Indefinite Delivery Indefinite Quantity (IDIQ)

Space Flight Systems Development and Operations Contract (SpaceDOC)

Rev: D

Dated: July 15, 2008

Statement of Work

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1. INTRODUCTION

The National Aeronautics and Space Administration (NASA) Glenn Research Center (GRC) implements several space-related programs within the Space Flight Systems Directorate (SFSD). GRC has space flight development responsibility for the Orion service and crew module, the Ares 1-X upper stage simulator, numerous microgravity research investigations on ISS, human research projects, space flight technology developments and demonstrations of advanced power, propulsion, communications and other systems, and the potential for space science instrumentation packages.

This statement of work (SOW) defines the contractor's efforts required to provide performance-based activities in the design, development, analysis, fabrication, assembly, test, verification, delivery, and/or operation of space flight systems. Particular requirements and tailoring of this SOW shall be defined in a Delivery Order issued for each specific deliverable and milestone. The statement of work is structured by the NASA project life-cycle phases as outlined in NHB 7120.5 for NASA Space Flight Programs (Figure 1):

Formulation

- Pre-Phase A Concept Studies
- Phase A Concept and Technology Development
- Phase B Preliminary Design and Technology Completion

Implementation

- Phase C Final Design and Fabrication
- Phase D System Assembly, Integration & Test, and Launch
- Phase E Operations and Sustainment
- Phase F Closeout

Requirements and end-item deliverables for each Delivery Order will be defined based upon the life-cycle phase of the project. The development approach shall be tailored as appropriate to most effectively meet the requirements of the particular deliverable.

Research and Technology Development projects will follow the requirements and guidelines defined in NPR 7120.8 which for the purposes of this statement of work will be similar to the formulation phases of the space flight programs and the appropriate sections will apply (Figure 2).

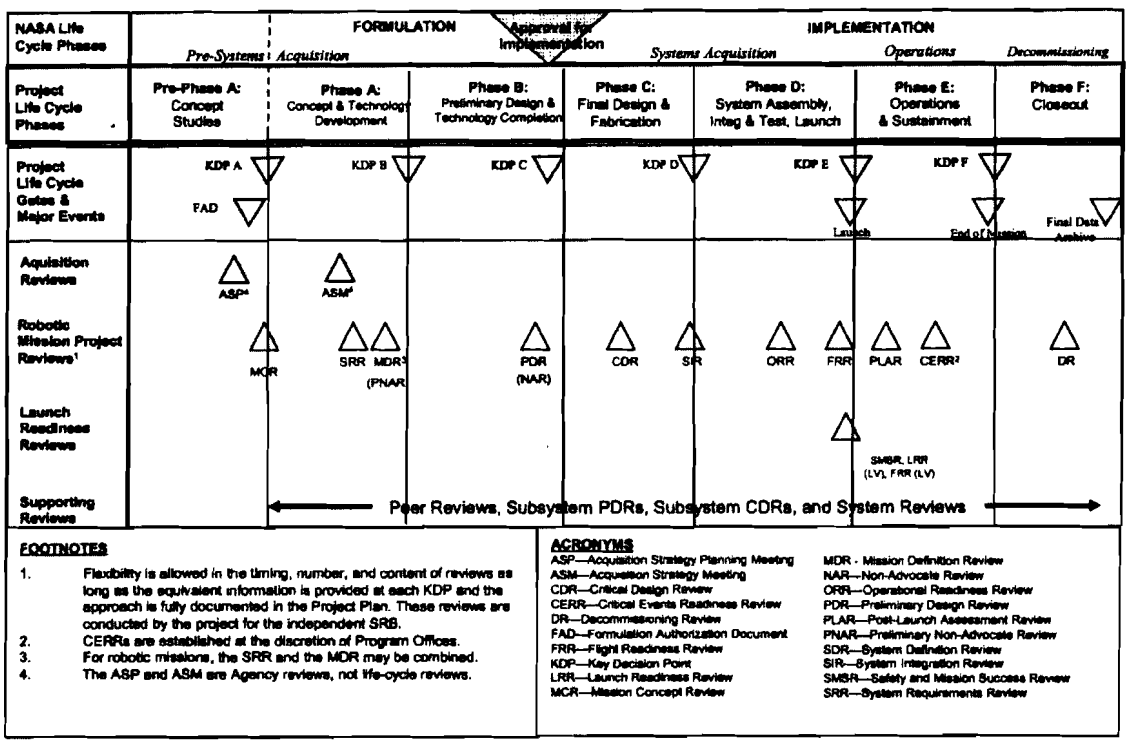

Figure 1 - Typical Project Management Process (Ref: NPR 7120.5D) (Note: Pre-Phase A and Phase A activities are nominally performed by the Government)

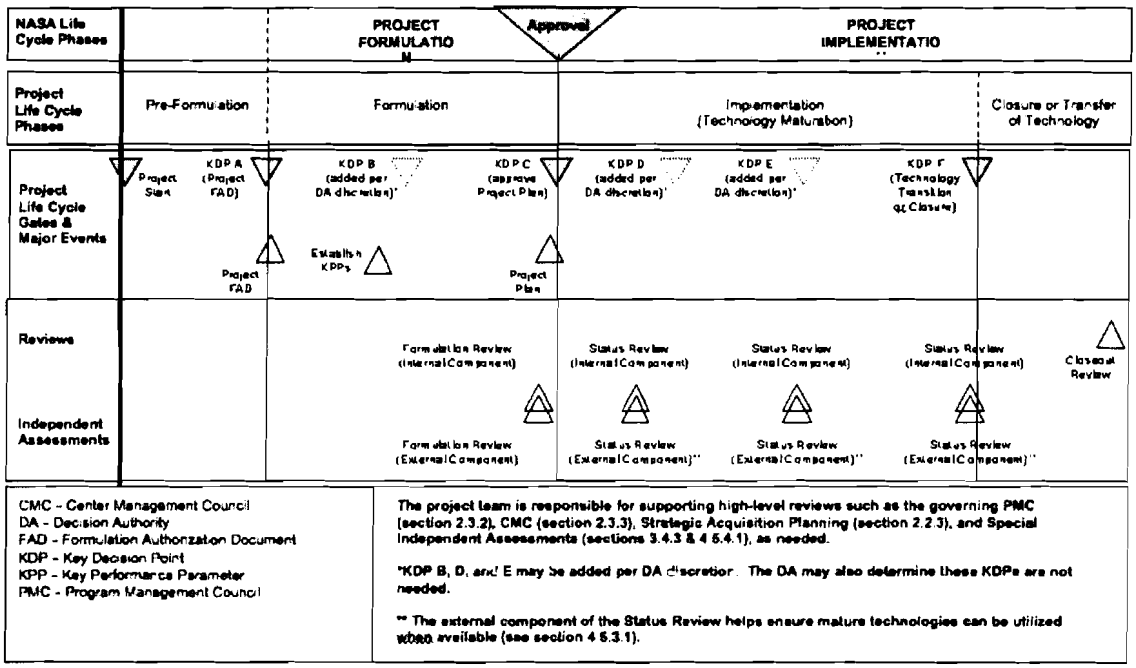

Figure 2 –NASA Technology Development Life Cycle (Ref: NPR 7120.8)

