or spare units. Reference Proposal SEP-CP-0090)	N
10	296	Addition of PPDU Thermal Vacuum testing for HEPS and addition of Mandatory Inspection Points	N
11.	297	Rocket Engine Nozzle Extension	N
13.	274	Increase in Phase E Operations due to Instrument Operation Complexity	N
14.	245	Fly Y Nod Articulation to accommodate IUVS	N
15.	252	Orbiter Magnetics Testing and Solar Array Magnetics testing	N

16.	257	Modify Mars Arrival Dates to eliminate Occulting at end of Mars Orbit Insertion	N
17.	276	MAG Roll Calibration Operations and Accommodations	N
18	298	Planetary Protection and Assaying	N
19.	357	Electra Diode Box	N
20	367	Procure spare Engineering Development Unit (EDU) C&DH Space Flight Computer (Rad750) from BAE Systems and and a CPS-J Power Supply from SEAKR.	N

OMB Approval 2700-0042

AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1. CONTRACT ID CODE	PAGE	OF	PAGES
	1		2

2. AMENDMENT/MODIFICATION NO.	3. EFFECTIVE DATE	4. REQUISITION/PURCHASE REQ. NO.	5. PROJECT NO. *(If applicable)*
00043	See Block 16C	4200418314	

6. ISSUED BY CODE 210.S
NASA Goddard Space Flight Center
Procurement Operations Division

7. ADMINISTERED BY *(If other than Item 6)* CODE 210.S
NASA/Goddard Space Flight Center
Space Sciences Procurement Office

8. NAME AND ADDRESS OF CONTRACTOR *(No. Street, county, State and ZIP: Code)*
LOCKHEED MARTIN CORP.
12257 STATE HWY
LITTLETON CO 80127-0000

CODE 04235 FACILITY CODE

(4) 9A. AMENDMENT OF SOLICITATION NO.

9B. DATED *(SEE ITEM 11)*

X 10A. MODIFICATION OF CONTRACT/ORDER NO. NNG09EK34C

10B. DATED *(SEE ITEM 13)* 04/02/09

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 one (1) copy 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 ACKNOWLEDGMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATA 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 data specified.

12. ACCOUNTING AND APPROPRIATION DATA *(If required)*

BNC: GJE PR: 4200418314 AMT: $10,000,000.00

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

(4) 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)
NFS 1852.232-81 CONTRACT FUNDING (JUN 1990)

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 provides incremental funding for continued contract performance and revises clause B.3 accordingly.

POC: Amy Aqueche. Email: amy.a.aqueche@nasa.gov

Continued....

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)* Amy A. Aqueche	
15B. CONTRACTOR/OFFEROR *(Signature of person authorized to sign)*	15C. DATE SIGNED	16B. UNITED STATES OF AMERICA BY Amy Aqueche *(Signature of Contracting Officer)*	16C. DATE SIGNED 12/09/2011

NSN 7540-01-152-8070
PREVIOUS EDITION UNUSABLE

STANDARD FORM 30 (REV. 10-83)
Prescribed by GSA FAR (48 CFR) 53.243

1. Revise Clause B.3 – CONTRACT FUNDING (1852.232-81) (JUN 1990) is revised to increase funds as set forth below:

	FROM (MOD 42)	BY	TO
Estimated Cost	[redacted]		
Base Fee			
Award Fee			
CPAF	$130,641,331	$10,000,000	$140,641,331

*The allotment date is through January 24, 2012.

2. All other terms and conditions remain unchanged and in full force and effect.

(END MODIFICATION)

OMB Approval 2700-0042

AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1. CONTRACT ID CODE	PAGE	OF	PAGES
	1		2

2. AMENDMENT/MODIFICATION NO.	3. EFFECTIVE DATE	4. REQUISITION/PURCHASE REQ. NO.	5. PROJECT NO. (If applicable)
00044	See Block 16C	N/A	

6. ISSUED BY	CODE	7. ADMINISTERED BY (If other than Item 6)	CODE
NASA Goddard Space Flight Center Procurement Operations Division	210.S	NASA/Goddard Space Flight Center Space Sciences Procurement Office	210.S

8. NAME AND ADDRESS OF CONTRACTOR (No. Street, county, State and ZIP: Code)	(4)	9A. AMENDMENT OF SOLICITATION NO.
LOCKHEED MARTIN CORP. 1257 STATE HWY LITTLETON CO 80127-0000		9B. DATED (SEE ITEM 11)
	X	10A. MODIFICATION OF CONTRACT/ORDER NO. NNG09EK34C
CODE 04235 FACILITY CODE		10B. DATED (SEE ITEM 13) 04/02/09

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 one (1) copy 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 ACKNOWLEDGMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATA 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 data specified.

12. ACCOUNTING AND APPROPRIATION DATA (If required)

BNC: GJE PR: N/A AMT: $26,497 *Funds Are Available on Contract*

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

(4)	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) Unilateral Pursuant to 1852.216-77 Award Fee for End Items (JUNE 2000)

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 documents the amount of interim award fee earned by the Contractor for the Phase C/D/E Period 2 Award Fee for performance during the period from May 1, 2011 – October 31, 2011.

POC: Amy Aqueche. Email: amy.a.aqueche@nasa.gov

Continued....

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)	
		Amy A. Aqueche	
15B. CONTRACTOR/OFFEROR	15C. DATE SIGNED	16B. UNITED STATES OF AMERICA	16C. DATE SIGNED
(Signature of person authorized to sign)		BY Amy Aqueche (Signature of Contracting Officer)	12/19/2011

1. The Government has determined that the Contractor has earned interim award fee in the amount o[redacted]r the period of May 1, 2011 through October 31, 2011, Evaluation Period 2 (Phase C/D/E). This earned amount represents 95% of th[redacted]5 available for Evaluation Period 2.

2. In recognition of the foregoing, Clause B.1, Estimated Cost and Award Fee (1852.216-85) (SEPT 1993) is revised as follows:

Period 1

Interim Available Award Fee	[redacted]
Interim Earned Award Fee	
Available Fee for Final Evaluation	
Provisional Award Fee Paid	

3. Clause G.1, Clause G.1, Award Fee for End Item Contracts (1852.216-77) (JUNE 2000), limits interim award fee payments to the lesser of the interim evaluation score or 80 percent of the fee allocated to that period, less any provisional payments made during the period. For this period, the interim evaluation score (95%) represents the greater amount, so the 80% limit does apply; 80% of the fee allocated for Period 2 equals [redacted]. There was one provisional award fee payment that shall apply to the period in the amount $[redacted](portion from voucher 00000080/dated 12/2/11). Thus, upon execution of this modification, the Government shall pay the Contractor award fee in the amount of [redacted]

4. All other terms and conditions shall remain in full effect.

END OF MODIFICATION

OMB Approval 2700-0042

AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1. CONTRACT ID CODE	PAGE	OF	PAGES
	1		2

2. AMENDMENT/MODIFICATION NO.	3. EFFECTIVE DATE	4. REQUISITION/PURCHASE REQ. NO.	5. PROJECT NO. (If applicable)
00045	See Block 16C	4200423994	

6. ISSUED BY	CODE	7. ADMINISTERED BY (If other than Item 6)	CODE
NASA Goddard Space Flight Center Procurement Operations Division	210.S	NASA/Goddard Space Flight Center Space Sciences Procurement Office	210.S

8. NAME AND ADDRESS OF CONTRACTOR (No. Street, county, State and ZIP: Code)	(4)	9A. AMENDMENT OF SOLICITATION NO.
LOCKHEED MARTIN CORP. 12257 STATE HWY LITTLETON CO 80127-0000		9B. DATED (SEE ITEM 11)
	X	10A. MODIFICATION OF CONTRACT/ORDER NO. NNG09EK34C
		10B. DATED (SEE ITEM 13) 04/02/09

CODE 04235 FACILITY CODE

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 one (1) copy 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 ACKNOWLEDGMENT TO BE RECEIVED AT THE PLACE DESIGNATED FOR THE RECEIPT OF OFFERS PRIOR TO THE HOUR AND DATA 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 data specified.

12. ACCOUNTING AND APPROPRIATION DATA (If required)

BNC: GJE PR: 4200423994 AMT: $45,000,000.00

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

(4)	
	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) NFS 1852.232-81 CONTRACT FUNDING (JUN 1990)

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 provides incremental funding for continued contract performance and revises clause B.3 accordingly.

POC: Amy Aqueche. Email: amy.a.aqueche@nasa.gov

Continued....

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) Amy A. Aqueche	
15B. CONTRACTOR/OFFEROR (Signature of person authorized to sign)	15C. DATE SIGNED	16B. UNITED STATES OF AMERICA BY Amy A. Aqueche (Signature of Contracting Officer)	16C. DATE SIGNED 01/24/2012

1. Revise Clause B.3 – CONTRACT FUNDING (1852.232-81) (JUN 1990) is revised to increase funds as set forth below:

	FROM (MOD 44)	BY	TO
Estimated Cost	[redacted]		
Base Fee			
Award Fee			
CPAF	$140,641,331	$45,000,000	$185,641,331

*The allotment date is through October 5, 2012.

2. All other terms and conditions remain unchanged and in full force and effect.

(END MODIFICATION)

OMB Approval 2700-0042

AMENDMENT OF SOLICITATION/MODIFICATION OF CONTRACT

1. CONTRACT ID CODE	PAGE	OF	PAGES
	1		2

2. AMENDMENT/MODIFICATION NO.	3. EFFECTIVE DATE	4. REQUISITION/PURCHASE REQ. NO.	5. PROJECT NO. (If applicable)
00046	See Block 16C	N/A	

6. ISSUED BY	CODE	7. ADMINISTERED BY (If other than Item 6)	CODE
NASA Goddard Space Flight Center Procurement Operations Division	210.S	NASA/Goddard Space Flight Center Space Sciences Procurement Office	210.S

8. NAME AND ADDRESS OF CONTRACTOR (No. Street, county, State and ZIP: Code)	(4)	9A. AMENDMENT OF SOLICITATION NO.
LOCKHEED MARTIN CORP. 12257 S WADSWORTH BLVD LITTLETON CO 80125-8504		9B. DATED (SEE ITEM 11)
	X	10A. MODIFICATION OF CONTRACT/ORDER NO. NNG09EK34C
CODE 04235 FACILITY CODE		10B. DATED (SEE ITEM 13) 04/02/09

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.

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12 ACCOUNTING AND APPROPRIATION DATA (If required)

BNC: GJE PR: N/A AMT: N/A

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

(4)	
	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) FAR 52.243-2 CHANGES - COST REIMBURSEMENT (AUG 1987)

E. IMPORTANT: Contractor ☐ is not, ☒ is required to sign this document and return _1_ copies to the issuing office.

14. DESCRIPTION OF AMENDMENT/MODIFICATION (Organized by UCF section headings, including solicitation/contract subject matter where feasible.)

The purpose of this modification is to update the vendor address and revise Clause J.1 to reflect the updated CDRL, MRD and FRD documents.

POC: Amy Aqueche. Email: amy.a.aqueche@nasa.gov

Continued....

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)	
Scott Grillo, Contract Negotiator		Amy A. Aqueche	
15B. CONTRACTOR/OFFEROR Scott Grillo (Signature of person authorized to sign)	15C. DATE SIGNED 2/23/12	16B. UNITED STATES OF AMERICA BY Amy Aqueche (Signature of Contracting Officer)	16C. DATE SIGNED 2/23/12

1. Revise J.1, LIST OF ATTACHMENTS, to read as follows:

Attachment	Description	Date
A	Statement of Work (SOW) – Phase B only	January 28, 2010
A-2	Statement of Work (SOW) – Phase C/D/E Effort – REV E	September 15, 2011
B	Financial Reporting Requirements	March 26, 2009
C	Small Business Subcontracting Plan	March 22, 2010
D	Safety and Health Plan	March 30, 2009
E	IT Security Plan	July 9, 2010
F	Organizational Conflict of Interest Avoidance Plan (OCI)	March 30, 2009
G	MAVEN Mission Requirements Document (MRD) – REV V	February 2, 2012
H	Applicable/Reference Documents List	March 27, 2009
I	Contract Data Requirements List (CDRLs) – REV C	December 15, 2011
J	Functional Requirements Document (FRD) – REV I	January 20, 2012
K	Government Furnished Property List	December 13, 2010
L	Mission Assurance Requirements (MAR)	December 10, 2007
M	Personal Identity Verification (PIV) Card Issuance Procedures	March 10, 2010

2. Block 8 of the SF30 is hereby updated to reflect the correct vendor address of 12257 S Wadsworth Blvd, Littleton, CO 80125-8504. This change shall remain in full effect through the close of the contract.

3. All other terms and conditions remain unchanged and in full force and effect.

END MODIFICATION

MAVEN
Mars Atmosphere and Volatile Evolution Mission
CU/LASP • GSFC • UCB/SSL • LM • JPL

Mars Atmosphere and Volatile Evolution (MAVEN) Mission

Contract Data Requirements List (CDRL)
MAVEN-PROC-LIST-0002
Revision C

Effective Date: December 15, 2011
Expiration Date: December 15, 2016

NASA

National Aeronautics and Space Administration

Goddard Space Flight Center
Greenbelt, Maryland

Released Version, December 15, 2011
CHECK https://MAVENmis.gsfc.nasa.gov
TO VERIFY THAT THIS IS THE CORRECT VERSION PRIOR TO USE.

CONFIGURATION MANAGEMENT (CM) FOREWORD

This document is a Mars Atmosphere and Volatile Evolution Mission (MAVEN) Project 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 MAVEN Configuration Management Office, 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:

MAVEN Configuration Management Office
Mail Stop 432
Goddard Space Flight Center
Greenbelt, Maryland 20771

REVIEW/APPROVAL PAGE

All reviews and approvals are electronic via the MAVEN MIS at:

https://mavenmis.gsfc.nasa.gov

D. Mitchell	CCB Chairperson
N. Jedrich	Instrument Manager
M. Jarosz	Observatory Manager
O. Cheatom	Chief Safety and Mission Assurance Officer
T. Priser	LM Mission Systems Engineer
T. Ajluni	Systems Engineer
R. Howard	Systems Engineer
S. Sparacino	Deputy Project Manager/Resources
A. Aqueche	Contracting Officer
C. Gomez-Rosa	Mission and Science Operations Manager
W. Sidney	LM Mission Operations
F. Wasiak	MOS/GDS Requirements

Mars Atmosphere and Volatile EvolutioN (MAVEN) Mission

DOCUMENT CHANGE RECORD

Sheet: 1 of 1

REVISION LEVEL	DESCRIPTION OF CHANGE	APPROVED BY	DATE APPROVED
Revision (-)	Initial Release per MAVEN-CCR-0087..	D. Mitchell	12/17/2009
Revision A	Updates per 2010 contract negotiations as per MAVEN-CCR-0211.	D. Carson	10/14/2010
Revision B	Updates per MAVEN-CCR-0276.	D. Carson	3/24/2011
Revision C	Updated to remove reference to OPS-16 as per CCR-0397.	D. Mitchell	12/15/2011

TABLE OF CONTENTS Page

1.0 INTRODUCTION

The Mars Atmosphere and Volatile EvolutioN (MAVEN) mission has developed this baseline Contract Data Requirements List and Schedule (CDRL) which provides more specific information on the deliverable items, listed in the Contract Statement of Work (SOW).

The table below provides a listing of all contract deliverables with the following information:

ID: A sequential numerical identifier for each item.

Title: Provides the Title of the deliverable item.

Schedule: Provides the fixed or relative date or time that the deliverable is required.

Action Required:

A = Approval - Documents in this category require Government review and approval prior to final acceptance. The Government will adhere to a controlled schedule for review of the initial submittal and subsequent changes. Documents shall meet specific format requirements, as specified in the Discovery Mission Configuration Management Procedures, and the content requirements, as defined in the Data Requirements Document. Deviations from the controlled schedule or format will be considered on a case by case basis

R= Review - Documents in this category do not require formal Government approval. They must be received within a specified time period and are subject to evaluation. The Government reserves the time-limited right of disapproval for each submission. No prescribed format is specified although a recommended format may be found in the Data Requirements Document.

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

CM Control: Documents in this category will be controlled by Government Configuration Management. (This category is intended to include all documents that affect segments, elements, subsystems and interfaces that are not completely under the Contractor's control.)

2.0 CDRL SUMMARY AND SCHEDULE

Shaded items were also covered by the Phase B CDRL.

PROJECT MANAGEMENT				
ID	Title	Schedule	Action Required	Quantity/ Distribution
PM-1	Communications and Information Exchange Plan	Due 30 days after contract award Update as required	A	Electronic
PM-2	Monthly Status Reports (MMR Package) Includes the following from the MAVEN MAR (MAVEN-PM-RQMT-0006): • MA 15-1 Alert / Advisory Disposition and Preparation	Report to be provided before the presentation and submitted electronically 1 day before the review or as directed by the Contracting Officer (CO)	I	Hard Copy and Electronic & distribution list provided by CO
PM-3	Monthly Contractor Financial Management Reports (533M)	Due monthly on the 15th day of the month following the month being reported	R	Electronic
PM-4	Quarterly Contractor Financial Management Reports (533Q)	Due quarterly on the 15th of the month prior to the quarter being reported	R	Electronic
PM-5	Work Breakdown Structure and Dictionary, and Cost Account Structure Reports	Due 30 days after Phase C/D ATP Update as required	A	Electronic
PM-6	Performance Measurement Baseline	To be established no later than January 31, 2011	A	Electronic
PM-7	Program Performance Management Directive	Due 90 days after Phase C/D ATP	I	Electronic
PM-8	Monthly Earned Value Management System Contractor Performance Report (CPR)	First report due on the 15th day of the month following the establishment of the PMB and thereafter due monthly on the 15th day of the month following the month being reported.	R	Electronic
PM-9	Individual Subcontract Reports and Summary Subcontract Reports	Due semi-annually (March 31 and September 30), in accordance with FAR 52.219-9, Small Business Subcontracting Plan, paragraph l, and 1852.219-75, Small Business Subcontracting Reporting	R	Electronic Submission in accordance with FAR 52.219-9, paragraph l

PM-10	Integrated Baseline Review Package	Due 60 days prior to IBR	R	18 hard copies of the IBR Package containing both the IBR Data Package and CAM Data Notebooks, in addition to the electronic delivery Electronic due NLT 3/17/2011 Hardcopies NLT 3/21/2011
PM-11	Spacecraft Schedules	First report due on the 15th day of the month following the establishment of the PMB and thereafter due monthly on the 15th day of the month following the month being reported.	R	Electronic
PM-12	Spacecraft Configuration Management Plan	Baselined at PDR Update as required	A	Electronic
PM-13	Spacecraft Project Review Data Packages	Final input is due 1 week prior to the review List of action items with assignees due 5 days after the conclusion of the review	R	Electronic
PM-14	Combined into PM-13			
PM-15	Combined into PM-13			
PM-16	Combined into PM-13			
PM-17	Combined into PM-13			
PM-18	Combined into PM-13			
PM-19	Combined into PM-13			
PM-20	Combined into PM-13			
PM-21	Combined into PM-13			
PM-22	Combined into PM-13			
PM-23	Combined into PM-13			
PM-24	Combined into PM-13			
PM-25	Combined into PM-13			
PM-26	Deleted			

PM-27	Deleted			
PM-28	Spacecraft Risk Management Plan	Baselined at PDR Risk status reported monthly in MMR	R	Electronic
PM-29	Deleted	The CDRL for Phase C/D Implementation Plan was deleted in lieu of CDE proposal which contains majority of requested content		
PM-30	Spacecraft Phase E Implementation Plan	Due 150 days before start of Phase E	A	Electronic
PM-31	Spacecraft Review Plan	Due 60 days after PDR	R	Electronic

SYSTEMS ENGINEERING				
ID	Title	Schedule	Action Required	Quantity/ Distribution
SE-1	Spacecraft Systems Engineering Management Plan	Update as needed	R	Electronic
SE-2	Deleted	The CDRL for the input to the Environmental Requirements Document was deleted and discussed in the Statement of Work		
SE-3	Electromagnetic Interference/Electromagnetic Compatibility (EMI/EMC) Control Plan	Baselined at PDR Update as needed	A	Electronic
SE-4	Flight System Fault Protection Design Specification	Due at PDR Update as needed	A	Electronic
SE-5	Integrated Structural and Thermal Math Models	Present results at SC PDR and make available upon request Update prior to CDR	A	Electronic
SE-6	Instrument Interface Control Documents (ICDs)	Baselined at PDR Update as needed	A	Electronic
SE-7	Deleted	The CDRL for Contribution to Orbit Determination Document was deleted and discussed in the Statement of Work		
SE-8	Deleted	The CDRL for Mass Properties Reporting was deleted and discussed in the Statement of Work		
SE-9	Spacecraft Subsystem Requirements Specification	Preliminary at PDR Update as needed Final at CDR	R	Electronic
SE-10	Deleted	The CDRL for the Input to Trajectory Analysis and Maneuver Planning Document was deleted and discussed in the Statement of Work		
SE-11	Deleted	The CDRL for the input to the Orbit Determination Performance Analysis was deleted and discussed in the Statement of Work		
SE-12	Deleted	The CDRL for the Contamination Control Plan is MA-13-1		
SE-13	Plume Impingement Analysis	Due prior to CDR	R	Electronic
SE-14	Spacecraft Requirements Specification	Baselined at PDR Update as needed	R	Electronic

SE-15	DSN Compatibility Test Plan and Report	Preliminary version due at CDR Updated version due at ARR Final version due at PSR	A	Electronic
SE-16	Flight System Verification Plan Includes the following from the MAVEN MAR (MAVEN-PM-RQMT-0006) • MA 9-1 System Performance Verification Plan	Preliminary version due at PDR Final version due at CDR	A	Electronic
SE-17	Spacecraft Test Laboratory Implementation Plan	Preliminary version due at PDR Final version due at CDR Update as needed	A	Electronic
SE-18	Deleted	Input to the NEPA process is not applicable		
SE-19	Flight System Test and Verification Reports Includes the following from the MAVEN MAR (MAVEN-PM-RQMT-0006): • MA 4-8 Trend Analysis • MA 9-3 Verification Reports	Reports as available Final prior to LRR	R	Electronic
SE-20	Pointing and Alignment Document	Preliminary prior to PDR Update at CDR	I	Electronic
SE-21	Electrostatic Discharge Control Implementation Plan Includes the following from the MAVEN MAR (MAVEN-PM-RQMT-0006) • MA 14-1 Electrostatic Discharge Control Plan	Preliminary prior to PDR Update at CDR	R	Electronic
SE-22	Magnetic Cleanliness Implementation Plan	Preliminary prior to PDR Update at CDR	R	Electronic
SE-23	Coordinate System Document	Preliminary prior to PDR Update at CDR	R	Electronic
SE-24	End Item Data Package	Due at LRR	A	Electronic

FLIGHT SOFTWARE Note: Descriptions of Flight Software CDRLs can be found in Section 4.2 of the MAVEN Software Management Plan				
ID	**Title**	**Schedule**	**Action Required**	**Quantity/ Distribution**
SW-1	Spacecraft Software Development Plan Includes the following from the MAVEN MAR (MAVEN-PM-RQMT-0006): • MA 5-1 Software Assurance Plan • MA 5-2 Software Management Plan • MA 5-3 Software Configuration Management Plan	Preliminary: SRR + 60 days Baseline: SW PDR -10 days	A	Electronic
SW-2	Spacecraft Software Test Plan	Preliminary: SW CDR Baseline: SW ATR	A	Electronic
SW-3	Spacecraft Software Requirements Specification	Preliminary: SRR + 120 days Baseline: SW PDR – 90 days	A	Electronic
SW-4	Spacecraft Software Test Reports	Run For Score + 15 days	A	Electronic
SW-5	Spacecraft Software Maintenance Plan	Preliminary Prior to CDR Baseline: Mission Operations Readiness Review	A	Electronic
SW-6	Deleted	Covered in Phase B CDRL list		
SW-7	Deleted	Covered in Phase B CDRL list		
SW-8	Spacecraft Software CDR (SwCDR) Data Package	Mission CDR – 10 days	A	Electronic
SW-9	Spacecraft Software Acceptance Test Readiness Review (SwATRR) Data Package	Prior to acceptance test run-for-score	A	Electronic
SW-10	Spacecraft Software Acceptance Review (SwAR) Data Package	Prior to Delivery	A	Electronic
SW-11	Spacecraft Software User's Manual (SwUM)	SW Acceptance Review	A	Electronic
SW-12	Flight Software Source Code	At Delivery		

INTEGRATION AND TEST				
ID	Title	Schedule	Action Required	Quantity/ Distribution
IT-1	Spacecraft/Orbiter and GSE Transportation Plan	Preliminary version due at TRR Final version due at PSR	A	Electronic
IT-2	Flight System Integration, Test and Launch Operations Plan	Preliminary version due at SRR Update 60 days after CDR Final version due 60 days before TRR	A	Electronic

LAUNCH VEHICLE				
ID	Title	Schedule	Action Required	Quantity/ Distribution
LV-1	Deleted			
LV-2	Deleted	The CDRL for the input to the LS IRD was deleted and discussed in the Statement of Work		
LV-3	Flight System Dynamic Model	As needed	R	Electronic
LV-4	Spacecraft to Launch Vehicle ICD	Preliminary prior to PDR Update at CDR	R	Electronic

MISSION OPERATIONS				
ID	Title	Schedule	Action Required	Quantity/ Distribution
OPS-1	MOS-GDS Implementation Plan	Preliminary version at PDR Final Version at CDR	A	Electronic
OPS-2	MOS-GDS Verification & Validation Plan	Preliminary version at PDR Final Version at CDR	A	Electronic
OPS-3	Mission Operations Concept	Preliminary version at PDR Final Version at CDR	A	Electronic
OPS-4	Mission Support Area (MSA) to Science Operations Center (SOC) ICD	Preliminary version at PDR Update at CDR Final version at MOR	A	Electronic
OPS-5	Training Plan	Due 1 year prior to launch	R	Electronic
OPS-6	Mission Operations Procedures (MOP) Vol. 1: Operations Scenarios	Preliminary version at CDR Final version at MOR	A	Electronic
OPS-7	Mission Operations Procedures (MOP) Vol. 2: Operations Processes	Preliminary version at CDR Final version at MOR	A	Electronic
OPS-8	Mission Operations Procedures (MOP) Vol. 3: Flight System Operations Procedures	Preliminary version at CDR Final version at MOR	A	Electronic
OPS-9	Mission Operations Procedures (MOP) Vol. 4: Operations Interface Agreements (OIA)	Preliminary version at CDR Final version at MOR	A	Electronic
OPS-10	Mission Operations Procedures (MOP) Vol. 5: Software Interface Specifications (SIS)	Preliminary version at CDR Final version at MOR	A	Electronic
OPS-11	Mission Operations Procedures (MOP) Vol. 6: Orbiter Operations Plan	Preliminary version at CDR Final version at MOR	A	Electronic
OPS-12	Mission Operations Procedures (MOP) Vol. 7: Command Dictionary	Preliminary version at MOR Final version at FRR	R	Electronic
OPS-13	Mission Operations Procedures (MOP) Vol. 8: Telemetry Dictionary	Preliminary version at MOR Final version at FRR	R	Electronic
OPS-14	Mission Operations Procedures (MOP) Vol. 9: Block Dictionary	Preliminary version at MOR Final version at FRR	R	Electronic

OPS-15	Mission Operations Procedures (MOP) Vol. 10: Flight Rules and Idiosyncrasies (Flight System Constraints and Restrictions)	Preliminary version at CDR Final version at MOR	A	Electronic

MISSION ASSURANCE Note: Descriptions of MA CDRLs can be found in the MAVEN MAR				
ID	Title	Schedule	Action Required	Quantity/ Distribution
MA 1-1	Heritage Hardware Matrix or Report	a) Initial 30 days prior to PDR b) Updates as developed c) Final 45 days prior to CDR	a) R & A b) R & A c) A	Electronic
MA 2-1	Quality Manual / Mission Assurance Implementation Plan	a) Due at SRR b) Updates prior to implementation	a) R & A b) R & A	Electronic
MA 2-2	Problem Failure Reports (PFRs)	a) Within 24 hours of occurrence b) Immediately after developer closure	a) I b) A	Electronic
MA 2-3	Deleted			
MA 3-1	System Safety Program Plan	a) Draft SSPP at SSR or first program review. b) Final SSP 30 days prior to PDR	a) R & A b) R & A	Electronic
MA 3-2	Deleted			
MA 3-3	Deleted			
MA 3-4	Operations Hazard Analysis (OHA)	a) Preliminary OHA at CDR b) Final OHA 45 prior to I&T operations (HTL included with Final OHA	a) R & A b) R & A	Electronic
MA 3-5	Deleted			
MA 3-6	Missile System Pre-Launch Safety Package Includes the following from the MAVEN MAR (MAVEN-PM-RQMT-0006): • MA 3-2 Safety Requirements Compliance Checklist • MA 3-3 Preliminary Hazard Analysis • MA 3-5 Safety Assessment Report • MA 3-7 Verification Tracking Log	a) Preliminary PDR + 30 days b) Intermediate: CDR+ 30days c) Final: 90 days Prior to PSR	a) R & A b) R & A c) R & A	Electronic
MA 3-7	Deleted			
MA 3-8	Ground Operations Procedures	30 days prior to first use	a) R & A	Electronic
MA 3-9	Safety Waivers	a) As identified	a) A	Electronic
MA 3-10	Deleted	The CDRL for the input to the Orbital Debris Assessment was deleted and discussed in the Statement of Work.		
MA 4-1	Reliability Program Plan	a) Draft 30 days after contract award b) Final 30 days prior to SDR c) Updates as required	a) R b) R & A c) R & A	Electronic
MA 4-2	Deleted	The CDRL for the input to the PRA was deleted and discussed in the Statement of Work.		
MA 4-3	Failure Mode and Effects Analysis, Critical Items List, and Critical Items Control Plan	a) Preliminary 30 days prior to PDR b) Final 30 days prior to CDR c) Updates as required	a) R b) R c) R	Electronic
MA 4-4	Fault Tree Analysis	a) Preliminary 30 days prior to PDR b) Revisions 30 days prior to	a) R b) R c) R	Electronic

		CDR c) Final 30 days prior to MOR d) Updates as required	d) R	
MA 4-5	Parts Stress Analysis	a) Final 45 days prior to CDR b) Updates as required	a) R b) R	Electronic
MA 4-6	Worst Case Analysis	a) 30 days prior to component CDR b) Updates with design changes	a) R b) R	Electronic
MA 4-7	Reliability Assessments and Predictions	Provide as applicable	R	Electronic
MA 4-8	Deleted			
MA 4-9	Limited Life Items List	a) Preliminary 30 days prior to PDR b) Final 30 days prior to CDR c) Updates as required	a) R b) A c) A	Electronic
MA 5-1	Deleted			
MA 5-2	Deleted			
MA 5-3	Deleted			
MA 9-1	Deleted			
MA 9-2	Deleted	Add to the SOW that GSFC will be included in table-top reviews of procedures		
MA 9-3	Deleted			
MA 10-1	Printed Wiring Coupons	a) 2 weeks prior to population of flight PWBs	a) A	Electronic
MA 11-1	Materials and Processes Control Plan	a) MPCP delivered with proposal	a) R & A	Electronic
MA 11-2	As-Designed Materials and Processes List Includes the following from the MAVEN MAR (MAVEN-PM-RQMT-0006) • MA 11-5 Polymeric Materials List • MA 11-7 Inorganic Materials List • MA 11-9 Lubrication Materials List • MA 11-11 Materials Process List	a) Ten days prior to meetings b) 30 days prior to PDR c) 30 days prior to CDR d) 30 days prior to acceptance e) Updates as required	a) I b) A c) A d) A e) A	Electronic
MA 11-3	Materials Usage Agreement Includes the following from the MAVEN MAR (MAVEN-PM-RQMT-0006): • MA 11-4 Stress Corrosion Evaluation Form	a) Provided as applicable	a) A	Electronic
MA 11-4	Deleted			
MA 11-5	Deleted			
MA 11-6	Materials Waiver	a) 15 days prior to use	a) A	Electronic
MA 11-7	Deleted			
MA 11-8	Fastener Control Plan	a) At SRR b) 30 days prior to PDR	a) R b) A	Electronic
MA 11-9	Deleted			
MA 11-10	Life Test Plan for Lubricated Mechanisms	a) 30 days prior to PDR b) 30 days prior to CDR c) 30 days before acceptance	a) R b) A c) A	Electronic
MA 11-11	Deleted			
MA 11-12	Certificate of Raw Material Compliance	a) Within 15 days of request	a) I	Electronic
MA 12-1	Parts Control Plan	a) Part of MAIP or delivered with b) Subsequent revisions	a) R & A b) A	Electronic
MA 12-2	Parts Control Board Reports	a) Reports within 5 working days of each PCB	a) R	Electronic
MA 12-3	Parts Identification List	a) 30 days prior to PDR	a) A	Electronic

		b) Monthly between PDR and CDR c) 30 days prior to CDR d) Changes - Quarterly e) ABPL 60 days prior to delivery	b) A c) A d) R	
MA 13-1	Contamination Control Plan	a) 30 days prior to PDR b) 30 days prior to CDR	a) R b) A	Electronic
MA 14-1	Deleted			
MA 15-1	Deleted			

3.0 PROJECT MANAGEMENT

PM-1 Communications and Information Exchange Plan

Description:

The contractor shall establish, internally, responsibility for implementing the communications and information exchange requirements specified in this contract. The responsibilities and methods needed to meet these requirements, plus any additional procedures the contractor deems necessary to adequately manage the communications and information exchange, shall be documented in a Communications and Information Exchange Plan. As an alternative, the contractor may submit their organization's existing Plan for GSFC approval if it meets the intent of the requirements herein.

Content:

Contractor shall address the following specific requirements:

- Where possible, submit documents, data, and reports in formats consistent with GSFC Standard Document Template. Templates are available on the Management Information System (MIS)
- Provide electronic access to documents, drawings, photographs, data, and reports or upload documentation to the Management Information System (MIS).
- Provide and use video conferencing capabilities to the extent practicable with GSFC for communications and information exchange.

PM-2 Monthly Status Reports

Description:

The monthly status reports shall provide a project assessment of contract technical accomplishments, summary of program cost, schedule, and performance, as well as the status of key technical issues and near-term milestones. These reports shall provide a summary of the activities for the month, highlight issues/problems/concerns, and briefly summarize plans for the following month. Detailed supporting technical data should only be provided on an as requested basis. Monthly status reports shall be provided in a PowerPoint presentation.