2. SCOPE

The contract encompasses the delivery of space flight hardware, ground support equipment, spares, operational support and research data. As such, the contractor shall be responsible for the design, development, analysis, fabrication, assembly, test, verification, delivery, and/or operation of space flight systems, associated support systems and equipment, and related ground development activities, that include research and technology developments, supporting NASA space flight missions under the Science Mission Directorate, the Exploration Systems Mission Directorate, and the Space Operations Mission Directorate. This content may involve:

1. Non-exploration fundamental research experiments on the International Space Station (and/or other space platforms) to study phenomena in fluid physics, combustion science, material science, bioscience and other microgravity areas and investigate commercial applications;
2. Applied research experiments on the International Space Station (and/or other space based platforms) to accommodate space exploration requirements for, however not limited to, life support systems, power, propulsion, radiation, human health, and energy storage and distribution;
3. Human Research experiments to include exercise countermeasures including advanced concept device development and exercise physiology studies for protocol development, exploration medical capability, physiological computational modeling, and Probabilistic Risk Assessment (PRA) for integrated medical modeling and crew health risk assessment;
4. Crew extravehicular (EVA) power, communications, avionics, and informatics advanced technology development;
5. Acceleration measurement instruments that measure and characterize the acceleration environment of or within space flight systems and/or vehicles;
6. Sustaining engineering and operations of ISS research investigations, facility payloads, EVA systems, acceleration measurement instruments, and space related operations;
7. Flight hardware and software development for the International Space Station (ISS) subsystems, space science satellite and robotic instruments, Space Shuttle, space flight vehicle subsystems, space flight test articles, and space communications systems;
8. Technology development experiments leading to advanced space flight systems in the areas of power, propulsion, in-space propulsion, lunar surface and in-situ resource applications, and energy storage and distribution.

The contractor shall, except as otherwise specified herein and/or in the Delivery Order, furnish all personnel, facilities, materials, services, and other items and functions necessary to complete the work. Acceptance of the work by NASA shall occur upon successful completion of the requirements and deliverables as specified in each Delivery Order, and accepted by the designated NASA Project Manager.

3. APPLICABLE DOCUMENTS

The nature of flight hardware development is such that conformance to various standards and codes shall (will) be specified if required. Those that are applicable will be specified in each Delivery Order. Typical standards and codes, which may be required of the contractor, are the following:

- American Society for Testing and Materials (ASTM International) Standards
- Military Specifications and Standards
- American National Standards Institute (ANSI) codes as sponsored by American Society Of Mechanical Engineers (ASME)
- Department of Transportation Regulations
- NASA Standards and Handbooks
- AS9100 Quality Management Systems – Aerospace - Requirements

NASA has established a set of technical standards that are required for all NASA Space Flight projects. These standards apply for spacecraft, launch vehicles, instruments developed for space flight projects, research and technology funded by and incorporated into space flight projects, critical technical facilities specifically developed or significantly modified for space flight systems, and ground systems that are in direct support of space flight operations. These technical standards are listed in the applicable documents Table 1.

The contractor shall suggest alternatives to these standards if use of alternatives can lead to a better or less costly product that satisfies requirements and regulations. The contractor shall also prepare and/or utilize other applicable documents, not explicitly called out herein, as needed to produce, test, and deploy hardware and software meeting the requirements. The contractor shall be responsible for identifying, acquiring, and properly using such documents. The contractor shall also utilize other applicable documents and efforts, including the performance of tests and analyses not otherwise explicitly stated herein, needed to produce the required flight and ground hardware, software, or support documentation. The contractor shall ascertain the totality of the applicable documents and shall use each in accordance with the document's purpose. In the event of conflicting requirements, the requirements stated in the Delivery Order shall take precedence.

Table 1 identifies the documents that are applicable for any element of work performed under this Contract. Refer to the most current approved version of documents listed below. Table 2 identifies some key reference documents that define NASA's approach to developing and managing space flight and technology development programs.

Table 1: Applicable specification and standards documents for the Prime Contract

Number	Title	Description
GLM.QE.8700.2	Space Assurance Requirements and Guidelines (SARG)	Defines safety, reliability, and quality assurance requirements and guidelines for developers of space equipment within the GRC system.
TBD	*Government Surveillance Plan*	Defines NASA's approach for contract surveillance in-sight activities for product assurance.
NASA-STD-4003	*Electrical bonding for NASA Launch Vehicles, Spacecraft, Payloads and Flight Equipment*	Applies to All NASA human rated and robotic missions.
NASA-STD-4005	*Low Earth Orbit Spacecraft Charging Design Standard*	Applies to All NASA human rated and robotic missions. Does not apply to payloads and hardware for atmospheric or sub-orbital flights. Does not apply to Class D* programs/payloads.
AIAA S-111-2005	*Qualification and Quality Requirements for Space Solar Cells*	Applies to All NASA human rated and robotic missions. Not to include non-space based applications and atmospheric flight vehicles at flight levels below 100K feet.
AIAA S-112-2005	*Qualification and Quality Requirements for Space Solar Panels*	Applies to All NASA human rated and robotic missions.
NASA-STD-6001	*Flammability, Odor, Off gassing and Compatibility Requirements & Test Procedures for Materials in Environments that Support Combustion*	Applies to All NASA human rated missions. All deviations, exceptions, and waivers from the requirements contained in NASA-STD-6001 shall be approved via a Materials Usage Agreement.
NAS410	*National Aerospace Standard Certification and Qualification of Nondestructive Test Personnel*	Applies to All NASA human rated and robotic missions. . All deviations, exceptions, and waivers from the requirements contained in NAS410 shall be approved via a Materials Usage

Number	Title	Description
		Agreement.
NASA-STD-5001	*Structural Design and Test Factors of Safety for Spaceflight Hardware*	Applies to All NASA human rated and robotic missions.
NASA-STD-7001	*Payload Vibroacoustic Test Criteria*	Applies to All NASA human rated and robotic missions. Does not apply to launch vehicles, payloads launched by sounding rockets, aircraft and balloons, and ground support hardware. Does not apply to Class D* payloads.
NASA-STD-7002	*Payload Test Requirements*	Applies to All NASA human rated and robotic missions. Does not apply to Class D* payloads.
NASA-STD-7003	*Pyroshock Test Criteria*	Applies to All NASA human rated and robotic missions. Not to include pryoshock testing of non-space rated vehicles, payloads and transport systems designed for atmospheric flight below 200 K ft.