The Contractor shall use the standard GSFC schedule milestone chart for any related schedule charts. In addition, any changes to the baseline schedule needs to be highlighted on these charts in a manner that shows the original baseline and the new modified baseline, with an explanation for the change.

Content:

- Schedule status reports
- Technical status reports
- Risk mitigation status
- Performance assurance status
- Performance Measurement Baseline status
- Contingency release status including lien list (cost, schedule, etc.)
- Action item status
- One-month look-ahead
- One page fever chart summarizing critical status of above elements
- Top ten critical items
- Alert/Advisory Disposition and Preparation

PM-3 Monthly Contractor Financial Management Reports (533M)

Description:

The Monthly Contractor Financial Management Reports (533M) provide contractual expenditure data of cost incurred during the month being reported, summaries of cumulative costs, and estimates of costs to complete. This information is necessary for the financial management of this contract.

Content:

Financial Management Reports shall be submitted by the contractor on the NASA 533 series reports, in accordance with the instructions on the reverse of the forms, NASA Procedures and Guidelines (NPG) 9501.2D entitled "NASA Contractor Financial Management Reporting" dated May 2001, and additional instructions issued by the GSFC Contracting Officer.

Level of Detail:

The contractor's 533 reports shall be provided at the contract summary level and also at WBS Level 4 (subsystem level, as shown below) during Phases B/C/D/E. The contracting officer (CO) may direct the contractor to provide 533 reports at lower WBS levels for select WBS elements. 533 reports shall contain a breakdown of each element of cost, i.e., direct labor hours/dollars, benefits and/or overhead, subcontracts, other direct cost, general and administrative expense, fee. The contractor shall provide the same report for all cost-reimbursement subcontracts in excess of $1,000,000.

The contractor shall use the following WBS for 533 reporting, providing a contract summary-level report and supporting reports at contract WBS Level 4 (subsystem level):

6.02	Spacecraft
6.02.01	Spacecraft Management
6.02.02	Spacecraft Systems Engineering
6.02.03	Spacecraft Product Assurance
6.02.04	Spacecraft Guidance Navigation and Control (GN&C)
6.02.05	Spacecraft Thermal Subsystem
6.02.06	Spacecraft Mechanical Subsystem
6.02.07	Spacecraft Propulsion Subsystem
6.02.08	Spacecraft Power Subsystem
6.02.09	Spacecraft Command and Data Handling (C&DH) Subsystem
6.02.10	Spacecraft Telecom Subsystem
6.02.11	Spacecraft Harness Subsystem
6.02.12	Spacecraft Software
7.02	Mission Operations
9.02	Ground Data System (GDS)
10.02	Assembly, Test and Launch Operations (ATLO) and Test Beds

In addition, the contractor shall provide a summary-level 533 report covering the task assignments issued under the level-of-effort provisions of the contract (WBS 6.02.01.08 Task Assignments), along with a separate 533 report covering each active task (WBS 6.02.01.08.XX).

Distribution

The contractor shall distribute 533 reports by posting to the MAVEN Management Information System (MIS) on or before the 15th calendar day of each month.

Content Requirements:

For contract summary reports and each WBS element report, the 533 shall provide cost data for reporting categories presented below:

- Direct Labor Hours

- Direct Labor Dollars
- Overhead Expense (Including Fringe Benefits, if applicable)
- Subcontracts, with subcontracts >$1M identified separately
- Other Direct Costs
- Travel
- Materials
- Consultants
- Subtotal (Direct Cost Plus Overhead)
- G&A Expense
- CAS 414
- Total Cost
- Unallocated Budget/Management Reserves
- Fee
- Total Cost Plus Fee

The contractor shall include a 533 contract summary report by WBS element.

The contractor shall include supplementary information, including but not limited to the following:

- A reconciliation report (Contract Value Summary) explaining the status of changes and outstanding proposals
- A reconciliation report (Risk Pool Summary) explaining the status of the risk pool (Unallocated Future Expense included in the contract value), showing requests, approved allocation, and remaining risk pool balance
- Actual workforce information, showing workforce by FTE by WBS at the same levels for which 533 information is delivered.
- A current estimate of monthly funding requirements

PM-4 Quarterly Contractor Financial Management Reports (533Q)

Description:

The Quarterly Contractor Financial Management Reports (533Q) provide contractual expenditure data of cost incurred and estimates of costs to complete. The 533Q reports provide a more detailed estimate of costs for the coming months and quarters than is contained in the 533M reports.

Content:

Financial Management Reports shall be submitted by the Contractor on the NASA 533 series reports, in accordance with the instructions on the reverse of the forms, NASA Procedural Requirements (NPR) 9501.2D entitled "NASA Contractor Financial Management Reporting," and additional instructions issued by the GSFC Contracting Officer. Instructions for level of detail, distribution, and contents (reporting categories) are the same as for Monthly Financial Management Reports (533M); see PM-03.

533Q reports delivered in March, June, and December shall update planned costs for months in the following quarter in Columns 8a, 8b, and 8c. The 533Q report delivered in September shall update planned costs for months in the following government fiscal year, replacing Columns 8d, 8e, 8f, and 8g with columns to show a month-by-month forecast for the next twelve months beginning with October. The 533Q report delivered in September shall also include a workforce plan for the next government fiscal year, presenting planned workforce (full-time equivalents) by month at the same WBS levels at which 533 reports are required.

PM-5 Work Breakdown Structure and Dictionary, and Cost Account Structure Reports

Description:

The work breakdown structure (WBS) and dictionary establishes the basic framework within which all effort necessary to meet the requirements of the contract is identified and defined. It provides the logical structure for planning and controlling costs.

Content:

The lowest level of the WBS shall correspond to at least the lowest level at which work scheduled and actual costs can be compared. This level shall be agreed upon during contract negotiations. The WBS shall be coded to establish the relationship among all of its levels. The established coding shall be used to identify each particular WBS item on all program budgets, schedules and financial reports. The WBS shall indicate which items require monthly financial reporting.

A WBS Dictionary shall be prepared to define each item of the WBS. These definitions shall describe the work to be performed, and the organization responsible for the work and the major deliverable(s) involved (if applicable).

PM-6 Performance Measurement Baseline (PMB)

Description

The Performance Measurement Baseline is the time-phased budget plan for accomplishing work, against which contract performance is measured. It includes the budgets assigned to scheduled control accounts and the applicable indirect budgets. For future effort, not planned to the control account level, the PMB also includes budgets assigned to higher level Contract Work Breakdown Structure (CWBS) elements, and to undistributed budgets. It does not include management reserve.

Content

The PMB should accurately represent only authorized work on the contract, a realistic network schedule baseline, and a realistic time phased spread of budget/resources to the baselined schedule. Procedures for the incorporation of authorized changes to the PMB should be reflected in the Program Performance Management Directive. These procedures should ensure that budget is not transferred independent of work scope, that budget and schedule changes are incorporated simultaneously, and that retroactive changes are strictly controlled.

PM-7 Program Performance Management Directive(Earned Value Management Plan)

Description:

The Program Performance Management Directive (PPMD) should contain practical information about how the EVM System Description will be followed and proper EVMS processes will be implemented. This is not the same document as the EVM System Description.

Content:

The plan shall demonstrate the use and understanding of the overall financial and project management system with regard to EVMS at all levels of management. The plan shall identify policies, methods, procedures, and training utilized to meet the requirements of NPR 7120.5D and NPR 9501.2D (NF533). The plan shall address processes for managing technical scope, schedule, cost and risk; for conducting variance analysis; and for developing ongoing and comprehensive estimates at completion.

This plan shall address the flow down of EVM requirements to all major subcontracts, except in the case where the contract type does not meet the criteria for EVM reporting (i.e. Firm Fixed Price and Time and Material) consistent with the criteria defined in NPR 7120.5D. The Plan shall ensure that the system provides for the results of all analyses based on EVM to be linked to or associated with the contractor's Risk Management System (as applicable). Any cost and/or schedule risk being managed by the contractor's Project Manager shall correlate the results of the EVM analysis process to track, manage, and mitigate risk.

Revision to the Program Performance Management Directive may be required at NASA's request if a change in the EVM system architecture occurs or in the event of a major contract modification.

PM-8 Monthly Earned Value Management System Contract Performance Report

Description:

The Contractor Performance Report (CPR) provides the monthly status of performance data and estimates at complete, identifies approved changes to the Performance Measurement Baseline, and reports variances and projected variances at complete including explanatory analysis.

Content:

The CPR shall include data pertaining to all authorized contract work, including both priced and un-priced effort that has been authorized at a not-to-exceed amount in accordance with the Contracting Officer's direction. The CPR shall separate direct and indirect costs and identify elements of cost for all direct reporting. The CPR shall include Formats 1, 3 and 5, down to a WBS Level 4. A lower level of reporting may be required for elements that are classified as special interest technical, schedule, or cost risk areas.

Earned value performance measurement data for NASA and/or contractor-identified medium- and high-risk WBS items shall be reported on Format 1 of the monthly CPR until such time as both NASA project management and the Contractor agree that they no longer represent medium or high risks. This reporting shall be at a level where the risk resides in the WBS. For medium- and high-risk elements lower than Level 4, specific narrative variance analyses are not required unless specified as special interest.

To ensure an integrated approach to risk management, the data provided shall be in consonance with the Work Breakdown Structure (WBS), Integrated Master Schedule (IMS), Risk Management Processes, Plans and Reports (where required), Probabilistic Risk Assessment Processes and Reports (where required), the Cost Analysis Data Requirement (CADRe) and the Monthly/Quarterly Contractor Financial Management Reports (533M/Q). The financial management reports shall include reconciliation between the 533Q and the Contractor Performance Report. This reconciliation may be included within the required CPR Formats.

Preparation Information:

FORMAT: CPR formats shall be completed according to the instructions outlined in DI-MGMT-81466A and the following forms: Format 1 (DD Form 2734/1); Format 3 (DD Form 2734/3); and Format 5 (DD Form 2734/5).

Variance Reporting (Format 5)

Variance analysis thresholds which, if exceeded, require problem analysis, narrative explanations and corrective action plan descriptions for all level four and other special interest WBS elements (in the previous paragraph). MAVEN variance analysis thresholds will initially be $25k and +/-10%of current and $50k and +/-10% of cumulative and $100k of at complete cost and schedule variance to date. The variance analysis thresholds may change once the MAVEN Project personnel evaluate the contractor's schedule and cost performance, and risk. Special emphasis should be placed in the variance analysis on cost and schedule growth linked to technical risks (e.g., technology development efforts; design engineering; integration; complexity; project management; systems engineering; duration constraints; etc.) identified by both NASA and the contractor. In addition to variance explanations, the following analyses will be required: Estimate at Completion. When the best or worst case estimates at completion differ from the most likely estimate, the Contractor must provide a brief explanation of the difference. Also, if the most likely management estimate at completion differs from the total entered in Format 1 or 2, the difference must be explained. The explanations should focus on such areas as a knowledgeable, realistic risk assessment; projected use of management reserve; estimate for undistributed budget; and higher management knowledge of current or future conditions. The reasons for significant shifts in time-phasing of the estimate at completion must be explained. Also, explain any variance between the undistributed budget and the estimate for undistributed budget. Identify the sources and uses of management reserve changes during the reporting period. For management reserve uses, identify the WBS and organizational elements to which applied, and the reasons for application. Explain reasons for significant shifts in time-phasing of the Performance Management Baseline (PMB)

shown on Format 3. Explain significant changes in the total staffing estimate at completion . Also, explain reasons for significant shifts in time-phasing of planned staffing.

Formal Reprogramming:

If the difference shown in Block 5 (contract data) on Format 3 changes in value, provide information on the following: Indicate the procuring activity authorization for the baseline change which resulted in a change in value and the reason for the change. Include how the change affected the CPR (i.e. adjustments to cost or schedule variances etc.).

CPR Submission:

The CPR shall be submitted electronically and followed up with a signed paper copy. The American National Standards Institute (ANSI) X12/XML standards (transaction sets 839 for cost and 806 for schedule), the United National Electronic Data Interchange for Administration, Commerce and Transport (EDIFACT) or any other electronic delivery method deemed acceptable to the MAVEN Project Office shall be used for Electronic Data Interchange.

PM-9 Individual Subcontract Reports (ISR) and Summary Subcontract Reports (SSR)

Description:

An ISR (formally the Standard Form 294) collects subcontract award data from prime/subcontractors that: (a) hold one or more contracts over $500,000 (over $1,000,000 for construction or public facility); and (b) are required to report subcontracts awarded to Small Business (SB), Small Disadvantaged Business (SDB), Women-Owned Small Business (WOSB), HubZone Small Business (HUBZone SB), Veteran-Owned Small Business (VOSB), and Service-Disabled Veteran-Owned Small Business concerns under a subcontracting plan. This form also collects subcontract awards for Historically Black Colleges and Universities (HBCUs) and Minority Institutions (MIs).

A SSR (formally the Standard Form 295) collects subcontract award data from prime/subcontractors that: (a) hold one or more contracts over $500,000 (over $1.000,000 for construction or public facility); and (b) are required to report subcontracts awarded to Small Business (SB), Small Disadvantaged Business (SDB), Women-Owned Small Business (WOSB), HubZone Small Business (HUBZone SB), Veteran-Owned Small Business (VOSB), and Service-Disabled Veteran-Owned Small Business concerns under a subcontracting plan. This form also collects subcontract awards for Historically Black Colleges and Universities (HBCUs) and Minority Institutions (MIs).

Content:Content defined in FAR 52.219-9, Small Business Subcontracting Plan, paragraph l, and 1852.219-75, Small Business Subcontracting Reporting, is implemented in the formats available at the Electronic Subcontracting Reporting System (eSRS) (http://www.esrs.gov).

PM-10 Integrated Baseline Review Package

Description:

An Integrated Baseline Review (IBR) is a joint assessment conducted by the NASA PM and Lockheed Martin to verify the realism and accuracy of the Performance Measurement Baseline (PMB). This involves verifying the technical content of the baseline and assessing the realism and accuracy of the related resources (cost, risk, and schedule). The Integrated Baseline Review is the major EVM review for the contract. This Review occurs within the first 180 days after contract award and as needed after the exercise of significant contract options or 60 calendar days after a significant funding or work scope realignment. The IBR Review package is a compilation of on-going operational project documents gathered together for the purpose of assessing the PMB.

Content:

An IBR Data Package shall be submitted in accordance with the IBR objectives stated above.

The Contractor Data Package shall contain the following:

- Program/Business Management and Control Account Notebooks that incorporates the data products requested by the Project Office (electronic copy)
- A baselined electronic version of the Integrated Master Schedule
- Contractor Earned Value Process Documentation (electronic)
- Two months of EV Performance data

Lockheed Martin shall ensure proper flow-down of this requirement to subcontractors per NPR7120.5D. The data package shall be delivered not less than six weeks prior to the IBR. Contents of an IBR Notebook are shown below.

- Notebook and presentation content:
  -
  -
  -)

Control Account Management (CAM) Data Notebook:

- Data content specific to the Control Account or Integrated Product Team Technical Scope/Cost:
  - Organization chart for the Control Account
  - RAM (show location in RAM with budget amounts)
  - Control Account technical scope – flow down from SOW to CAMs
  - Work Authorization Documentation: trace to authorized budget
    - Show how work gets authorized from high to low levels
  - Time Phased Control Account Plan
    - WPs and PPs
    - Resource loading of task work packages and planning packages
  - Baseline Metrics
    - Phased dollars by element of cost breakdown
    - Phased workforce profiles (FTEs) by work package
  - Labor Reports

- Schedules:
  - Flow-down of intermediate schedule into detailed schedules
  - Including any critical path
  - Key handoffs\deliverables
  - Schedule Metrics
- Risk List
  - Current or anticipated risks that impact the CA

- Earned Value Methodology:
  - EV techniques and rationale for each work package
  -
  - Variance analysis reporting if applicable
  - Internal communication and action planning within the CA

Additional IBR Products:

- Brief overview of EVM Process (included in PPMD)
- Top level planning and baseline assumptions
- Program percentages (LOE versus Discrete)

- CPR submittals (2 months of data)
- Management Reserve levels and approach (included in PPMD)
- Undistributed budgets, if any
- Subcontractor Management Plan (if applicable) to include:
    - Management review or reporting cycle
    - Technical/Schedule/Cost/Risk Plan and status
    - EVM flow-down (if applicable)
    - IBR results (if applicable)
- Program WBS (if previously not submitted)
- Program EOC RAM
- EAC assumptions (if different from negotiated BAC values)
- Top level Program Work Authorization
- WBS Dictionary (if previously not submitted)
- Integrated Master Schedule (IMS)
    - Show vertical and horizontal traceability
    - Show critical path
- Risk Management Approach
    - Risk list (with current top risks) by WBS
    - Funding profile (if not included as part of 533M)

PM - 11Spacecraft Schedules

Description:

The spacecraft schedules shall be provided for planning, controlling, modeling and specifying work activities throughout the project life cycle.

Content:

Detailed network diagrams shall be developed, delivered, and maintained for each subsystem. These subsystem networks may be provided separately, or combined into an Integrated Master Schedule (IMS). These networks shall reflect the significant activities in sufficient detail to permit adequate visibility into work progress. The network diagrams shall also include all logical relationships (interdependencies) between tasks. Schedules shall contain the approved baseline as well as current forecasted dates and shall be traceable to the approved Work Breakdown Structure (WBS). All key milestones shall be clearly identified including: contract milestones, design reviews, readiness reviews, and major receivables/deliverables among subsystems/organizations (including subcontractor effort). Milestones shall be logically linked to related tasks. Clearly identified schedule margin tasks and dates needed for GFP shall be included in the network. A log of changes to the schedule baseline will be maintained and reported monthly.

Scheduling Tool/Process: The contractor shall use an application that is compatible to Microsoft Project 2007 The tool shall support data transfer and integration.

The following status and analysis reports shall be provided monthly:

Master Level Logic Network: A logic network summarizing the Intermediate/Detailed networks using Microsoft Project 2007 shall be maintained in the Intermediate schedule.

Top-Level Contractor Summary Schedule: Top-level schedule (chart), in project compatible software, suitable for a formal presentation.

60-Day Window Report: The contractor will construct a filter to facilitate 60 day window viewing and work with the Project to put any other filters into the MS Project file that might be beneficial or informative to the project

Receivable/Deliverable Report: A monthly IMS generated report, which reflects the float/slack for deliverable items and major milestones as determined by the project and/or the contractor. This report shall provide a comparison of the current float to the prior month's float. The contractor shall also explain all changes that exceed the established Stoplight threshold. This report shall be included in the Monthly Management Review (MMR) package. Manufacturing Schedules: Manufacturing schedules and status obtained from subcontractors and vendors are not required to be submitted with the monthly schedule submittal, however, they shall be supplied to the Project Office upon request. with their component status reflected in the appropriate section or subsystem in the intermediate schedule..

PM – 12 Spacecraft Configuration Management Plan

Description:

The CM plan describes the methods and procedures used to manage the functional and physical characteristics of configuration items, and their interfaces and identification documents, during design, fabrication, assembly, and testing.

Content:

- The plan shall describe the contractor's configuration management organization and personnel responsibilities.
- The plan shall describe the contractor's configuration identification system, including drawing and specification standards.
- The plan shall accommodate the requirements of the contract relative to technical direction and approvals.
- The plan shall describe the contractor's change control system and shall include sample change documents and/or forms.
- The plan shall define the interfaces between the contractor's change control system and GSFC CM Office.
- The plan shall describe which types of changes will be submitted to GSFC for approval.
- The plan shall define the contractor's engineering data management activities (including archiving process), documentation approvals, release procedures, and categories of release.
- The plan shall describe the contractor's configuration status accounting system including samples of lists and reports used.
- The plan shall describe the contractor's approach to verification and configuration audit to ensure that performance and functional requirements have been achieved by the design.
- The plan shall describe contractor's approach for using photographs as part of the Configuration Management/documentation process

PM – 13 Spacecraft Project Review Data Packages

Description:

Review data packages are input to the following project-level reviews and contractor reviews:

- PM-13A – CDR
- PM-13B – MSA CDR
- PM-13C – SIR/ARR
- PM-13D – PER
- PM-13E – ORR
- PM-13F – PSR
- PM-13G – FRR
- PM-13H – LRR
- PM-13I – PLAR
- PM-13J – CERR
- PM-13K – DR

Related Documents:

GSFC-STD-1001A "Criteria for Flight and Flight Support Systems Lifecycle Reviews"

Content:

Review packages shall follow the objectives, success criteria, evaluation factors, and desired results as defined in GSFC-STD-1001A, "Criteria for Flight and Flight Support Systems Lifecycle Reviews."

PM-28 Spacecraft Risk Management Plan

Description:

The RSP Risk Management Plan summarizes how the contractor will implement the NASA continuous Risk management process. Include the initial Significant Risk List and appropriate actions to mitigate each risk. Projects with international or other U.S. Government agency contributions must plan for, assess, and report on risks due to international or other government partners and plan for contingencies.

Related Documents:

NPR 8000.4 "Risk Management Procedural Requirements"

Content:

Develop a stand-alone Risk Management Plan that includes the content required by NPR 8000.4 "Risk Management Procedural Requirements" or develop an input to the Project-level risk Management Plan.

The risk management plan should clearly describe:

- Risk identification approach
- Risk mitigation philosophy
- Risk mitigation plan
- Interface of risk management to schedule and financial/cost management process.
- How the contractor's risk management process supports the Project risk management process.

PM-29 Spacecraft Phase C/D Implementation Plan

Description:

The Plan provides the basis for Contractor's delta cost proposal for Phase C/D

Content:

The Contractor shall prepare a Phase C/D Implementation Plan that describes the Contractor's approach to completing Flight System design, fabricating and verifying the Flight System, integrating the science and engineering payload and completing Flight System acceptance testing and subsequent launch operations and post-launch checkout.

The implementation plan shall be correlated to the WBS and shall identify cost and schedule plans, plus deltas, with rationale from the initial baseline for Phase C/D.

The Plan shall include as a minimum the following:

- Technical and programmatic changes in Phase B that impact Phase C/D cost and schedule (identify each change and its impact on cost and schedule).
- Flight System summary description, including key or driving requirements
- Key open issues and plan for resolution, including payload accommodation
- Plan for completing reliability analyses including schedule, staffing, and phasing with design and implementation activities.
- Electronics parts procurement and screening plan, and phasing with implementation activities. In particular, long lead or high-risk parts should be identified and include a discussion of how schedule and technical risk will be managed.
- Implementation approach for flight hardware subsystems and assemblies including

  - Key requirements
  - Make or buy approach, including Contractor division and facility or subcontractor at which assemblies will be manufactured
  - Changes to originally planned cost and schedule with rationale and basis
  - Surveillance provisions, including meetings and reviews, to insure that technical, mission assurance and program requirements and constraints are met
  - Summary test and verification plan
  - Summary delivery and end item data package requirements
- Implementation approach for flight software, including key requirements and functions, make or buy approach, use of simulators, test-beds and the flight system for test and verification.
- Plan for verifying payload interfaces with Flight System using test-beds and/or simulators.
- ATLO flow plan and description, facility requirements (including Contractor-provided facilities for payload processing), support equipment development & verification approach.
- MOS development and support plan, including MOS and DSN compatibility testing, and end-to-end test.
- Plan for initial in-flight checkout of Flight System
- Phase C/D organization and staffing plan
- Risk items eliminated in Phase B, identified risk items for C/D and mitigation measures
- Transition plan from Phase B into Phase C/D

PM-30 Spacecraft Phase E Implementation Plan

Description:

The Plan provides the basis for Contractor's delta cost proposal for Phase E.

Content:

The Contractor shall prepare a Phase E Implementation Plan that describes the Contractor's approach to providing post-launch mission operations support.

The implementation plan shall be correlated to the WBS and shall identify cost and schedule plans, plus deltas, with rationale from the previous baseline.

The Plan shall include as a minimum the following:

- Technical and programmatic changes that impact Phase E cost (identify each change and its impact on cost and schedule)
- Baseline MOS support description, including key or driving requirements
- Plan for maintaining test-beds at Contractor's facilities
- Plan and approach for monitoring routine in-flight telemetry and assessing Flight System health
- Key open issues and plan for resolution
- Plan for initial in-flight checkout of Flight System
- Phase E organization and staffing plan
- Risk items and mitigation measures
- Transition plan from Phase C/D into Phase E

PM-31 Spacecraft Review Plan

Description

The review plan is a summary package that lists the planned spacecraft and subsystem reviews, their purpose , and locations

4.0 SYSTEMS ENGINEERING

SE-1 Spacecraft Bus Systems Engineering Management Plan (SEMP)

Description:

The contractor shall provide a SEMP to describe all aspects of the systems engineering effort throughout all phases of MAVEN. The purpose of the SEMP is to document, clarify and communicate the systems engineering effort.

Content:

The SEMP shall include descriptions of all system engineering processes and functions, system analysis tasks and the tools to accomplish these tasks, the methodology to monitor technical progress, and how systems engineering supports the time phased activities of the MAVEN project.

The SEMP shall comply with both GPR 7123.1 Systems Engineering, and NPR 7123.1A, NASA Systems Engineering Processes and Requirements.

SE-2 Electromagnetic Interference/Electromagnetic Compatibility (EMI/EMC) Control Plan

Description:

This document shall describe the design and test verification methods that will used to insure that the spacecraft will be compatible with the performance requirements.

Content:

The EMC/EMI Compatibility Plan shall include the following minimum material.

- Description of how the spacecraft will be designed to ensure compatibility between the various subsystems, the launch vehicle, and payloads.
- Design and test plans that will be used at the system, subsystem and component levels.
- EMC/EMI test matrix that describes which components, and/or subsystems will be tested for Conducted Emissions, Conducted Susceptibility, Radiated Emissions, Radiated Susceptibility and Electrostatic Discharge.
- Description of the EMC/EMI and ESD Test Plans.
- Descriptions of the proposed accept/reject test criteria that will be used at the system, subsystem and component levels of assembly.
- Description of proposed design guidelines that will be employed to ensure that the EMC/EMI requirements will be met, such as bonding, grounding and isolation, wiring harnesses design, EED circuits, shielding, etc.
- Describe the plan for providing the predicted and measured values of the S/C radiation interference levels at GFE instrument interfaces.

Special Preparation Instructions:

The scope of this document shall include the spacecraft, instruments, and associated ground support equipment.

SE-3 Flight System Fault Protection Design Specification

Description

Provide the specifications for the flight system fault protection design for all in-flight phases of the MAVEN mission. Include fault protection for the spacecraft and the instruments.

SE-4 Integrated Structural and Thermal Math Models

Description:

To provide test verified mathematical models that represent the static and dynamic structural characteristics of the spacecraft and can be utilized with other data to predict structural accelerations, deflections, and internal loads. Also, to provide the dynamic model for use by the launch vehicle contractor in the performance of the flight loads analyses.

Item D (below) shall be used by NASA to evaluate the on-orbit structural accelerations and dynamic interactions. This model will be quite different than the model for launch condition.

To provide for the comprehensive, detailed review and validation of the thermal design and to predict the thermal performance of the spacecraft and instruments in all modes of operation.

Content:

The contractor shall develop and document test-verified mathematical structural models of the spacecraft in the launch configuration. These shall include a structural finite element model and a dynamic model in Craig-Bampton form, developed, verified, and documented as described below. The finite element model shall represent the structural and dynamic characteristics of the spacecraft. Interface degrees of freedom shall be compatible with corresponding attachment degrees of freedom on the model of the launch vehicle. The dynamics model shall be based on the finite element structural model using standard reduction techniques such as Craig-Bampton reduction.

The test verified structural finite element models and dynamic models shall be provided on electronic medium in a format acceptable to the launch vehicle contractor for the performance of the verification loads cycle analysis.

The dynamic models shall:

- Include the overall system (spacecraft and components),
- Be in Craig-Bampton form with modes that represent the dynamic characteristics of the spacecraft to at least 100 Hz,
- Define dynamic degrees of freedom to allow calculation of acceleration levels and relative deflections at critical points, and
- Include Load Transformation Matrices (LTM) described in the next section.

The finite element model documentation shall include the following:

- A listing of the input data for the model,
- Model definition plots, coordinate system definition, mass properties, and any other pertinent model definition information, along with documentation of the correlation between the modeled properties and the spacecraft design (GFE instrument models will be provided by their subcontractors),
- Mode shapes, frequencies, modal damping, modal participation factors, modal effective weights, correlation between analytical and test modes, and all data required to demonstrate test-verification of the models
- Characterization of all significant frequencies and mode shapes for the spacecraft constrained at the launch vehicle boundary points

B. LOAD TRANSFORMATION MATRICES (LTM's)

The Load Transformation Matrices shall be fully documented and provided on electronic medium in a format acceptable to the launch vehicle contractor. The LTMs shall:

- Consist of influence coefficients relating selected output variables to the associated dynamics model response variable,
- Include launch vehicle interface reaction forces, component/spacecraft interface reaction forces, and reaction force at support locations for deployables,
- Include force, shear, and moment coefficients for determining internal loads in critical structural members, and
- Include coefficients for determining absolute and relative deflections of spacecraft internal elements.

The LTM documentation shall provide:

- A description of the model(s) from which the LTMs were generated,
- A description of each row of the LTM,

- Instructions for use of the LTM, including discussion of the equations used for computing internal transient loads.
- Results of standard checks performed for verification of the LTM (e.g., response to 1g accelerations and unit displacements at the interface).

C. STRUCTURAL MODEL VERIFICATION PLAN

In support of the development of the test-verified structural models, the contractor shall develop a verification plan which includes:

- Identification of the modeling techniques and analysis programs to be utilized,
- Analytical and testing techniques to be used to verify the analytical models and, where required, plans for revising models and repeating analyses based on verification results,
- A description of analyses to be performed, along with the objective, scope, and output of each analyses, and description of testing which will be used for model verification, and
- A compilation of required loads interface data (e.g., loads to components or deployables, or loads from launch vehicle(s), etc.), and a schedule of need dates.

D. ON-ORBIT INTERACTIONS

Repeat item "A" above for fully deployed, on orbit operating conditions and milli-g level vibrations.

The requirements and guidelines for the Combined Comprehensive S/C- Instrument Analytical Thermal Model is described below:

The Combined Comprehensive S/C-Instrument thermal model is a mathematical representation of the heat transfer between the s/c, the instruments and the environment. This model shall accurately predict the heat flows and the resulting temperature changes for any alteration in the environment, internal power dissipation, or any other thermal model parameter. The mathematical representation shall consist of a geometric math model (GMM), with which radiation couplings and environmental heat fluxes are calculated, and a thermal math model (TMM), which calculates the heat transfer and resultant temperatures.

The requirements for the Geometric and Thermal Math Model are described below:

Thermal mass model of the system will be available upon request. Provide a list of all nodes with nodal descriptions. Sketches showing how nodes correspond to s/c Instrument components shall be included. Describe each node of the TMM, its correspondence to a surface or surfaces of the GMM, and discuss the nodalization rationale and how accurately the nodalization thermally represents the actual s/c Instrument hardware.

Special Preparation Instructions:

For items A thru C, all models, simulations, and/or databases required by this DID shall be delivered on electronically compatible with the hardware platform on which it is to execute and include everything necessary to provide a fully functioning computer model whose execution requires only commercially available hardware and software.

For item D, all analysis, simulations, and/or databases for this report shall be available for review at the contractor's facilities.

The instrument structural models shall be incorporated in the spacecraft model and all analyses shall include the instruments.

Part 1 is to be provided at subsystem PDR and Part 2 one month after submittal of PLAC model to the launch vehicle contractor.

The instrument thermal models shall be incorporated into the spacecraft model by the contractor. All S/C thermal analyses shall include the instrument model.

SE-5 Instrument Interface Control Document (ICD)

Description:

The ICDs, listed below, documents will be used to define the contractor's electrical, mechanical and thermal interface to the GFE instruments.

- SE-5A – NGIMS
- SE-5B – PFP
- SE-5C – RSP
- SE-5D – Electra

Content:

The contractor shall provide detailed information regarding the spacecraft bus interface to each instrument payload. The data provided by the Government, in the form of written words, drawings, and schematics, will be incorporated into this combined spacecraft bus to instrument ICD for applicable signatures.

The spacecraft bus to instrument interface is defined per the following topics as a minimum:

A. Physical Requirements – such as mass properties, dynamic propulsion (angular momentum, disturbance torques), footprint, clearance envelope, drill template, alignment, orientation, fields of view (optical, thermal, glint, RF), including tolerances, and special accesses. Electrical Connectors - regarding sex, type, orientation, pin assignments. Thermal control coatings, blankets, heat flow and operating limits. Red and green tag items for test and flight.

B. Electrical Power and Signals - such as timing clock pulses, data busses, signal (name, type, function), voltage and current limits, frequencies, waveforms, rise and fall time, duration, periodicity, shielding, grounding, formats, fusing, voltage, currents, ripple, regulation, impedance, and isolation.

C. Software - such as codes, processors, memory storage, application description, uses.

D. Payload Environmental – such as vibration, shock, acoustic, EMI/EMC, ESD, thermal, contamination, purges.

E. Safety - such as pyrotechnics, energy storage, trip-over, hazardous materials.

F. Ground Support Equipment - such as mechanical, electrical, test specific, targets, stimulators.

G. Operational Factors – such as ground contacts needed per day, data storage capacity, general flight rules and limitations.

H. Cabling and RF Waveguide - such as routing support brackets, and dummy loads.

Show sufficient detail on both sides of each interface to provide clear and complete documentation of the resultant mated interface. For example, electrical interfaces should be presented in schematic detail (logic elements and piece parts) to the point where impedance and transfer characteristics are fully described.

SE-9 Spacecraft Subsystem Requirements Specification

Description:

The spacecraft subsystem requirements specification is the requirements on the subsystems derived from the spacecraft-level requirements. These requirements shall be entered into the DOORS database.

SE-13 Plume Impingement Analysis

Description:

Plume Impingement Analysis is required to predict contamination and degradation of performance of spacecraft and instrument surfaces and components. Plume impingement can contaminate surfaces, degrade optical properties (including thermal radiation and absorption), and affect instrument performance.

Content:

Provide analysis of thruster firing plume impingement on spacecraft and instrument components, surfaces and fields of view.