* Class D as defined in NPR 8705.4, Risk Classification for NASA Payloads

Table 2: Reference documents for the Prime Contract

Number	Title	Description
NPR 7120.5	*NASA Program and Project Management Processes and Requirements*	This document establishes the management system for implementing the management system that governs the formulation, approval, implementation, and evaluation of all Agency programs and projects.
NPR 7120.8	*NASA Research and Technology Program and Project Management Requirements*	This document establishes the process by which NASA will formulate and implement research & technology programs and projects managed or funded by NASA consistent with the governance model contained in NPD 1000.0, *NASA Strategic Management*

Number	Title	Description
		and Governance Handbook.
NASA-STD-3000	*Man-Systems Integration Standards*	
NPR 7123.1A	*NASA Systems Engineering Processes & Requirements*	Establishes the requirements for performing, supporting and evaluating systems engineering
	AS9100 Certification	AS9100 standardizes, to the maximum extent possible, the quality system requirements of the aerospace industry. AS 9100 includes aerospace sector specific requirements to assure the safety, reliability and quality of aerospace products.

4. PERFORMANCE WORK STATEMENTS

The following describes the functional performance work required of the contractor (upon receipt of a Delivery Order) necessary for the successful and on-time implementation to meet the mission-specific Delivery Order requirements.

4.1. MANAGEMENT

The contractor shall provide a management function for the monitoring, control, and reporting of the specific Delivery Order effort. The contractor's management function shall provide to NASA GRC a schedule, with the critical path clearly identified, out to the projected delivery date. The schedule shall be in accordance with the project Work Breakdown Structure (WBS) and reported to the 4th level WBS, unless otherwise specified in the Delivery Order. The contractor shall include within their working schedule the end-to-end integration requirements with the vehicle, carrier or with the integrated system (as applicable). The integration section of the schedule shall be integrated with the schedule of the vehicle, carrier's or integrated system schedule, or, at a minimum, include the appropriate integration milestones and activities with the appropriate vehicle, carrier, or system. The contractor's management function shall provide to NASA reporting and real-time insight into status in accordance with the Contractor Financial Management Reporting requirements (Data Item Description (DID)# CD-01), as well as, technical and performance measurement of all contractor responsibilities and activities performed under the Delivery Order. The contractor shall be responsible for the submission of all change

order proposals (DID# PM-05) as required by this contract. The contractor shall implement appropriate management systems that prevent the improper dissemination of NASA, Government and/or commercial sensitive information. The contractor shall work with NASA to obtain proper classification of documentation prior to dissemination. All contractor and subcontractor internal data, reviews, audits, meetings, and other activities pertinent to the execution of a Delivery Order shall be open to NASA attendance to provide NASA insight. To facilitate NASA attendance the contractor shall provide to NASA reasonable and timely notification of events. The following paragraphs describe detailed requirements for performance measurement, configuration management, property management, and review requirements that apply to all elements.

4.1.1. Cost Reporting/ Earned Value Management

The contractor shall provide NASA with the necessary information to implement the Government Surveillance Plan to monitor product assurance, identify significant problems, and implement corrective action. The contractor shall generate Contractor Financial Management Reports (DID# CD-01) for the contract. Additional Delivery Order specific technical performance measurement requirements may also be identified in the Delivery Order. The contractor shall participate for each Delivery Order in a monthly progress review meeting with the identified NASA Project Manager (Delivery Order technical manager) to review their cost analysis, schedule technical status, issues, and technical interchange to assure understanding of all Delivery Order requirements. The contractor is not required to develop information or deliver data beyond what is normally produced by the contractor in the day-to-day management of the Delivery Order. The contractor shall work with NASA to develop simplified methods to manage the delivery orders using Earned Value Management principles. A simplified approach to EVM shall be in accordance with Earned Value Management Reporting (DID# CD-02) requirements.

4.1.2. Configuration Management

The contractor shall establish a configuration management process to control critical hardware, software, and documentation. The specific process to be used during development and operations of the specific deliverable shall be defined in an overall contract Configuration Management Plan (DID# PM-04), based on the level of hardware and software complexity and vehicle, carrier or integrated system requirements. The contractor shall also implement an engineering control system that shall review and approve changes to drawings, documentation, software design, software code, parts lists, assembly/handling procedures, test procedures and quality procedures once a baseline has been established. Any modifications to requirements or deviations shall be in accordance with DID# PM-05. In some cases, individual

NASA Programs may require the contractor to utilize certain existing databases and software tools managed by the Government for input of design data, status, risk, etc.

The contractor shall have in place procedures to provide traceability of engineering models, prototypes, qualification and flight hardware, software and systems.

4.1.3. Property Management

The contractor shall maintain an inventory of all Government Furnished property and of items purchased for Contract Delivery Orders for both GRC on-site and at contractor facilities per the Property Clauses of the contract. The contractor shall provide NASA with a current inventory list quarterly and be subject to annual audits. During the audits, the contractor shall verify the accuracy of the inventory listing and verify the existence and locations of listed items. All flight hardware shall be identified and controlled based upon the configuration management plan that shall include a bonded storage capability to control the tracking of and physical access to flight and ground support hardware, and any government-owned equipment.

4.1.4. Systems Engineering Management

The contractor shall perform systems engineering processes and procedures in the performance of flight hardware development. The contractor shall have proper procedures and processes in place for the management of the various system engineering functions as define in NPR 7123.1, "NASA Systems Engineering Processes and Requirements." The contractor shall develop a Systems Engineering Management Plan that provides the basis for implementing the technical effort and documents the overall technical approach. A tailored plan will most likely be required that is specific for each flight development project that defines any tailoring and project specific technical approaches.

4.1.5. Reviews

The contractor shall provide engineering, management, documentation and planning support for NASA design reviews required by NASA Headquarters, other NASA field centers and NASA GRC to certify hardware and software maturity readiness. NASA design reviews are based upon the project life cycle defined in NPR 7120.5 and described in NPR 7123.1. The contractor shall also participate in other technical reviews based on the individual Delivery Order, such as Verification and Safety Reviews.

Reviews shall be held at the location specified by the individual Delivery Order. System Acceptance Reviews (Pre-ship reviews) will normally be held at the location of the deliverable equipment so that it may be viewed and inspected prior to shipment.

The contractor shall ensure that appropriate personnel attend each review. The baseline dates for each review and any modifications to the review requirements shall be defined in the Delivery Order to meet unique project requirements. No later than one month prior to each review, the contractor shall develop and deliver a review plan for NASA acceptance. In this plan the contractor shall define the scope and content of the review and identify modifications to the review requirements for more value-added reviews and/or cost reductions. All review presentation packages shall be delivered to the Government for review 10 working days prior to the scheduled review, unless otherwise specified in the Delivery Order. Review presentation packages shall be developed in accordance with DID# D-01, unless otherwise defined in the Delivery Order. Action Items from the reviews shall be generated by NASA and shall require written responses for closure from the contractor within 30 days of receipt of the Engineering Panel or Review Board Report, unless specified otherwise in the DO.

4.2. PRODUCT ASSURANCE

The contractor shall be required to plan, implement and maintain a product assurance system to support all tasks under the Contract. The governing Product Assurance requirements will be defined in the delivery order. Specific NASA Programs may have additional product assurance requirements which will be included in the DO, when applicable. The contractor's product assurance system is subject to periodic review by NASA GRC or its designated NASA representative(s) as defined in Government's Surveillance Plan.

The contractor shall be required to prepare, implement and maintain an overall contract Product Assurance Plan (DID# PA-01) and other documentation or procedures, which assure compliance with product assurance requirements. The contractor shall develop specific plans per the Delivery Order to show how applicable product assurance requirements for individual deliverables will be addressed. Product Assurance Plans shall include system safety, risk assessment, materials and processes, quality assurance, problem reporting and corrective action system (PRACA), reliability and maintainability and software product assurance.

4.2.1. Quality Management

The contractor shall be certified to AS 9100, in the process of becoming certified or, as a minimum, have an established proven effective quality program that is in accordance with FAR 42.202-3 Higher-level Contract Quality Requirements. (e.g. MIL-Q-9858). The contractor's Quality Management system shall be capable of meeting the quality assurance requirements or other program quality assurance requirements of the documents specified in Section 3. The Quality Management system is subject to review as defined in the Surveillance Plan specified in the applicable documents list by NASA GRC or its representative.

4.2.2. System Safety

The contractor shall assure the overall system safety of the design that eliminates, reduces, or minimizes safety risk to an acceptable level. The contractor shall deliver all safety documentation required by and in accordance with the applicable vehicle and/or carrier requirements. The contractor shall support all reviews of this safety documentation. The contractor shall meet the requirements for ground safety operations, as specified by the launch site or work site used for hardware testing and/or processing (e.g. NSTS 1700.7, NSTS 1700.7 Addendum, NSTS/ISS 18798, and KHB 1700.7 where applicable for operations at Kennedy Space Center). Any activity conducted at NASA GRC facilities shall be conducted in accordance with NASA Glenn Safety Manual and the GRC Environmental Programs Manual. The contractor shall impose the above mentioned applicable safety requirements on all subcontractors and suppliers.

The contractor shall provide an overall contract Safety and Health Plan based on DID# PA-11. This plan shall address all hazards related to the work to be performed at GRC, other NASA facilities, and the contractor's facilities, hazardous exposures to workers and GRC personnel, and plans to mitigate these hazards.

4.2.3. Materials and Processes

The contractor shall have a materials assurance process for documenting the Materials and Processes associated with the final design hardware using a Materials Identification and Usage List (MIUL), see DID# PA-06. Materials Usage Agreements shall also be submitted for all materials on the MIUL that are not rated "A" or better per MSFC-Handbook-527. Materials not located in MSFC-Handbook-527 shall be tested per NSTS 22648 for Flammability Configuration, NASA-STD-6001, or NASA-STD-(I)-6016 for all testing. The materials assurance process must provide for certification of all parts and materials for composition and properties as defined by the design criteria. Materials used in applications that can be classified as limited life items, safety critical, and fracture critical shall be traceable through all critical processing procedures up to end-item application. The contractor shall assure NASA that the space flight materials used meets all relevant safety requirements and can be flight certified by NASA.

For hardware developed under the contract, the contractor shall give consideration to materials used in the fabrication of space flight hardware based on the design application and operational requirements. The properties of the candidate materials can be obtained per Mil-Handbook-5 "Metallic Materials and Elements for Aerospace Vehicle Structures" and Mil-Handbook-17, "Polymer Matrix Composites". Material properties that shall be considered include, but not limited to, mechanical properties, fracture toughness, flammability, off-gas characteristics, corrosion, stress

corrosion, thermal and mechanical fatigue properties, thermal vacuum stability, and fluid compatibility. Material codes used for evaluation shall be obtained from MSFC-Handbook-527 "Materials Selection List for Space Hardware Systems". For International Space Station payloads, refer to SSP 30233 "Space Station Material and Processes" for the material assurance requirements. Depending on the vehicle and/or carrier, other program-specific materials requirements may be applicable, e.g. Orion, Ares, and stand alone hardware.

4.2.4. Reliability and Maintainability

The contractor shall perform all the reliability, availability, and maintainability engineering and assurance processes defined in section 7.0 of the Space Assurance Requirements and Guidelines (SARG) document for science experiment projects and payloads on the International Space Station (ISS). All reliability, availability, and maintainability (RAM) engineering and assurance processes and Probabilistic Risk Assessment (PRA) required for projects under the Constellation program shall be performed in accordance with the requirements and processes called out in the Constellation SR&&QA document, RAM methodology document, PRA Methodology document, and Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL) Methodology document.

Hardware and Software shall be designed, assembled, tested, and inspected according to the Program requirements in order to meet the requirements stated in the Systems Requirement Document. The contractor shall be responsible for imposing the RAM requirements on all subcontractors and suppliers and to integrate all subcontractor and supplier RAM products into a comprehensive compliance package as specified in SARG.