SE-14 Spacecraft Requirements Specification

Description:

The spacecraft requirements specification consists of requirements derived from the mission-level requirements. These requirements shall be entered into the DOORS database.

SE-15 DSN Compatibility Test Plan and Report

Description:

This report will describe the plan for testing compatibility with the Deep Space Network (DSN).

SE-16 Flight System Verification Plan

Description:

Provide a description of the system performance and verification test program, and describe the specific tests and/or analysis that will collectively demonstrate that the hardware/software complies with the performance requirement and the payload ICD's. This CDRL shall include the information described in the MAVEN MAR (MAVEN-PM-RQMT-0006), MA 9-1 System Performance Verification Plan

Content:

This plan shall identify the test plans and analyses to be performed at each level of assembly in the system, subsystem through fully integrated s/c and SSGS, to demonstrate that the system (hardware and software) meets its performance and environmental requirements. The plan shall identify, where applicable, the combination of tests and analyses to be used to verify each performance and/or environmental requirement and whether verification is conducted on test modules or flight hardware/ software. Included should be descriptions of functional measurements planned at the component, subsystem, integration and system level as well as descriptions of methods planned to make the measurements.

Also, this plan shall include a description of when and how frequently all redundant components and cross-strapped paths will be tested during each environmental test activity. In addition, a list of performance parameters, by subsystem, shall be identified that will be used for monitoring data trends during qualification and acceptance test programs. The plan shall provide the following contents as a minimum:

A. Performance Verification Matrices (PVM) which map performance and design requirements/parameters against the verification methods, to include the level of verification, test procedure reference and, when applicable analysis documents to prove compliance with the system specifications. The Performance Verification Plan (PVP) shall be deliverable in both electronic database and in hardcopy format as a separate volume of the PVP.

   1. A "requirement sort" of the matrices will report all of the verifications attributable to a specific requirement, which can be evaluated for the comprehensiveness of the verification set.

   2. A "verification sort" will report all of the requirements attributable to the verification that will indicate to the verification planner the exact objectives of any specific verification (the requirements to be verified).

   3. Both of these sorts of the matrices will be available within the electronically delivered version of the CDRL. For example, a specific sort of "verification type = test - and - level = system" will list all system level tests. Specific sorts shall be available on request.

B. Detailed test flow sequence charts showing sequence of development and subsystem testing, including integration and qualification/acceptance activities for components, subsystem, spacecraft, GFE instruments, the SEM instruments, and the INR system (i.e., spacecraft and SSGS).

C. Component Life Test Plans that describe the test article configuration and how specification life requirements will be verified. These Plans apply to all component hardware to be life tested and should describe details such as instrumentation monitoring, facility control sequences, test article functions, test parameters, quality control checkpoints, pass/fail criteria, data collection, reporting requirements, and safety and contamination control provisions.

D. Plan for the verification of all previously flown and qualified hardware, including identification of additional verifications required.

E. An environmental test plan that documents the spacecraft contractor's approach for qualification and acceptance tests. It is intended to provide general test philosophy and an overview of the system-level environmental testing to be performed to demonstrate adequacy of the spacecraft for flight (e.g. static loads, vibration, acoustics, shock, etc.) It should include test objectives, unit under test, configuration and general test methods.

F. End-to-End System and Compatibility Test Plans that describe the tests to be performed to verify that the entire spacecraft system (end-to-end) meets performance requirements that are described in Attachment F. This document shall provide details on how the fully integrated system will be tested in an executable system configuration (End-to-End), the sequence and schedule of the test flow, and it shall include a verification matrix. The plan also describes the test facilities and support resources needed for this test.

G. Plan for certification for spacecraft and GFE instrument handling equipment.

H. A list of performance parameters by subsystem shall be identified that will be used for monitoring data trends during the spacecraft qualification and acceptance test programs.

I. Provide the test plan, test sequence, and a description of the tests and activities that will be performed at the launch site.

J. Provide the descriptions for tests that are identified in the performance verification matrix.

K. Describe the proposed ESD qualification test plan that will be used at the component and spacecraft levels of assembly.

L. Provide the post-launch test plan that will be followed prior to spacecraft engineering hand-over (24 days) to the government.

M. Provide the recommended test plan that the government will perform during the PLT phase.

1. Describe the recommended test plan for each s/c subsystem that will characterize its baseline in-orbit performance.
2. Describe the recommended plan for testing the primary, redundant and/or cross-strap signal paths and equipment.
3. Provide a recommended post-launch INR test approach describing the tests to be performed by NASA to initialize and/or characterize INR on-orbit performance and the interval required between calibrations. Test groups may be used in lieu of test plans for each required INR calibration and/or initialization procedure to provide a clear overview of the overall procedure. Each test plan/group presented above shall contain the number of times the test is expected to be performed to characterize each calibration and/or the interval required between calibrations, and recommendations for when the test should or be done (e.g., seasonally, time of day).
4. Spacecraft-level thermal balance and thermal test profiles.

SE-17 Spacecraft Test Laboratory Implementation Plan

Description:

The Plan provides the basis for Contractor's implementation of the Spacecraft Test Laboratory.

Content:

The Contractor shall prepare a Spacecraft Test Laboratory (STL) Implementation Plan that describes the Contractor's approach to developing and using the STL for pre-ATLO activities, during ATLO and for providing post-launch mission operations support.

The Plan shall include as a minimum the following:

- Technical and programmatic plans for implementation
- Baseline MOS support description, including key or driving requirements
- Plan for maintaining test-beds at Contractor's facilities
- Key open issues and plan for resolution
- Risk items and mitigation measures
- Transition plan from Phase C/D into Phase E

SE-19 Flight System Test and Verification Reports

Description:

Provides the results obtained during system performance and verification testing, which, collectively, demonstrates that the hardware/software complies with all applicable performance requirements and ICD's, and includes the EMI/EMC test report. This CDRL shall include the information described in the MAVEN MAR (MAVEN-PM-RQMT-0006), MA 4-8 Trend Analysis and MA 9-3 Verification Reports.

SE-20 Pointing and Alignment Document

Description:

The Pointing and Alignments Document (PAAD) captures the spacecraft pointing and alignment budgets, allocations, and margins. The PAAD addresses instrument as well as engineering components. Quantifiable and verifiable requirements are derived from the PAAD to be included in the Spacecraft Specification and flowed into the Spec Tree.

SE-21 Electrostatic Discharge Control Implementation Plan

Description:

The Electrostatic Discharge Control Implementation Plan will describe how the contractor will implement the Project's Electrostatic Discharge Control Plan. This CDRL is described in the MAVEN MAR (MAVEN-PM-RQMT-0006), MA 14-1 Electrostatic Discharge Control Plan.

SE-22 Magnetic Cleanliness Implementation Plan

Description:

The Magnetic Cleanliness Implementation Plan will describe how the contractor will implement the Project's Magnetic Cleanliness Plan.

SE-23 Coordinate System Document

Description:

The Coordinate System Document defines all relevant (down to the component-level) coordinate systems, numbering conventions, boresight/spin vectors, and rotational polarities, and relates them back to a common spacecraft coordinate system.

SE-24 End Item Data Package

Description:

The contractor shall prepare an end item data package (EIDP) which documents the design, fabrication, assembly and test of the hardware and software being delivered for integration. The following list details what will be contained in the EIDP at a minimum. As most of these items are already DIDS, no specific DID is called out for this data package. The EIDP will be submitted for review and approval by GSFC at the PSR.

- Acceptance testing (as run) procedures and reports including total number of failure free testing
- Environmental Testing (as run) reports
- Final Assembly Work Order
- Material Certification or Analysis Forms
- Waivers, Deviations or MUAs
- As-built EEE parts list
- As-built materials list (ABML)
- End Item Inspection Report
- Nonconformance or problem/failure reports and corrective action summaries
- List of Open items or one-time occurrences
- As-built final assembly drawing
- Photographic documentation of all flight hardware per section 2.3
- Any pertinent analyses (mechanical, electrical, reliability, stress, thermal, worst case)
- As-built configuration list (Item, Manufacturer, Model, etc)
- Certificate of Compliance signed by management
- PWB Coupon Results

5.0 FLIGHT SOFTWARE

Descriptions of Flight Software CDRLs can be found in Section 4.2 of the MAVEN Software Management Plan.

6.0 INTEGRATION AND TEST

IT-1 Spacecraft/Orbiter and GSE Transportation Plan

Description:

The transportation plan describes the method of transportation and explains how the implementation will meet all environmental requirements during transport.

IT-2 Flight System Integration, Test and Launch Operations Plan

Description:

This plan provides information on how the spacecraft will be tested and how its performance will be verified during Integration and Test. It also provides the documentation required to support launch operations. This document will be used as an input document for transmittal of all MAVEN requirements to ER and is the primary document used by ER for the preparation of their Launch Site Support Plan (LSSP) and Payload Requirements Document (PRD). Additionally, it will provide a plan to obtain approval for use of the launch site facilities and resources and for the safety measures to be employed for spacecraft operations.

Content:

The contractor shall provide detailed test procedures to be used during Spacecraft Level Testing. These procedures shall be prepared for each test activity defined in the Performance Verification Plan and shall cover all spacecraft test operations, interfaces, and spacecraft performance requirements (i.e., electrical, structural and mechanical, EMC), and shall cover specialized tests such as mechanical function and deployments, environmental exposure tests (i.e., vacuum, vibration), spacecraft calibration, GSE calibration and checkout, and pre-launch end-to-end tests. As a minimum, the procedures shall contain such information as:

- Test Objectives
- Test Methods
- Applicable Documents and Software
- Required Spacecraft Configuration
- Test Equipment Configuration
- Test Equipment Identification
- Test Instrumentation
- Safety Provisions and Cautions
- Program Quality Requirements
- Test Instructions
- Data Recording Requirements
- Data Recording Forms and Tables
- Accept/Reject Criteria
- Test Termination Procedure

The Launch Site Integration Plan shall define and document the support activities that are necessary for pre-launch activities and the technical aspects of launch operations. This plan shall describe the pre-launch checkout test plan and integration with the launch vehicle; participation in launch vehicle/spacecraft integrated systems test; and inspection, checkout, and fueling operations. All GFE facilities, services and materials must be specified in this document. This includes facilities required for spacecraft checkout and assembly, power, clean room provisions, office space, and communications.

The contractor shall document compliance with all ER safety training, security and Personal Reliability Program requirements.

This document should describe all aspects of the program while at the launch site. A suggested format for the Launch Site Integration Plan is given below:

1.0 General
- 1.1 Plan Organization
- 1.2 Plan Scope
- 1.3 Applicable documents
- 1.4 Spacecraft Hazard System Summary

2.0 Pre-launch/Launch Test Operations Summary
- 2.1 Schedule
- 2.2 Layout of Equipment (each facility) including Test Equipment
- 2.3 Description of Events at Launch Site
  - 2.3.1 Spacecraft Delivery Operations
  - 2.3.2 Payload Processing Facility Operations
  - 2.3.3 Hazardous Processing Facility Operations
  - 2.3.4 Launch Complex Operations
- 2.4 Launch Hold Criteria
- 2.5 Environmental Requirements for Facilities during Transport

3.0 Test Facility Activation
- 3.1 Activation Schedule
- 3.2 Logistics Requirements
- 3.3 Equipment Handling
- 3.4 Maintenance

4.0 Administration
- 4.1 Test Operations

5.0 Security Provision for Hardware/Software

6.0 Special Range Support Requirements
- 6.1 Voice Communications
- 6.2 Mission Control Operations

The contractor shall submit a Ground Operations Plan (GOP) for each spacecraft to be launched. Contents shall be in accordance with Eastern and Western Range Safety Requirements 127-1. The GOP generation shall begin in the design phase and continue through the project development production and integration and test phases. The GOP must be approved by the launch range prior to the start of any hazardous operations on the range.

Each GOP submittal or supplemental submittal shall include addenda and updates required to ensure that the plan is current for each spacecraft launch

7.0 LAUNCH VEHICLE

LV-2 Flight System Dynamic Model

Description:

The flight system dynamic model shall be provided to the launch services provider. This shall include the MAVEN coupled modes analysis.

LV-3 Spacecraft to Launch Vehicle ICD

Description:

The spacecraft to launch vehicle interface control document (S/L ICD) is designed to provide the Spacecraft requirements definition, interface details, launch site facilities, and safety data between the launch vehicle and the spacecraft. It defines the mission requirements and interfaces as they are known. It shall also include any other contractor furnished hardware and services required such as transportation, propellants or analytical support services. The S/L ICD will evolve as mission requirements are identified.

Content:

Following is a sample S/L ICD format of appropriate detail. An S/L ICD format of similar detail shall be provided by the spacecraft Contractor.

1. Introduction
   - 1.1 Mission Information
   - 1.2 Purpose
   - 1.3 Launch Vehicle Description
     - 1.3.1 Configuration
     - 1.3.2 Non-Standard Service Hardware
   - 1.4 Spacecraft Description
   - 1.5 Definitions, Abbreviations/Acronyms
2. Applicable and Reference Documents
3. Mission Characteristics
   - 3.1 Launch Site
   - 3.2 Launch Vehicle Performance
   - 3.3 Mission Design Requirements
     - 3.3.1 Orbital Parameters
     - 3.3.2 Spacecraft Separation
       - 3.3.2.1 Orientation
       - 3.3.2.2 Translational and Rotational Rates
     - 3.3.3 Collision/Contamination Avoidance Maneuver
   - 3.4 Launch window
     - 3.4.1 Eclipse Constraints
     - 3.4.2 Sun Angle Constraints
     - 3.4.3 Ascending Node Constraints
   - 3.5 Mission Time line
   - 3.6 Launch Date
   - 3.7 Spacecraft Systems Launch Configuration
   - 3.8 Spacecraft Mass and Dynamic Properties
     - 3.8.1 Launch Mass
     - 3.8.2 Reference Coordinates/Drawing
     - 3.8.3 Center of Mass Location and Alignment
     - 3.8.4 Moments of Inertia
     - 3.8.5 Fundamental Frequencies (Axial/Lateral)

- 3.8.6 Time Constant and Energy Dissipation Sources
- 3.9 Spacecraft Hazardous Systems
  - 3.9.1 Propulsion
  - 3.9.2 Electrical Explosive Devices (EEDs)
  - 3.9.3 Pressurized Systems
  - 3.9.4 Hazardous Fluids/Materials
  - 3.9.5 RF Systems
  - 3.9.6 Other
- 4. Spacecraft Interfaces
  - 4.1 Mechanical Interface
    - 4.1.1 Spacecraft Attach Fitting
    - 4.1.2 Spacecraft Dynamic or Static Envelope
      - 4.1.2.1 Envelope Incursions
      - 4.1.2.2 Compatibility Drawing
    - 4.1.3 Separation System
    - 4.1.4 Fairing
      - 4.1.4.1 Access
      - 4.1.4.2 Thermal Insulation
      - 4.1.4.3 Acoustic Blankets
    - 4.1.5 Spacecraft Integration
  - 4.2 Electrical Interface
    - 4.2.1 Spacecraft Telemetry
      - 4.2.1.1 Stations
      - 4.2.1.2 Airborne Telemetry Support
      - 4.2.1.3 Data Rate/Type
      - 4.2.1.4 Special Hardware
        - 4.2.1.4.1 RF Window/Door
        - 4.2.1.4.2 Re-radiator
        - 4.2.1.4.3 Other
    - 4.2.2 Launch Vehicle Provided Electrical Firing Pulses
    - 4.2.3 Launch Vehicle Provided Discrete Commands
    - 4.2.4 Vehicle Interface Connectors/Pin Assignments
      - 4.2.4.1 Launch Vehicle Interface Connectors
      - 4.2.4.2 Spacecraft Interface Connectors
      - 4.2.4.3 Pin Assignments
    - 4.2.5 Separation Switches/Pads
    - 4.2.6 Mission Peculiar Vehicle Telemetry
      - 4.2.6.1 Stations
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    - 4.3.3 Vibration
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     - 5.1.1 Operational Areas and Office Support Equipment
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     - 5.1.3 Block House
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     - 5.1.7 Spacecraft Handling/Test Equipment
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     - 8.2.5 Combined Electrical Readiness Test (CERT)

8.0 OPERATIONS

OPS-1 MOS-GDS Implementation Plan

Description:

Encompasses all components of the MAVEN Mission Operations System – Ground Data System (MOS-GDS) hosted in the Lockheed Martin Mission Support Area (MSA) as well as the backup Mission Support Area (bMSA) at NASA's Goddard Space Flight Center (GSFC), including network connectivity between the two facilities. Describes the functionality of each component as well as the work required to bring each component on-line within the overall GDS architecture. Describes plans for enhancement and development of new code, database population, and overall system adaptation to accommodate the MAVEN mission, including the plan for modification and enhancement of the existing Orbiter Analysis System (OAS) suite of software tools.

OPS-2 MOS-GDS Verification & Validation Plan

Description:

Encompasses all components of the MAVEN Mission Operations System – Ground Data System (MOS-GDS) hosted in the Lockheed Martin Mission Support Area (MSA). Describes planned demonstrations and verification & validation tests prior to full deployment in the ops configuration. This includes System Verification Tests (SVT) as well as Operations Readiness Tests (ORT) involving End-to-End interfacing.