For specific Delivery Orders, the contractor shall be required to perform RAM assessments. In addition, the contractor may be required to conduct tests to demonstrate the ability of deliverables to survive mission simulation conditions, be reliable/maintainable in the space environment.

4.2.5. Software Product Assurance

The contractor will be required to assure the management, safety, and control of all flight-related software/firmware (including that used for ground support or mission operations) and the software development process (reference NASA-STD-2201-93). The contractor will be expected to assess the control level of the software and its safety related requirements and level (reference NASA-STD-8719.13A & NASA-GB-1740.13-96). Based on software control level (reference LeR-P-2.10.2 and the GRC Software Development Manual) the contractor will be expected to develop and utilize an overall Software Assurance Plan (DID# PA-10) to assure the management, safety, and control of the software products and the software development process (e.g.,

configuration management, risk management, performance, functionality, safety, reliability, verification & validation processes and non-conformance reporting).

4.2.6. Risk Management

The contractor shall have a risk management process to control critical flight hardware, software, and documentation. Specific attention shall be given to the control of physical and functional interfaces. The specific process to be used by the contractor shall be defined in the overall contract Risk Management Plan (DID# PM-02), based on the level of hardware complexity and carrier requirements. The contractor shall provide a status of the critical risks identified at the Technical Information Meetings or Progress Reviews as defined in the management section.

4.3. CONCEPT STUDIES

The Government shall nominally provide initial system level concept(s) for the Mission Concept Review (MCR) to meet the requirements as defined by the researcher and/or technologist (R/T), identify any engineering feasibility issues and perform key tests that demonstrate the proposed engineering/science requirements can be satisfied. The Government will support the R/T's identification and refinement of the engineering/science requirements by designing and developing bench-top hardware (breadboards) and rigs for laboratory and/or low-gravity ground-based testing. The NASA development phases are defined in 7120.5D for Space Flight Systems and 7120.8 for Technology Development. These requirement documents shall be used as the set of initial requirements for each area of the project cycle. The following sections are provided to emphasize the key areas of activities that will be defined in a Delivery Order for the Concept Studies phase of the project:

4.3.1. Key Activities

The system design and mission analysis are conducted to produce feasible concept(s) that address the requirements and to evaluate potential mission carrier options. The concepts identify possible subsystems that address the project objectives and the key high-risk development areas. The mission analysis may include: technology alternatives, operations scenarios, risks identification, and infrastructure evaluations.

Engineering feasibility issues are identified based on the project requirements to determine a resolution approach and perform initial breadboard level testing as required. Engineering feasibility issues include: fundamental capabilities required to meet project objectives, reduce life-cycle costs, assess technical viability based on current industry capabilities, and assess the diagnostic methods utilized in prior work.

4.3.2. Reviews

The key review for the Concept Studies phase is the Mission Concept Review (MCR), or equivalent, that affirms the mission need and examines the proposed mission's objectives and the concept for meeting those objectives.

4.3.3. Documentation/Deliverables

The key deliverables during this phase of the project shall include but are not limited to a draft set of project requirements and a mission concept report/presentation that defines the project. Breadboard hardware and associated test reports/data from performing risk reduction activities shall also be provided to the Government.

4.4. CONCEPT AND TECHNOLOGY DEVELOPMENT

During this phase, the contractor shall thoroughly define project requirements and provide sufficient detailed definition of the project technical, management, budget, and institutional support plans needed to enable a firm NASA commitment to accomplish the project objectives on schedule and within budget. The outcome of the Concept and Technology Development phase is to establish, through peer-review, that the engineering concept of the project will be sufficient to meet the detailed requirements, the engineering requirements derived from the project requirements have been determined, major feasibility issues have been resolved or feasibility resolution plans established, and the project plan and initial costs have been developed to enable NASA to assess the readiness of the project to enter the preliminary design phase. The NASA development phases are defined in 7120.5D for Space Flight Systems and 7120.8 for Technology Development. These requirement documents shall be used as the set of initial requirements for each area of the project cycle. The following sections are provided to emphasize the key areas of activities that will be defined in a Delivery Order for the Concept and Technology Development phase of the project:

4.4.1. Key Activities

The contractor shall define the fundamental system requirements based on engineering, science, potential carrier, operations, and safety and quality requirements. The contractor shall determine the overall feasibility of the candidate project concept(s) that consider affordability, technology readiness, operations, infrastructure, content, risk, safety, reliability, and potential procurement strategies. The technology readiness assessment shall evaluate the fundamental technology requirements of the project concept to ensure that specified project objectives will be met, project cost or risk will be minimized and identifies where significant technology gaps exist, such that it would be difficult for a concept to be realized.

The contractor shall develop an initial integrated concept of the project that includes the design constraints and interfaces of the recommended carrier (MLM, HTV, ATV, etc), launch vehicle (NSTS, Ariane, H-2, etc), destination, (ISS, Orion, etc.) or next higher-level element. This initial concept shall provide sufficient detail to show the overall feasibility, compliance to the system requirements, integration compatibility, and subsystem level packaging. The integrated concept may require the use of ground integration units or simulators to determine overall feasibility; this need shall be identified to NASA for proper availability for testing.

The contractor shall minimize development risk based on identified engineering feasibility issues through the design and development of breadboards, as appropriate, to evaluate functional performance. Breadboard testing should be focused on determining whether the engineering concept will meet the project requirements. Any concept limitations should be identified and alternate concepts and technologies should be tested in areas where meeting a project requirement may be challenging. The results of the breadboard testing shall be made available for NASA review. Any requirement for additional hardware breadboards of high risk subsystem function(s) or special equipment that are necessary to be performed during the Preliminary Design phase shall be identified and documented in the SDR presentation package (DID# D-01).

The contractor shall formulate an overall engineering plan that defines and details the approach, schedule, hardware classification, and resource requirements, so that programmatic commitments can be made. The contractor shall also provide a life cycle costing analysis necessary to produce the selected concept. Schedule and budget information shall be developed and presented as part of the SDR review package with a rough order of magnitude estimate for the life cycle costs and overall schedule that includes key milestones and an implementation approach to flight. The schedule shall be detailed to the next review milestone and identify the critical path.

4.4.2. Reviews

The key reviews for the Concept and Technology phase are the Systems Requirements Review (SRR) and System Definition Review (SDR). The SRR examines the functional and performance requirements that are defined for the project and ensures that requirements and the selected concept will meet the project objectives. The System Definition Review examines the proposed project formulation and the flow down of the functional elements of the system. The SDR and the SRR are defined in NPR 7123.1A that includes the entrance and success criteria. Any tailoring of these reviews shall be called out in the Delivery Order.

4.4.3. Documentation/Deliverables

The key deliverables during this phase of the project shall include but are not limited to a draft set of project requirements and a mission concept report/presentation

that defines the project. Also, a requirement compliance matrix shall be required for the established baseline concept. The selected concept shall be documented as part of the SDR or in a draft Baseline Concept Description (DID# D-03) document per the Delivery Order. Breadboard hardware and associated test reports/data from performing risk reduction activities shall also be provided to the Government.

4.5. PRELIMINARY DESIGN & TECHNOLOGY COMPLETION

During this phase, the contractor shall develop a preliminary design and technology development that can demonstrate at the system, subsystem and component level compliance to the system and project requirements with acceptable risk. The outcome of the Preliminary Design and Technology Completion phase is to establish, through independent engineering-review, that the proposed engineering design solution for the project is expected to meet the performance and functional requirements at the configuration item level, the design is verifiable and does not pose major problems which may cause schedule delays or cost overruns, all interfaces and verification methodologies have been identified, and all system requirements have been allocated to the subsystem and component level and the flow down is adequate to verify system performance. The NASA development phases are defined in 7120.5D for Space Flight Systems and 7120.8 for Technology Development. These requirement documents shall be used as the set of initial requirements for each area of the project cycle. The following sections are provided to emphasize the key areas of activities that will be defined in a Delivery Order for the Preliminary Design and Technology Development phase of the project:

4.5.1. Key Activities

The key activities during this phase shall consist of establishing the overall system architecture, identifying all the external interfaces, developing an operations concept, developing equipment layouts, developing requirements for flight and ground support hardware and software, producing preliminary drawings, software design, mass properties, interface schematics, and preliminary materials & parts lists. The requirements for the design are defined in the specific Project Requirements Document and System Requirements Document or as identified in the Delivery Order. The contractor shall perform engineering analyses (thermal, dynamic, vibration, optics, etc.) as appropriate in the design of the mechanical, electrical, and system hardware. The contractor shall also develop a software design and initial programming in parallel with the hardware design.

The contractor shall also identify, design and develop/procure any required ground support equipment necessary for the development and/or implementation of the project hardware. This shall include identifying any transportation and handling

considerations that will impose requirements on the flight hardware or support equipment.

The contractor shall minimize system and/or subsystem development risk based on identified engineering feasibility issues through the design, development and fabrication of system and/or subsystem-level mockups, breadboards, brassboards and prototype hardware, as specified by the Delivery Order. The hardware may be required to evaluate form, fit and/or functional performance, as well as manufacturing techniques, to determine overall performance and compliance to the system requirements. Risk reduction hardware development and testing should be focused on the details of the engineering project design in meeting all of the requirements defined in the project's system requirements. Any hardware limitations should be identified and alternate design prototypes should be built and tested in areas where meeting a system and/or subsystem requirement may be challenging. The results of the prototype testing shall be made available for NASA review and incorporated into the final design and if appropriate, the engineering model.

The contractor shall provide assurance that the preliminary design will meet all vehicle and/or carrier safety and verification requirements. The contractor shall perform safety hazard analyses to identify hazards and mitigation methods to assure that the proposed preliminary design does not violate any safety requirements, which will endanger human life or mission success. The contractor shall identify and design any simulators required for training, integration, and operations to support the mission. The identified simulators and concepts for each shall be provided as part of the PDR presentation package.

The contractor shall perform reliability and maintainability analysis where appropriate to assure that the project's preliminary design will meet the mission requirements through reliable subsystems/components and/or through maintenance. Reliability analysis is based on sound methodology and presents realistic predictions for logistics planning and life cycle cost analysis. The results of this analysis shall be part of the PDR presentation package.

4.5.2. Reviews

The key reviews for the Preliminary Design and Technology Development phase are the Preliminary Design Review (PDR) and the Phase 0/1 Safety Review. The PDR demonstrates that the preliminary design meets all system requirements with acceptable risk and within cost and schedule constraints. The PDR establishes the basis for proceeding with detailed design and is a key decision point for the project to proceed. The PDR is defined in NPR 7123.1A that includes the entrance and success criteria. Any tailoring of this review shall be called out in the Delivery Order. The Phase 0/1 Safety Review is dependent on the anticipated carrier/vehicle, such as the

International Space Station and shall conform to that specific review boards requirements.

4.5.3. Documentation/ Deliverables

The contractor shall develop the following set of documentation for this project phase:

- Preliminary Design Review package, per DID# D-01: Charts that shows a mature understanding of the mission objectives and requirements (Packaging, Mechanical, Thermal, Testing of components, electrical, EMI) and preliminary drawings.
- Baseline Concept Description document, per DID# D-03: Preliminary design documented.
- Materials Identification and Usage List (Preliminary), per DID# PA-06: Identify material usage and justify the use of non-A-rated materials (MUA) in space flight hardware.
- Integration Agreement main volume (Preliminary), per DID# R-03
- Software Requirements Document (Preliminary), per DID# R-04: Clearly define the hardware/software interfaces and identify software requirements.
- Design-to Specifications (Preliminary), per DID# R-01: Document that incorporates the project requirements, vehicle and/or carrier requirements, and all interface requirements, including software interfaces.
- Interface Control Document (Preliminary), per DID# R-02: Clearly identified interfaces with the vehicle, carrier, or other element based on the appropriate integration template. The estimated resources required of the vehicle and/or carrier shall also be determined including resource allocation and appropriate margins.
- Master Requirements and Verification Compliance Plan/Matrix (DID# V-01): Compliance with project requirements shall be determined based on the preliminary design.
- Safety Hazard Reports (DID# PA-03)
- Phase 0/1 Safety Compliance Data Package (DID# PA-05)
- Safety Critical Structures Data Package (Preliminary): The safety critical structures shall be identified through analysis and documented.
- Fracture Control Plan (DID# PA-04)
- Fastener Control Plan (DID# PA-16)
- Systems Engineering Management Plan (DID# PM-09): A detailed engineering plan that defines the structure, approach, and processes required to complete the final design, development, fabrication, assembly, and test of the required hardware, software, and associated infrastructure. The engineering plan shall also include a

delivery schedule with the critical path and integration activities clearly delineated.