OPS-3 Mission Operations Concept

Description:

Document provides an overview of the MAVEN Mission Phases and the operations concept, sequence of events, and operations timeline during each phase of the MAVEN mission. The Mission Operations Concept document serves as a primer for the Project-level Mission Plan document and the Mission Operations Procedures (MOP) Volume 1: Operations Scenarios, defined below.

OPS-4 Mission Support Area (MSA) to Science Operations Center (SOC) ICD

Description:

Describes in detail all aspects of the interfaces between the MSA and the SOC.

Content:

1. INTRODUCTION
    - 1.1Purpose
    - 1.2 Document Organization
    - 1.3 Scope
2. APPLICABLE DOCUMENTS
    - 2.1 Related Documents
    - 2.2 Document Control
3. FUNCTIONAL DESCRIPTIONS
    - 3.1 General
    - 3.2 Interfacing Facilities Overview
        - 3.2.1 MSA
        - 3.2.2 SOC
            - 3.2.2.1 SOC Payload Operations Center
            - 3.2.2.2 SOC Science Data Center
4. INTERFACE CONFIGURATION AND CONTROL 4-1
    - 4.1 Organizational Responsibilities
5. APPLICATION LAYER
    - 5.1 Definition
    - 5.2 Product Summaries

6. PRESENTATION LAYER
    6.1 Definition
    6.2 General File Format
    6.2.1 File Naming Convention
    6.2.1.1 Group Identification
    6.2.1.2 Product Type
    6.2.1.3 Product Generation Date
    6.2.1.4 Version Number
    6.2.1.5 File Suffix
7. SESSION LAYER
    7.1 Definition
    7.2 Transmission Protocol
    7.3 Real-time Data Transfer
    7.3.1 Real-Time Data Flow
8. NETWORK/TRANSPORT LAYER
    8.1 Definition
    8.2 Network
    8.3 Transport
9. DATA LINK LAYER
    9.1 Definition
    9.1.1 Data Link Interface
10. PHYSICAL LAYER
    10.1 Definition
10.1.1 Physical Interface

OPS-5 Training Plan

Description:

The contractor shall provide training materials to familiarize personnel who have not already acquired "on-the-job" experience with the MAVEN flight system and/or ground system. This may include new personnel who will support MAVEN flight operations, as well as instrument team personnel who will provide temporary support in the spacecraft test and/or operations environments.

OPS-6 Mission Operations Procedures (MOP) Vol. 1: Operations Scenarios

Description:

The MOP is comprised of Ten Volumnes which define the Mission Operations System scenarios, processes, team and software interfaces, commands, telemetry, command blocks, procedures and contingency plans for the MAVEN mission. The MOP is intended to supplement the Project-level Mission Plan and the Mission Operations Concept document (OPS-3).

Volume 1 of the MOP defines by mission phase the operational scenarios and implementation approach that will allow the MOS to accomplish the MAVEN requirements and goals. The scenario definitions will be utilized prior to launch for the flight operations teams to determine staffing requirements and for guiding the generation of flight-like test products for ATLO System Verification testing. Post-launch, the flight operations teams will utilize Volume 1 as the reference source for the development of actual flight sequences and as a training reference document supporting the development and use of OPS-10: Training Scenarios and Training Course Materials described above.

OPS-7 Mission Operations Procedures (MOP) Vol. 2: Operations Processes

Description:

The MOP is comprised of Ten Volumnes which define the Mission Operations System scenarios, processes, team and software interfaces, commands, telemetry, command blocks, procedures and contingency plans for the MAVEN mission. The MOP is intended to supplement the Project-level Mission Plan and the Mission Operations document (OPS-3).

Volume 2 of the MOP defines the mission operation processes that will allow the MOS to accomplish the operations scenarios described in Volume 1. The process definitions will be used in flight to conduct operations per the operational scenario described for each mission phase: Pre-Launch, Launch, Cruise, Mars Orbital Insertion (MOI), Transition, Science Mapping, and Extended Mission & Relay. Operations processes are grouped into three categories: Uplink, Downlink, and Management.

OPS-8 Mission Operations Procedures (MOP) Vol. 3: Flight System Operations Procedures

Description:

The MOP is comprised of Ten Volumnes which define the Mission Operations System scenarios, processes. team and software interfaces, commands, telemetry, command blocks, procedures and contingency plans for the MAVEN mission. The MOP is intended to supplement the Project-level Mission Plan and the Mission Operations Concept document (OPS-3).

Volume 3 of the MOP, specifically, defines the mission operation procedures that will allow the MOS to accomplish the operations scenarios described in Volume 1. These procedures will be used in flight to conduct orbiter subsystem operations per the operational scenario described for each mission phase: Pre-Launch, Launch, Cruise, Mars Orbital Insertion (MOI), Transition, Science Mapping, and Extended Mission & Relay.

OPS-9 Mission Operations Procedures (MOP) Vol. 4: Operations Interface Agreements (OIA)

Description:

The MOP is comprised of eleven volumes which define the Mission Operations System scenarios, processes, team and software interfaces, commands, telemetry, command blocks, procedures and contingency plans for the MAVEN mission. The MOP is intended to supplement the Project-level Mission Plan and the Mission Operations Concept (OPS-3).

Volume 4 of the MOP defines the Operational Interface Agreements for the MAVEN mission operations. Operational Interface Agreements (OIAs) are signed receivable/deliverable items betweens institutions comprising the MAVEN Mission Operations System. These items represent necessary products required to perform the operational processes described in Volume 2 of the MOP and the operations procedures described in Volume 3 of the MOP. The MAVEN GDS Product Interchange Table (OPS-4) serves as a "master table" to the ICDs and OIAs, and as such augments Volumes 4 and 5 of the MOP.

OPS-10 Mission Operations Procedures (MOP) Vol. 5: Software Interface Specifications (SIS)

Description:

The MOP is comprised of Ten Volumnes which define the Mission Operations System scenarios, processes, team and software interfaces, commands, telemetry, command blocks, procedures and contingency plans for the MAVEN mission. The MOP is intended to supplement the Project-level Mission Plan and the Mission Operations Concept document (OPS-3).

Volume 5 of the MOP, specifically, defines the Software Interface Specifications for the MAVEN Ground Data System. The MAVEN ground software interface specifications include any data/information that flows from, or to, a software configuration item in the GDS and is under formal configuration control. The following functional areas are defined for MAVEN/GDS subsystem-level Software Interface Specifications (SIS)):

(a) DSN, for any software interface/data flow from/to the Deep Space Network (DSN);

(b) SEQ, for any ground software interface/data flow necessary to perform spacecraft data acquisition, command and sequence generation, and engineering analysis for spacecraft operations;

(c) Mission Navigation, for any ground software interface/data flow necessary to perform flight and orbit control, spacecraft tracking and navigation, is included in the MAVEN ground software.

(d) TLM, for any ground software interface/data flow necessary to analyze and archive downlinked telemetry data, during testing and operations;

(e) MON, for any ground software interface/data flow necessary to monitor and store data, during testing and downlink/uplink operations;

(f) SCI, for any ground software interface/data flow necessary for science data analysis, to generate science results;

(g) MIS, for any ground software interface/data flow commonly needed by two or more Operations teams, which does not belong exclusively to one of the above areas

OPS-11 Mission Operations Procedures (MOP) Vol. 6: Orbiter Operations Plan

Description:

The MOP is comprised of Ten Volumnes which define the Mission Operations System scenarios, processes, team and software interfaces, commands, telemetry, command blocks, procedures and contingency plans for the MAVEN mission. The MOP is intended to supplement the Project-level Mission Plan and the Mission Operations Concept document (OPS-3).

Volume 6 of the MOP, the MAVEN Orbiter Operations Plan, contains a major section describing the spacecraft team organization roles and responsibilities and another which describes the SOC and Instrument Team roles and responsibilities. The document is a Lockheed Martin CDRL; the spacecraft component is provided by Lockheed Martin, while the SOC and Instrument Team components will be worked collaboratively by the SOC, the Instrument Teams and Lockheed Martin.

OPS-12 Mission Operations Procedures (MOP) Vol. 7: Command Dictionary

Description:

The MOP is comprised of Ten Volumnes which define the Mission Operations System scenarios, processes, team and software interfaces, commands, telemetry, command blocks, procedures and contingency plans for the MAVEN mission. The MOP is intended to supplement the Project-level Mission Plan and the Mission Operations Concept document (OPS-3).

Volume 7 of the MOP, the Command Dictionary, describes the formats for all MAVEN commands. The command dictionary also provides an overview of the uplink path from the RF signal to the spacecraft, to completed commands, sequences, flight software loads, or file loads being stored and/or executed on-board. This overview includes discussion of the hardware and software involved, and a description of the behavior of each with regards to the uplink and command processing. A condensed, tabular listing of commands by subsystem category is provided. Detailed command data will be obtained via on-line electronic interrogation of the actual Command Database.

OPS-13 Mission Operations Procedures (MOP) Vol. 8: Telemetry Dictionary

Description:

The MOP is comprised of Ten Volumnes which define the Mission Operations System scenarios, processes, team and software interfaces, commands, telemetry, command blocks, procedures and contingency plans for the MAVEN mission. The MOP is intended to supplement the Project-level Mission Plan and the Mission Operations Concept document (OPS-3).

Volume 8 of the MOP, the Telemetry Dictionary, describes the formats for all MAVEN telemetry. The Telemetry Dictionary also provides an overview of the downlink path, from the sampling of measurements, through the creation of the packets and frames (and products if applicable) to the downlink and display of the telemetry data. This overview includes discussion of the hardware and software involved, and a description of the behavior of each with regards to the telemetry processing. A condensed, tabular listing of telemetry points by subsystem category is provided. Detailed telemetry data will be obtained via on-line electronic interrogation of the actual Telemetry Database.

OPS-14 Mission Operations Procedures (MOP) Vol. 9: Block Dictionary

Description:

The MOP is comprised of Ten Volumnes which define the Mission Operations System scenarios, processes, team and software interfaces, commands, telemetry, command blocks, procedures and contingency plans for the MAVEN mission. The MOP is intended to supplement the Project-level Mission Plan and the Mission Operations Concept document (OPS-3).

Volume 9 of the MOP, the Block Dictionary, defines the command blocks that will be used to conduct the mission as defined in the Mission Plan and MOP Volume 1, Operations Scenarios. Blocks are defined for repeated functions (e.g., DSN communications, Mars orbital mapping instrument operations, etc.) and for critical one-time only events (e.g., Launch, Mars Orbit Insertion).

OPS-15 Mission Operations Procedures (MOP) Vol. 10: Flight Rules and Idiosyncrasies (Flight System Constraints and Restrictions)

Description:

The MOP is comprised of Ten Volumnes which define the Mission Operations System scenarios, processes, team and software interfaces, commands, telemetry, command blocks, procedures and contingency plans for the MAVEN mission. The MOP is intended to supplement the Project-level Mission Plan and the Mission Operations Concept document (OPS-3).

Volume 10 of the MOP, the Flight Rules and Idiosyncrasies, provides the MAVEN Flight Operations Team with all the in-flight constraints, limitations and restrictions imposed by the Project on the use of spacecraft and payload capabilities and resources. This includes MAVEN spacecraft configuration and operational constraints and restrictions (spacecraft configuration restrictions and environmental considerations for test and for flight), as well as potential command conflicts. This provides the MAVEN Flight Operations Team with the established methodology for populating databases to support both automated and manual checking of products against established flight rules and constraints.

9.0 MISSION ASSURANCE

Mission Assurance CDRL descriptions are shown in the MAVEN MAR.

MAVEN
Mars Atmosphere and Volatile Evolution Mission
CU/LASP • GSFC • UCB/SSL • LM • JPL

Mars Atmosphere and Volatile EvolutioN

(MAVEN)

Mission Requirements Document

MAVEN-PM-RQMT-0005

Revision V

Effective Date: February 2, 2012

Expiration Date: February 2, 2017

Prepared By: Martin Houghton
Mission Systems Engineer
Code: 5990

This is a MAVEN controlled document and only approved MAVEN CCRs can change the content of this document.

Goddard Space Flight Center
Greenbelt, Maryland

National Aeronautics and Space Administration

CM FOREWORD

This document is a Mars Atmosphere and Volatile Evolution Project controlled document. Changes to this document require prior approval of the MAVEN Project CCB Chairperson. Proposed changes shall be submitted to the MAVEN Project Configuration Management Office (CMO), along with supportive material justifying the proposed change.

Questions or comments concerning this document should be addressed to:

MAVEN Configuration Management Office
Mailstop 432
Goddard Space Flight Center
Greenbelt, Maryland 20771

REVIEW/APPROVAL PAGE

All reviews and approvals are electronic via the MAVEN MIS at:

https://mavenmis.gsfc.nasa.gov.

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Ajluni, Thomas, 432.0, Dec 09, 2011
Cauffman, Sandra, 4630, Jan 23, 2012
Cheatom, Oscar, 300, Jan 31, 2012
Demcak, Stuart, 343A, Dec 19, 2011
Folta, Dave, 595, Jan 25, 2012
Gomez-Rosa, Carlos, 5810, Dec 09, 2011
Houghton, Martin, 5990, Jan 24, 2012
Jarosz, Mark, 432, Dec 14, 2011
Jedrich, Nicholas, 432, Dec 09, 2011
Kozon, Robert, 428, Dec 21, 2011
Possel, William, LASP, Dec 21, 2011
Priser, Timothy, LMCO, Dec 13, 2011
Sidney, Wayne, 4320, Dec 08, 2011
Sparacino, Susan, 432, Dec 09, 2011
Wasiak, Francis, 444.0, Dec 09, 2011

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Cheatom, Oscar, 300, Jan 31, 2012
Houghton, Martin, 5990, Dec 21, 2011
Jarosz, Mark, 432, Dec 19, 2011
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Mars Atmosphere and Volatile EvolutioN (MAVEN) Mission

Mission Requirements Document

DOCUMENT CHANGE RECORD

Sheet: 1 of 1

REVISION LEVEL	DESCRIPTION OF CHANGE	APPROVED BY	DATE APPROVED
Revision (-)	Initial Release, MAVEN Missioin Requirements Document as per MAVEN-CCR-0021.	D. Mitchell	12/10/2007
Revision A	Updates per MAVEN-CCR-0029.	D. Mitchell	12/10/2007
Revision B	Updates per MAVEN-CCR-0038.	D. Mitchell	7/24/2008
Revision C	Updates per MAVEN-CCR-0056.	D. Mitchell	8/6/2009
Revision D	Updates per MAVEN-CCR-0070.	D. Mitchell	9/29/2009
Revision E	Updates per MAVEN-CCR-0080.	D. Mitchell	1/14/2010
Revision F	Updates per MAVEN-CCR-0116.	D. Mitchell	3/4/2010
Revision G	Updates per MAVEN-CCR-0125, 0126 and 0127.	D. Mitchell	3/25/2010
Revision H	Updates per MAVEN-CCR-0115, 0119, 0134 and 0159.	D. Carson	5/6/2010

REVISION LEVEL	DESCRIPTION OF CHANGE	APPROVED BY	DATE APPROVED
Revision I	Updates per MAVEN-CCR-0144. CCR was approved/signed by Don Carson on the MIS on April 18, 2010, released officially on the MIS on September 16, 2010 after all CCB actions were complete.	D. Carson	6/6/2010
Revision J	Updates per MAVEN-CCR-0152 and CCR-0183.	D. Mitchell	6/11/2010
Revision K	Updates per MAVEN-CCR-0146 and missed requirement add (MRD410) from CCR-0125 and delete MRD20 from CCR-0126.	D. Mitchell	7/22/2010
Revision L	Updates per MAVEN-CCR-0200, CCR-0203, 0208 and CCR-0210.	D. Mitchell	9/16/2010
Revision M	Updates per MAVEN-CCRs-0194, 0201, 0212, 0216 and 0224.	D. Mitchell	11/12/2010
Revision N	Updates per MAVEN-CCRs-0222, 0223 and 0229.	D. Mitchell	12/10/2010
Revision O	Updates per MAVEN-CCRs-0129, 0130, 0131, 0138 and 0248.	D. Mitchell	2/10/2011
Revision P	Updates per MAVEN-CCRs-0249, 0251 and 0256.	D. Mitchell	3/3/2011
Revision Q	Updates per MAVEN-CCRs-0136, 0137, 0160, 0278 and 0282.	D. Mitchell	4/14/2011
Revision R	Updates per MAVEN-CCRs-0139, 0140, 0141, 0285, 0289 and 0299.	D. Mitchell	5/5/2011
Revision S	Updates per MAVEN-CCRs-0254, 0318, 0326, and 0331.	D. Mitchell	7/21/2011

Revision T	Updates per MAVEN-CCRs-0301, 0310, 0314, 0330, 0363 and 0381.	D. Mitchell	11/14/2011
Revision U	Updates per MAVEN-CCRs-0377 (MRD420 & MRD423) & 0426 (Update MRD16).	D. Mitchell	1/8/2012
Revision V	Update MRD373 per MAVEN-CCR-0429 and MRD174 per MAVEN-CCR-0433.	D. Mitchell	2/2/2012

ID : MRD2

Section : 1.

Title : Mission Lifetime

MAVEN shall be designed and built for a mission lifetime of 1-earth-year + Cruise duration (roughly 10 months) + transition from capture orbit to final orbit (roughly 1 month). All consumables shall be sized consistent with the TRAS (MAVEN-MDES-RQMT-0036).

ID : MRD3

Section : 1.

Title : Mission Assurance

The MAVEN mission shall meet the Safety and Mission Assurance (S&MA) requirements in the Mission Assurance Requirements Document.

ID : MRD4

Section : 1.

Title : Compliance with GSFC-STD-1000

All MAVEN elements shall comply with GSFC-Std-1000. Exceptions to this will require waiver approval from GSFC Engineering.

ID : MRD5

Section : 1.

Title : Planetary Protection

As a Mars orbiter, MAVEN is a Category III mission and shall comply with requirements specified in Planetary Protection documents NPD 8020.7F and NPR 8020.12C.

ID : MRD7

Section : 1.

Title : Orbiter Coordinate SystemAll orbiter coordinate systems shall be consistent with those defined in the Coordinate Systems Document.

ID : MRD410

Section :

Title : Technical Resource Allocation Specification

All elements shall comply with Technical Resource Allocation Specification

SC, PF, NGIMS, RS must provide links.

ID : MRD409

Section :

Title : Relay

MAVEN shall perform no more than one relay session per 4.5 hour (orbit) period, comprised of no more than one 60-minute DSN uplink, one 30-minute MAVEN proximity link session, and one 30 minute DSN downlink, not accounting for the intermediate slew durations, Earth-link occultations, and/or other intermediate spacecraft/Electra operations (including warmup and shutdown of the Electra hardware).

ID : MRD14

Section : 1.

Title : Mars Orbit Telecommunications Durations

During the mapping phase, MAVEN shall support two dedicated DSN passes, each 5 hours in duration, per week.

ID : MRD15

Section : 1.

Title : Ground Contact Frequency

During nominal operations, the MAVEN orbiter shall be designed to operate without ground intervention outside of the nominal communication schedule of 2 passes per week.

ID : MRD16

Section : 1.

Title : Data Availability

When in normal operation mode, i.e., not safe hold, MAVEN shall lose no more than 2% of the transmitted engineering and science data.

ID : MRD21

Section : 1.2

Title : Nominal Science Orbit Parameters

The nominal MAVEN science orbit shall be an elliptical orbit, with an inclination of 75 +/-1.875 degrees, and a period of 4.5 +/- .11 hours, targeted to a periapsis density corridor of 0.05 to 0.15 km/kg3.

ID : MRD22

Section : 1.2

Title : Deep Dip Orbit Parameters

During the deep dips, the orbit periapsis shall be lowered to target a density of 2 - 3.5kg/km3.

ID : MRD23

Section : 1.2

Title : Deep Dip Orbit Duration

Each deep-dip shall last a minimum of 20 orbits.

ID : MRD24

Section : 1.2

Title : Deep Dip Frequency

MAVEN shall be capable of performing up to five "deep-dips" during its nominal mission.

ID : MRD31

Section : 1.3

Title : Mass Range of Neutrals Measurements

MAVEN shall measure planetary neutrals in a mass range bounded by 4 to 46 AMU with unit mass resolution.

ID : MRD32

Section : 1.3

Title : Mass Range of Ions Meausurements

MAVEN shall measure thermal planetary ions in a mass range bounded from 12 to 46 AMU with unit mass resolution.

ID : MRD33

Section : 1.3

Title : Adjacent Mass Cross-Talk

The adjacent mass cross-talk of in-situ MAVEN neutral gas measurements shall be less than 1E-4.

ID : MRD34

Section : 1.3

Title : Neutrals Measurement Density Range

MAVEN shall measure neutral densities from 120km to 400km with density precision of 25% or better.

ID : MRD35

Section : 1.3

Title : Ions Measurement Density Range

MAVEN shall measure thermal ion densities from 120km to 400km with density accuracy of 25% or better.

ID : MRD36

Section : 1.3

Title : Open Source Field-Of-View

MAVEN measurements of distributions of reactive species and ions shall have a field-of-view about RAM of 10deg or better.

ID : MRD37

Section : 1.3

Title : Closed Source Filed-of-View

MAVEN measurements of distributions of non-reactive species shall have a field-of-view about RAM or 45deg or better.

ID : MRD38

Section : 1.3

Title : Vertical Spatial Measurement Resolution of Neutrals

MAVEN shall have a spatial vertical resolution of better than one half of a scale height for neutrals (< 6 km for CO2).

ID : MRD424

Section : 1.3

Title : Vertical Spatial Measurement Resolution of Ions

MAVEN shall have a spatial vertical resolution of better than one half of a scale height for ions (< 30km for O2+).

ID : MRD39

Section : 1.4

Title : Deuterium-to-Hydrogen Measurement Accuracy

MAVEN shall measure the ratio of Deuterium-to-Hydrogen with an precision of 30%

ID : MRD40

Section : 1.4

Title : Spectral Line Measurement Wavelength Range

MAVEN shall measure spectral lines from H (wavelength of 120nm) to CO2 (wavelength of 330nm).

ID : MRD41

Section : 1.4

Title : Major Species Spectral Line Measurement Wavelength Resolution

The science data spectral resolution of RS shall be better than 0.5nm from 120 to 180 nm. (FUV Channel)

ID : MRD413

Section :

Title :

The science data spectral resolution of RS shall be better than 1.0nm from 180 to 330 nm. (MUV Channel)

ID : MRD42

Section : 1.4

Title : Deuterium and Hydrogen Spectral Line Wavelength Resolution

To resolve spectral lines for D and H, MAVEN shall have wavelength resolution of 13,000 or better.

ID : MRD44

Section : 1.4

Title : Horizontal Spatial Measurement Resolution

For UV measurements, MAVEN shall have a horizontal spatial resolution of 340km or better at the center of the FOV.

ID : MRD45

Section : 1.5

Title : In Situ Electron Density Measurement Range

MAVEN shall measure electron densities in the Mars atmosphere in a range from 1E2 to 1E6 cm-3 with an precision of at least 20% below the ionopause

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ID : MRD46

Section : 1.5

Title : In Situ Electron Temperature Measurement Range

MAVEN shall measure electron temperatures in the Mars atmosphere over a temperature range of 500 to 5,000 k with an precision of 20% or better below the ionopause

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ID : MRD47

Section : 1.5

Title : Electric Field Measurement Frequency Range

MAVEN shall measure electric field over a frequency range of 0.05 to 10Hz with a wave power sensitivity of at least 1E-8 (V/m)-squared/Hz.

ID : MRD48

Section : 1.5

Title : Electron Temperature Spatial Resolution

MAVEN shall measure electron temperatures with spatial resolution of 60km or better.

ID : MRD49

Section : 1.5

Title : Solar Lyman-Alpha Flux Monitoring

MAVEN shall monitor the solar Lyman-alpha irradiance with a precision of at least 30%

ID : MRD50

Section : 1.5

Title : Solar Coronal EUV Flux Monitoring

MAVEN shall monitor the coronal EUV irradiance to 15%

ID : MRD51

Section : 1.5

Title : Solar Activity Time Measurement Resolution

MAVEN shall measure solar activity such as flares and CMEs with a temporal resolution of 10 minutes

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ID : MRD52

Section : 1.6

Title : Ion Flux Measurement Range Below 800km

MAVEN shall measure ion outflow below 800km at 20s resolution and 25% precision

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ID : MRD53

Section : 1.6

Title : Ion Flux Measurement Range Above 800km

MAVEN shall measure sheath and pick-up ions above 800km at 30 minute resolution and 25% precision

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ID : MRD54

Section : 1.6

Title : Ion Mass Measurement Range

MAVEN shall measure ions at Mars with a mass range from 1amu (H+) to 44amu (CO2+).

ID : MRD55

Section : 1.6

Title : Ion Mass Measurement Resolution

The mass resolution for suprathermal ion measurements shall be at least 2 (m/dm).

ID : MRD405

Section : 1.6

Title : Ion Energy Measurement Resolution

MAVEN ion measurements shall have an energy resolution of dE/E 30% or better.

ID : MRD406

Section : 1.6

Title : Ion Energy Measurement Angular Resolution

MAVEN ion measurements shall have an angular resolution of 30deg or better.

ID : MRD57

Section : 1.6

Title : Thermal Ion Measurement Below 800 km Viewing

To simultaneously measure thermal and suprathermal ions, MAVEN shall have field-of-view in both the nadir and RAM directions of at least 60deg by 180deg.

ID : MRD58

Section : 1.7

Title : Electron Flux Measurement Range

MAVEN shall make solar wind electron measurements with differential energy range from 1E4 to 1E8 eV/cm2-sec-ster-eV.

ID : MRD59

Section : 1.7

Title : Electron Energy Measurement Sensitivity

MAVEN shall have sufficient sensitivity to measure expected electron fluxes from 10 to 500 eV at Mars with the required temporal resolution (MRD61).

ID : MRD60

Section : 1.7

Title : Impact Ionization Rate Measurement Energy Range

MAVEN shall make solar wind electron measurements in an energy range from 10eV to 1000eV with a resolution of 30% or better.

ID : MRD61

Section : 1.7

Title : Electron Measurement Temporal Resolution

MAVEN shall make electron measurements at Mars with a temporal resolution of 20s or better. (MRD59)

ID : MRD62

Section : 1.7

Title : Electron Measurement Angular Resolution

MAVEN shall make electron measuremets at Mars with an angular resolution of 45 degrees or better.

ID : MRD63

Section : 1.7

Title : Electron Measurement Field of View

MAVEN shall make electron measurements over at least 50% of the Mars sky.

ID : MRD64

Section : 1.8

Title : Solar Wind Ion Flux Measurement Range

MAVEN shall make solar wind ion measurements with differential energy range from 1E7 to 1E10 eV/cm2-sec-ster-eV.

ID : MRD65

Section : 1.8

Title : Solar Wind Ion Velocity Measurement Range

MAVEN shall measure solar wind ion flows with velocities ranging from 50 to 1000 km/s

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ID : MRD66

Section : 1.8

Title : Solar Wind Ion Energy Measurement Resolution

MAVEN shall measure solar wind ion energy with an energy resolution of 15% or better .

ID : MRD67

Section : 1.8

Title : Solar Wind Ion Energy Measurement Angular Resolution

MAVEN shall measure solar wind ion energy with an angular resolution of 30deg or better and 10deg or better in the direction of the sun.

ID : MRD68

Section : 1.8

Title : Solar Wind Ion Energy Measurement Temporal Resolution

MAVEN shall measure the solar wind ion energy with a temporal resolution to 1 minute or better.

ID : MRD69

Section : 1.8

Title : Solar Wind Ion Energy Measurement Field of View

MAVEN shall be capable of measuring ion energy in a field-of-view of 30deg or greater centered on the sun

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ID : MRD70

Section : 1.9

Title : Magnetic Field Measurement Dynamic Range

The dynamic range of MAVEN magnetic field measurements shall encompass 3 to 3000 nT.

ID : MRD71

Section : 1.9

Title : Magnetic Field Measurement Accuracy

MAVEN shall measure the magnetic field at Mars with a precision of 1% or better over the range of 3 to 3000nT.

ID : MRD72

Section : 1.9

Title : Magnetic Field Measurement Resolution

MAG shall have a precision of better than 1% over its dynamic range

---

ID : MRD73

Section : 1.9

Title : Magnetic Field Measurement Temporal Resolution

MAVEN shall measure the magnetic field at Mars with a temporal resolution of 20s or better.

ID : MRD74

Section : 1.10

Title : SEP Flux Measurement Range

MAVEN shall make solar energetic particle measurements in a differential energy flux range from 10 to 10E6 eV/cm2-sec-ster-eV and a precision of 30%.

ID : MRD75

Section : 1.10

Title : Solar Energetic Particle Energy Detection Range

MAVEN shall measure solar energetic particles in a measurement range from 50keV to 5MeV.

ID : MRD76

Section : 1.10

Title : Solar Energetic Particle Energy Measurement Resolution

MAVEN shall measure solar energetic particles with an energy resolution of at least 50%.

ID : MRD77

Section : 1.10

Title : Solar Energetic Particle Energy Temporal Resolution

MAVEN shall measure solar energetic particle energy with a temporal resolution of 1 hour or better.

ID : MRD80

Section : 2.1

Title : Compatibility with Natural and Induced Environments

The MAVEN flight segment shall be compatible with the natural and induced environments as specified in the ERD (MAVEN-SYS-RQMT-0010)

ID : MRD83

Section : 2.1

Title : Electrostatic

All orbiter external surfaces shall meet the conductance and grounding requirements defined in the ERD and controlled by the MAVEN EMI/EMC Plan (MAVEN-SYS-PLAN-0078). All waivers to these requirements will need concurrence from the MAVEN ESC board.

ID : MRD85

Section : 2.1

Title : Magnetic Cleanliness Controls

The Orbiter, including the solar arrays, and the instruments shall meet the magnetic requirements defined in the ERD and controlled by the MAVEN EMI/EMC Plan (MAVEN-SYS-PLAN-0078). All waivers to these requirements will need concurrence from the MAVEN Magnetics Control Board.

ID : MRD90

Section : 2.4.1

Title : Atmospheric Density Indication

The spacecraft shall provide density sensitivity protection for atmospheric density sensitivities above 2.5 kg/km^3

ID : MRD93

Section : 2.4.1

Title : Spacecraft Fault Tolerance

No single credible failure in the spacecraft, payloads, spacecraft-payload interfaces, and/or single ground error shall permanently preclude meeting the baseline Level 1 requirements.

ID : MRD95

Section : 2.4.1

Title : Autonomous Operations

The spacecraft shall be capable of operating autonomously for 7 days during normal operations

---

ID : MRD96

Section : 2.4.1

Title : Fault Management

The Orbiter shall perform autonomous fault management, configurable by ground command

---

ID : MRD97

Section : 2.4.1

Title : Payload Safing

MAVEN shall actively protect from known conditions that could damage the instruments as defined in the spacecraft-to-instrument ICDs.

ID : MRD101

Section : 2.4.1

Title : Return to Normal Operations

Within 24 hours of being commanded out of safe mode, the orbiter shall be capable of returning to an operational state that allows the orbiter to resume planned activities

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ID : MRD414

Section : 2.4.1

Title : Science During Solar Flares

MAVEN shall collect science data with at least a 70% probability throughout a worst week solar flare event as defined in MAVEN-SYS-SPEC-0014, section VI.A.2.

ID : MRD102

Section : 2.4.2

Title : Atlas V Compatibility

MAVEN shall be compatible with Atlas V requirements as defined in the MAVEN Launch Vehicle Interface Requirements Document (IRD).

ID : MRD103

Section : 2.4.2

Title : Payload Accommodation

The spacecraft shall accommodate the payloads per the Spacecraft to Instrument Interface Control Document (ICDs).

ID : MRD104

Section : 2.4.2

Title : Minimum First Mode Natural Frequency of Deployables

The first mode natural frequencies of all deployed masses (deployed appendage mass + mass carried by the appendage) shall be at least a decade away from the spacecraft ACS controller bandwidth (will waive for LPW).

ID : MRD108

Section : 2.4.2

Title : LPW Boom Stiffness

The deployed LPW and boom assembly shall have a minimum first mode natural frequency > 0.25 Hz.

ID : MRD109

Section : 2.4.2

Title : Thruster Plume Avoidance

Booms, solar arrays, instrument apertures, and HGA shall be mounted so that they remain clear of the modeled thruster plumes.

ID : MRD117

Section : 2.4.3

Title : Spacecraft Operations

MAVEN shall be capable of operating spacecraft subsystems and all of the instruments as defined in the Design Reference Mission.

ID : MRD121

Section : 2.4.3

Title : Electra Power During Nominal Science Operations

After achieving the primary science orbit, the spacecraft shall be capable of providing the Electra Payload with the energy necessary for Electra relay passes. If this requires reducing the energy allocated to the instruments, as a minimum, instrument survival heaters shall remain powered during relay passes.

ID : MRD126

Section : 2.4.4

Title : Receipt of Commands and Generation of Telemetry

Once separated from the launch vehicle, the orbiter shall be capable of continuously receiving commands and transmitting real time and stored telemetry, except during spacecraft processor reboot.

ID : MRD129

Section : 2.4.4

Title : Spacecraft Telemetry Storage

The spacecraft shall provide on-board storage for at least 7 days of Orbiter housekeeping and science data assuming an aggregate instrument orbit average data rate of 5.8 kbps.

ID : MRD130

Section : 2.4.4

Title : Critical Event Telemetry

For critical events (as defined in GSFC-STD-1000), the spacecraft shall store spacecraft engineering and health data for subsequent playback.

ID : MRD133

Section : 2.4.4

Title : Data Link Anomaly

The instruments shall safe themselves in response to data link anomalies, as documented in the spacecraft-to-instrument ICDs.

ID : MRD137

Section : 2.4.4

Title : Spacecraft Clock Drift

The spacecraft on-board time reference (spacecraft clock) shall drift by no more than +/-100 milliseconds (3-sigma) over seven days.

ID : MRD138

Section : 2.4.4

Title : Spacecraft to Ground Clock Correlation

The correlation between the spacecraft clock and the ground clock shall be less than 15 msec (3-sigma).

ID : MRD144

Section : 2.4.4

Title : Science Data Characterization

The spacecraft shall provide ancillary engineering data that enables correlation of the orbiter's state and environment with the science data.

ID : MRD149

Section : 2.4.4

Title : Unambiguous Orbiter State

The spacecraft shall provide sufficient time tagged engineering telemetry to define an unambiguous orbiter state within 30 minutes of DSN lockup at the minimum telemetry data rate.