- Software Management and Development Plan (Preliminary), per DID# PM-03: Provides the overall approach for development of the project software. The plan shall show changes, if any, that differs from the overall contract Software Management and Development Plan.
- Risk Management Plan (DID# PM-02): The key risks shall be identified and approach to manage engineering and project risks.
- Failure Modes and Effects Analysis (Preliminary), per DID# PM-08: An analysis of the potential failure modes of the design to assure that the design is robust to meet the mission requirements.
- Reliability Analysis (Preliminary), per PA-13: A preliminary analysis of the systems reliability shall be determined to show compliance to the system requirements.

4.6. FINAL DESIGN AND FABRICATION

During this phase, the contractor shall develop a final design that can demonstrate at the system, subsystem and component level compliance to the system, vehicle and/or carrier, product assurance, and project requirements, as well as other applicable requirements identified in the Delivery Order. During this phase the contractor begins fabrication of the test and flight components, assemblies, and subsystems. The performance standard for successful completion of this work element occurs upon NASA approval at a Critical Design Review (CDR) and a System Integration Review (SIR). The NASA development phases are defined in 7120.5D for Space Flight Systems. The following sections are provided to emphasize the key areas of activities that will be defined in a Delivery Order for the Final Design and Fabrication phase of the project:

4.6.1. Key Activities

The contractor shall generate complete system build-to specifications and drawings that include hardware and software. Requirement traceability establishing the linkage of all derived requirements shall also be generated. The contractor shall perform, where required, system level analyses and trade studies to optimize the operating design conditions; support the development of the final design; demonstrate overall compliance with requirements; support the verification activities; establish system performance; evaluate thermal, environmental and structural behavior (vibration, loads, etc.); determine reliability and maintainability; and support the integration of developed components.

The contractor shall develop an overall detailed reference design such that all

requirements are achieved, unless specifically waived by NASA. As part of this final design effort, the contractor shall develop overall system schematics, layouts, interface requirements and drawings, ground support hardware, mass properties, volumetric characteristics, re-supply requirements, and resource requirements. The contractor shall develop a system layout showing the relationship of each component or subsystem, the system structure, harnessing, mounts and assembly requirements.

The contractor shall develop a software design and code based on the hardware design and requirements that may also include simulator software, training software and ground support software, based on carrier requirements, hardware requirements, and NASA software development requirements. The contractor shall also develop the software design that includes software simulations and prototyping to eliminate any potential risks, which may hamper software coding, and integration.

If defined in the Delivery Order, the contractor shall minimize development risk through the design, development and fabrication of an engineering model. The contractor shall perform the testing and integration activities associated with the engineering model and/or component, subsystem, and system development required to validate the final design. The results of the testing and integration activities shall be made available for NASA review and incorporated into the final design.

The contractor shall develop a comprehensive verification program that includes plans and procedures to assure that the project hardware and associated software will meet all defined requirements. The Verification Plan(s) shall identify clearly where, how, and when each function and performance requirement is verified in the verification program before launch and, if applicable, how these requirements are again going to be verified on-orbit. The contractor shall provide assurance that the final design will meet all vehicle and/or carrier safety and verification requirements.

The contractor shall assure that all the chosen materials for the hardware design meet safety requirements for corrosion resistance, stress corrosion cracking susceptibility, out-gassing, flammability, fluid compatibility, and off-gassing in habitable areas.

The contractor shall perform an integrated safety analysis of the final design that shows that there are no outstanding hazards, which cannot be controlled or are within an acceptable risk level if waivers are required.

The contractor shall perform the analysis and implementation planning necessary to define, prepare for and execute the operation of the project, including design or development of any equipment required for operations. The project schedule shall include at a minimum hardware and software simulator needs, data sets, integrated testing, turnover activities, operation activities with remote operations facilities, and training activities. The contractor shall prepare the project's operational requirements and plans, operations concepts, mission profiles, mission rules, crew procedures and

timelines, and contingency plans. The contractor shall provide the carrier with required data sets per the carrier's integration template that includes operational requirements, configuration data, training requirements, data services, logistic support, and launch site requirements.

The contractor shall perform the integrated logistic analyses required to formulate optimum spares provisioning and maintenance strategies for the life of the equipment. The transportation and handling of the project hardware and associated ground support equipment shall be identified. The contractor shall also determine the predicted reliability of the system hardware.

Upon completion of the appropriate lower-level CDR, the contractor shall initiate procurement and fabrication of flight article components, assemblies and/or subassemblies. The contractor shall also initiate the qualification and acceptance testing of flight article components, assemblies, and/or subsystems.

4.6.2. Reviews

The key reviews for the Final Design and Fabrication phase are the Critical Design Review (CDR), Systems Integration Review (SIR) and the Phase 2 Safety Review. The CDR demonstrates that the maturity of the design is appropriate to support proceeding with full-scale fabrication, assembly, integration, and test. The CDR is a key decision point for the project to determine if the technical effort is on track to complete the flight and ground system development and mission operations, meeting mission performance requirements within the cost and schedule constraints. Following the successful completion of the CDR, the system is baselined. Subsequent changes will require NASA approval. The SIR ensures that the system is ready to be integrated. Segments, components, and subsystems are available and ready to be integrated into the system. Integration facilities, support personnel, and integration plans and procedures are ready for integration. The CDR and SIR are defined in NPR 7123.1A that includes the entrance and success criteria. Any tailoring of this review shall be called out in the Delivery Order. The Phase 2 Safety Review is dependent on the anticipated carrier/vehicle, such as the International Space Station and shall conform to that specific review boards requirements.