ID : MRD152

Section : 2.4.4

Title : Retransmission of Onboard Data

The spacecraft shall provide, by ground command, the capability to retransmit previously transmitted data if that data has not been overwritten by ground command or onboard storage.

ID : MRD153

Section : 2.4.4

Title : Electra Data Volume

Relay Return Link Data

The spacecraft shall be capable of storing 1 GB of Electra return link relay data and delivering that data to the Mars Exploration Program.

ID : MRD154

Section : 2.4.4

Title : Relay Forward Link Data

Relay Forward Link Data

The spacecraft shall be capable of storing 14 MB of Mars Exploration Program forward link relay data and delivering that data to the Electra payload.

ID : MRD156

Section : 2.4.4

Title : Short Frames

The spacecraft shall produce downlink telemetry frame lengths as short as allowed by CCSDS when the downlink rate is 40 bps or lower.

ID : MRD157

Section : 2.4.4

Title : Command/Accountability Verification

MAVEN shall ensure integrity of commands and software loads including patches prior to execution and report information to the ground operators to assess verification of command and software load receipt and execution.

ID : MRD160

Section : 2.4.4

Title : Uplink Loss

MAVEN shall autonomously initiate emergency telemetry in the event that no commands are received within a ground-selectable time period

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ID : MRD163

Section : 2.4.5

Title : Payload Pointing

The Orbiter shall provide the pointing and stability performance, defined in MRD422, within the operational constraints defined in the Design Reference Mission, except during reaction wheel de-saturations, slews, control vector singularities, and entering and exiting solar eclipse.

ID : MRD422

Section : 2.4.5

Title : Payload Pointing

Payload Pointing and Stability Requirements Table

Instrument	Accuracy (3 sigma)		Knowledge (3 sigma)		Stability (3 sigma)		Reference
EUV	1.00 deg	Per Axis	0.15 deg	Per Axis	0.05 deg/10 sec	Per Axis	SC z-axis to Sun
LPW	5.00 deg	Total	4.49 deg	Total	2 deg/64 sec	Total	LPW boom to Sun
SWEA	5.00 deg	Total	2.00 deg	Total	1 deg/64 sec	Total	SC z-axis to Sun
SWIA	5.00 deg	Total	1.00 deg	Total	1 deg/64 sec	Total	SC z-axis to Sun or na
SEP	3.00 deg	Per Axis	1.90 deg	Per Axis	1 deg/64 sec	Per Axis	SC z-axis to Sun
MAG	N/A	N/A	1.43 deg	Per Axis	0.25 deg/1/8 sec	Per Axis	Inertial
IUVS (Limb Scan @ Periapsis)	1.00 deg	Per Axis	0.30 deg	Per Axis	0.06 deg/1 sec 0.15 deg/60 sec	Per Axis	APP i-axis to RAM, k-axis to o
IUVS (Disc Map @ Apoapsis)	3.00 deg	Per Axis	1.00 deg	Per Axis	0.22 deg/15 sec 0.25 deg/15 min 0 5 deg/70 min	Per Axis	APP j-axis to line of apsides, k-axis
IUVS (Stellar Occultation)	0.30 deg	Per Axis	0.30 deg	Per Axis	0 06 deg/1 sec 0.25 deg/4 min	Per Axis	APP j-axis to Star, i-axis paral
IUVS (Inward D/H and O Scan)	3.00 deg	Per Axis	1.00 deg	Per Axis	0 5 deg/1 hr 0.25 deg/15 min	Per Axis	APP i-axis to orbit normal, j-axis perp
IUVS (Outward D/H Scan)	3.00 deg	Per Axis	1.00 deg	Per Axis	1 deg/1 hr	Per Axis	APP i-axis to orbit normal, j-axis perp
STATIC	5.00 deg	Per Axis	1.00 deg	Per Axis	1 deg/64 sec	Per Axis	APP i-j plane to orbit normal
NGIMS	2.50 deg	Total	0.25 deg	Total	0 1 deg/20 sec	Total	APP i-axis to surface-relative ve
Electra	5.00 deg	Total	N/A	N/A	N/A	N/A	Nadir

ID : MRD166

Section : 2.4.5

Title : Momentum Management Delta-V Uncertainty during Cruise

The delta-v uncertainty due to momentum management during cruise (transfer trajectory) shall be less than 1 mm/s (3-sigma) per axis per event. This requirement applies to all predicted values.

ID : MRD417

Section :

Title : Momentum Management Delta-V Uncertainty in Mars Orbit

The delta-v uncertainty due to momentum management in Mars orbit shall be less than 2 mm/s (3-sigma) per axis per event. This requirement applies to predicted values up to 10 days in advance.

ID : MRD167

Section : 2.4.5

Title : Frequency of Momentum Management

Momentum management event shall nominally occur no more frequently than once per orbit during the science and extended mission phases.

ID : MRD168

Section : 2.4.5

Title : Orbit Maintenance - Mapping Phase

MAVEN shall be capable of performing orbit trim maneuvers (OTMs) as frequently as every 7 days

ID : MRD169

Section : 2.4.5

Title : Orbit Maintenance - Deep Dips

MAVEN shall be capable of performing OTMs as frequently as once per day during deep dips

ID : MRD172

Section : 2.4.5

Title : Ephemeris Reconstruction

Positional knowledge of the orbiter shall be reconstructed to within 3 km (3-sigma, 3D), excluding DSN tracking gaps and atmospheric blooming events.

ID : MRD174

Section : 2.4.5

Title : Response to Mars Atmospheric Density Increases

MAVEN shall autonomously respond to unpredicted Mars atmospheric density increases.

ID : MRD178

Section : 2.4.6

Title : Safehold

Spacecraft safehold shall be capable of being maintained for at least 28 days without ground intervention

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ID : MRD181

Section : 2.4.6

Title : Safehold

The spacecraft shall exit SafeHold only by ground command except during MOI.

ID : MRD182

Section : 2.4.7

Title : Delta V

The Orbiter shall provide the delta-V for all translational and rotational propulsive maneuvers required for all mission phases as defined in the Design Reference Mission.

ID : MRD186

Section : 2.4.7

Title : Trajectory Correction Maneuvers (TCM)

MAVEN shall be capable of performing the first TCM anytime after launch plus 8 days.

ID : MRD187

Section : 2.4.7

Title : Late TCM Execution

MAVEN shall have the ability to perform a TCM as late as 6 hours prior to MOI.

ID : MRD188

Section : 2.4.7

Title : Maneuver Orientations

MAVEN shall be capable of executing a Delta V maneuver in any inertial direction, subject to the accommodation of payload sun time-of-travel requirements as stated in the payload ICDs.

ID : MRD189

Section : 2.4.8

Title : Interleaved Communications

MAVEN shall be capable of transmitting real-time housekeeping data and stored orbiter data simultaneously.

ID : MRD192

Section : 2.4.8

Title : Safe Mode Comm Coverage

MAVEN shall autonomously transition to a low-rate telemetry mode capable of supporting recovery operations in the case of any conceivable Safehold condition.

ID : MRD197

Section : 2.4.8

Title : Link Margins

MAVEN shall be meet its uplink and downlink data rate requirements with > 3 dB of link margin.

ID : MRD198

Section : 2.4.8

Title : Bit Error Rates

The Orbiter to DSN link shall have a maximum bit error rate (BER) of 1 x 10-5 for uplink and 1 x 10-6 for downlink.

ID : MRD199

Section : 2.4.8

Title : Modulation and Encoding

MAVEN shall support all modulation and encoding schemes and data rates detailed in the Flight to Ground ICD Document (ICD).

ID : MRD205

Section : 2.4.8

Title : DSN Compatibility

MAVEN shall be compatible with the Deep Space Network (DSN) at X-band as described in the DSN Interface Document JPL 810-005, as tailored by the Flight to Ground ICD Document (ICD).

ID : MRD206

Section : 2.4.8

Title : CCSDS Compatibility

MAVEN shall use CCSDS standards for communications between the space segment and ground segment as described in the Flight to Ground ICD Document (ICD).

ID : MRD208

Section : 2.4.8

Title : Delta Differential One-Way Ranging (DDOR) Capability

MAVEN shall be capable of supporting DDOR for the purposes of ground based navigation during select portions of the Cruise phase.

ID : MRD210

Section : 2.4.8

Title : Combined Electra and X-Band Operations

The Orbiter shall be capable of transmitting simultaneously at X-band (LGA) and Electra UHF

ID : MRD214

Section : 2.4.9

Title : Instrument Thermal Management

Each instrument shall be responsible for managing its operational thermal environment provided that the spacecraft meets the thermal interface requirements specified in the spacecraft to instrument ICDs

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ID : MRD217

Section : 2.4.10

Title : Spacecraft Absolute Time and Relative Time Commands

The spacecraft FSW shall support absolute time commands and relative time commands

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ID : MRD219

Section : 2.4.10

Title : Spacecraft Table Uplink Accommodation

The spacecraft FSW shall accommodate spacecraft and instrument flight table uplinks

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ID : MRD222

Section : 2.4.10

Title : In Flight Software Updates

The spacecraft FSW architecture shall provide for in-flight software updates. It shall be possible to both patch selected FSW tasks and to upload an entire image

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ID : MRD226

Section : 2.4.10

Title : Spacecraft Boot Memory

The spacecraft shall implement a boot memory segment that is non-writable on-orbit in-flight.

ID : MRD231

Section : 2.4.10

Title : Invalid and Restricted Commands

The spacecraft shall prevent the execution of invalid and restricted commands, and safety critical commands without proper enables.

ID : MRD235

Section : 2.5

Title : Sudden Removal of Power

All instruments shall be designed such that the sudden removal of power will not cause damage to the instrument

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ID : MRD239

Section : 2.5

Title : Interface Requirements

All instruments shall conform to the interface requirements contained in the spacecraft to instrument ICDs.

ID : MRD241

Section : 2.5

Title : Commanding

Instrument mode changes during each orbit shall be commanded by a stored sequence

---

ID : MRD242

Section : 2.5

Title : Instrument Health and Safety Out-of-Limits Assessment

The DPU FSW shall detect out-of-limit conditions while monitoring its associated instrument health and safety.

ID : MRD244

Section : 2.5

Title : Boot Memory

The instruments shall implement a boot memory segment that is non-writable in-flight.

ID : MRD246

Section : 2.5

Title : Long-Term Instrument Trending

Instrument teams shall be responsible for long term instrument trending.

ID : MRD247

Section : 2.5

Title : Instrument Calibration At Delivery To ATLO

At delivery for integration to the Orbiter, all instruments shall be sufficiently calibrated to meet their performance requirements

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ID : MRD340

Section : 3.1

Title : LSC Interface with the Flight

The Launch Services Contractor (LSC) shall interface with the Flight Segment as specified in the MAVEN Launch Vehicle Interface Control Document.

ID : MRD347

Section : 4.1

Title : General MOS-GDS Capability

The MOS-GDS shall provide mission management, orbiter operations, data routing and navigation for the life of the MAVEN mission

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ID : MRD348

Section : 4.1

Title : MOS-GDS Interface with the Flight Segment

The MOS-GDS shall interface with the flight segment as specified in the Flight to Ground Interface Control Document (ICD).

ID : MRD351

Section : 4.1

Title : MOS-GDS Single Point Failures

The MOS-GDS shall have no single point of failure for the orbiter operations functions required for critical orbiter operations

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ID : MRD354

Section : 4.1

Title : MOS-GDS Mission Test Support

The MAVEN MOS-GDS shall support spacecraft, instrument, end-to-end and pre-launch test and simulation activities

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ID : MRD355

Section : 4.1

Title : Mission Operations Security

The MAVEN MOS-GDS shall meet the requirements of NPR2810.1A, Security and Information Technology for mission information

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ID : MRD371

Section : 4.3

Title : MSA Interfaces To DSN

The MSA shall interface with the DSN as specified in the MSA to DSN ICD

ID : MRD372

Section : 4.3

Title : MSA Interfaces To The SOC

The MSA shall interface with the SOC as specified in the MSA to SOC ICD

ID : MRD373

Section : 4.3

Title : MSA Interfaces To Navigation

The MAVEN MSA shall interface with the Jet Propulsion Laboratory (JPL) Navigation element for interplanetary navigation and maneuver support activities as described in the MAVEN Operational Interface Agreement Document.

ID : MRD375

Section : 4.3

Title : MSA Interfaces To Instrument Teams

The MSA shall provide a direct interface (i.e., not via the SOC) to each of the instrument package organizations during ATLO as documented in the relevant ICDs

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ID : MRD391

Section : 4.4

Title : Science Data Archive

The MAVEN mission shall archive data in the Planetary Data System (PDS) in accordance with the MAVEN-to-PDS Memorandum of Understanding (MOU)

ID : MRD407

Section : 4.5

Title : Use of Metric Units

The MAVEN mission shall use metric units unless design or manufacturing heritage makes this impractical.

ID : MRD408

Section : 4.5

Title : Use of Non-Metric Units

All uses of non-metric units used on the MAVEN mission shall be documented and approved as a Project waiver request.

ID : MRD419

Section : 4.6

Title : MOS/GDS MCI Frame

The MOS/GDS shall predict the Earth and Sun ephemeris in the MCI frame to within 1 km, per axis, 3-sigma.

ID : MRD420

Section : 4.6

Title : Orbit and SC position

The Nav system shall predict the MAVEN orbit and spacecraft position to within the following accuracies (3-sigma) for at least 9.5 days from the orbit determination cutoff time during nominal science and relay orbits:

* Semi-major axis: +/- 50 km

* Eccentricity: +/-0.025

* Inclination: +/-0.20 deg

* Longitude of Ascending Node: +/-0.04 deg

* Argument of periapsis: +/-0.3 deg

ID : MRD423

Section : 4.6

Title : Orbit and SC position

The Nav system shall predict the MAVEN orbit and spacecraft position to within the following accuracies (3-sigma) for at least 2.8 days from the orbit determination cutoff time during deep dip orbits:

* Semi-major axis: +/- 50 km

* Eccentricity: +/-0.025

* Inclination: +/-0.20 deg

* Longitude of Ascending Node: +/-0.04 deg

* Argument of periapsis: +/-0.3 deg

ID : MRD434

Section : 4.6.1

Title : Coherent Ranging

The MAVEN mission end to end coherent (2-way) ranging data shall provide position accuracy better than 2 m (1 sigma) for a 60 second sampling interval and a range clock frequency of 1 MHz.

ID : MRD435

Section : 4.6.1

Title : X-band Doppler Error (High Sun Angle)

The MAVEN mission end to end coherent (2-way) X band Doppler error for a 10 second sampling interval shall be better than 0.23 mm/s (1 sigma) for Sun Earth Probe angles >= 45 deg.

ID : MRD436

Section : 4.6.1

Title : X-band Doppler Error (Low Sun Angle)

The MAVEN mission end to end coherent (2-way) X band Doppler error for a 10 second sampling interval shall be better than 0.31 mm/s (1 sigma) for Sun Earth Probe angles >=15 deg.

ID : MRD425

Section :

Title : Supportable Relay Contacts During Primary Science Phase

The MAVEN flight and ground segments shall implement a capability to support relay passes at a rate of 1 per sol during the primary science phase if the relay communication link closes, at the direction of the Mars Program Office, and with significant and non-recoverable impact to MAVEN science.

ID : MRD426

Section :

Title : Supportable Relay Contacts After Primary Science Phase

The MAVEN flight and ground segments shall implement a capability to support relay passes at a rate of 4 per sol after the 1 Earth year primary science phase if the relay communication link closes.

ID : MRD427

Section :

Title : End-to-End Return Link Latency

MAVEN shall implement the capability to deliver a user's return link data product to the DSN no later than 90 min after the end of the intended relay service, assuming available DSN coverage and no additional delays due to occultations, and a return link data volume of up to 250 Mb. The 90 minute period is allocated as follows: slew time 20 min, DSN lockup 10 min, downlink duration 20 min, one way propagation delay 25 min, unallocated margin 15 min.

ID : MRD428

Section :

Title : Forward Link File Handling - Number of Products

MAVEN shall support onboard storage of up to 20 individual uniquely-named forward link data products per relay session.

ID : MRD429

Section :

Title : Forward Link File Handling - Product Size

MAVEN shall support cumulative on board storage of individual uniquely-named files not to exceed 1 MB total.

ID : MRD430

Section :

Title : Forward Link File Handling - File Ordering

MAVEN shall provide a file-naming mechanism for specifying the file order and the capability to associate multiple named forward link data products with a specific relay contact and of directing these products to the Electra UHF transceiver for forward link transmission during that pass, without any gaps or fill frames between individual products.

ID : MRD431

Section :

Title : Data Quality - High Value Products

MAVEN shall have the capability to transmit a designated return link relay product to Earth multiple times, storing the product on the orbiter until positive confirmation of complete receipt of the product on the ground is received, in order to achieve enhanced reliability for high-value return link relay products.

ID : MRD432

Section :

Title : Phasing of Orbit Anomaly

MAVEN shall be capable of adjusting its true anomaly to any specified value in the range of 0 - 2 pi, with a time-of-flight accuracy of 60 s, assuming a minimum of 3 months advance notification of the desired true anomaly target.

ID : MRD433

Section :

Title : Compatibility Test Capability

MAVEN shall maintain a spacecraft testbed capability to support ground-based relay compatibility testing and end-to-end relay data flow testing.