4.6.3. Documentation / Deliverables

The contractor shall develop the following set of documentation and deliverables for this project phase that consists of the following:

- Critical Design Review package, per DID# D-01: Charts that shows a design that meets all requirements.
- Master Requirements and Verification Compliance Plan/Matrix per DID# V-01
- Individual Item Verification Test/Demonstration Procedures, per DID# V-02

- Materials Identification and Usage List (Final), per DID# PA-06: Identify material usage and justify the use of non-A-rated materials (MUA) in space flight hardware.
- Integration Agreement main volume (Final), per DID# R-03
- Software Requirements Document (Final), per DID# R-04: Clearly define the hardware/software interfaces and identify software requirements.
- Software Design Document, per DID# D-06: The software design is documented that describes the interface design, data requirements and architectural design of the software.
- Design-to Specifications (Final), per DID# R-01: Document that incorporates the project requirements, vehicle and/or carrier requirements, and all interface requirements, including software interfaces.
- Interface Control Document (Final), per DID# R-02: Clearly identified interfaces with the vehicle, carrier, or other element based on the appropriate integration template. The estimated resources required of the vehicle and/or carrier shall also be determined including resource allocation and appropriate margins.
- Safety Hazard Reports (DID# PA-03)
- Phase 2 Safety Compliance Data Package (DID# PA-05)
- Safety Critical Structures Data Package (Final): The safety critical structures shall be identified through analysis and documented.
- Fracture Control Plan (DID# PA-04)
- Systems Engineering Management Plan (DID# PM-09): A detailed engineering plan that defines the structure, approach, and processes required to complete the final design, development, fabrication, assembly, and test of the required hardware, software, and associated infrastructure. The engineering plan shall also include a delivery schedule with the critical path and integration activities clearly delineated.
- Software Management and Development Plan (Final), per DID# PM-03: Provides the overall approach for development of the project software. The plan shall show changes, if any, that differs from the overall contract Software Management and Development Plan.
- Carrier specific Data Sets, per DID# R-03. Per the Carrier's integration template schedule.
- Logistics Support Plan, per DID# OP-01

The hardware deliveries will be defined in the Deliver Order and can consist of:

- Mass thermal model for carrier acoustics level testing
- Engineering Model Units

4.7. SYSTEM ASSEMBLY, INTEGRATION & TEST, LAUNCH

During this phase, the contractor shall complete the assembly, test, verification, and delivery of the required hardware, software, and associated integration documentation required for launch. The outcome of the System Assembly, Integration & Test, and Launch phase is to provide an operational system that satisfies the ultimate user. The performance standard for successful completion of this work element occurs upon NASA approval at a Flight Readiness Review (FRR) and a System Acceptance Review (SAR) and/or Pre-Ship Review (PSR) with a Certification for Flight Readiness. Also, an Operational Readiness Review will be held to ensure the system is complete and ready for operations. The NASA development phases are defined in 7120.5D for Space Flight Systems. The following sections are provided to emphasize the key areas of activities that will be defined in a Delivery Order for the System Assembly, Integration & Test, and Launch phase of the project:

4.7.1. Key Activities

The contractor shall complete the assembly and test the flight unit(s) that meets the specifications, quality and product assurance requirements identified in the Delivery Order for the project classification and flight carrier. The flight unit(s) shall be subjected to acceptance test levels and durations with its intended use to be operational in space as defined in the Verification Plan. All integrated testing shall be coordinated with the vehicle and/or carrier and identified on the project schedule.

The contractor may be required to fabricate, assemble, and test a qualification unit to determine flight acceptance verification and compliance with specifications. The qualification unit shall consist of the same systems and subsystems as the flight unit and shall be verified to be physically and functionally identical to the flight unit. The primary function of the qualification unit is to demonstrate through testing to qualification levels that the flight unit design meets all requirements. The qualification unit is not intended for flight unless otherwise specified in the Delivery Order. The qualification unit shall be maintained under the same quality control and configuration management procedures as the Flight Unit.

The contractor shall perform mission and technical integration efforts necessary to assure delivery of a fully functional system (flight and ground unit), which satisfies all applicable vehicle and/or carrier requirements. The contractor shall ensure compatibility of the major subsystems with each other and shall assure compatibility of the total system with all required test facilities, the selected carrier, and the associated transportation system. This effort shall also include development and/or support of the appropriate integration documentation and its annexes (DID # R-03) in accordance with development and delivery of required interface and operational data

in the appropriate vehicle and/or carrier integration format; support of all vehicle and/or carrier integration working groups and panels; and development of required safety, operation, and training documentation. Functional, thermal, fracture control, and fatigue analyses shall be performed as required in accordance with the selected vehicle and/or carrier requirements documents to demonstrate that the hardware design satisfies system requirements.

A Ground Unit may also be required (per the Delivery Order) to be used for ground integration activities, trouble shooting of the on-orbit hardware, and/or the checkout of proposed upgrades to the on-orbit hardware. This unit is typically identical to the flight unit, but may not receive full flight qualification testing.

The contractor shall supply and maintain the spare parts required supporting the flight and ground-based hardware and related equipment as specified in the Delivery Order and the project's Integrated Logistics Support Plan. All fabrication, inspection, checkout, acceptance test, and preparation for delivery requirements, applicable to deliverable hardware and software, shall also apply to the spare items furnished.

The contractor shall develop, verify, validate, and maintain all software necessary to control and utilize the hardware deliverables developed to Delivery Order specifications. The contractor shall install and verify/validate all software necessary for the operation of all developed hardware per the Delivery Order such as the Ground Unit, Qualification Unit, Flight Unit, Trainers, interface verification, ground support equipment, and simulators.

The Contract shall conduct all necessary activities as defined in the Assembly, Integration, and Test Plan to ensure the successful integration of all hardware and software with the selected vehicle and/or carrier. These activities shall be in accordance with applicable vehicle and/or carrier interface documentation to ensure that hardware and software comply with all vehicle and/or carrier payload certification requirements, as well as to ensure that all operational, safety, and reliability requirements are met. Results of this task shall be reported in accordance with the hardware Verification Plan (Certification Certificates). The contractor shall provide calibration, proof testing, dynamic balancing and integrated operation of the project system and functional checkout of fabricated systems and components as specified in the Delivery Order. Specific Delivery Orders may require assembly, installation and system checkout in NASA facilities. The contractor shall inspect all work prior to delivery to insure compliance to requirements.

The contractor shall conduct qualification, acceptance and verification activities (test, analysis, inspections, etc.) on components, subsystems, combined assemblies, and integrated with the carrier. These activities shall be in accordance with the Verification Plan (DID# V-01) to assure that the payload hardware and associated software meets all defined requirements. The contractor shall verify integrated

performance, assembly interactions, and interfaces, as appropriate. Unless furnished by NASA, the contractor shall provide all test support equipment, test fixtures, ground support equipment, and simulators, required in the performance of the verification tests. The contractor shall generate and maintain a requirements management and traceability and close-out system to ensure and document that all design and performance requirements requiring verification are addressed by the verification program and all verification requirements are closed-out. The closeout system shall maintain verification and assessment reports, certification statements, and comprehensive verification reports (DID # V-03). The software shall also be verified and validated based on a Software Verification and Validation Plan (DID# V-04).

The contractor shall provide assurance that the project system meets all vehicle and/or carrier safety and verification requirements. The contractor shall perform an integrated safety analysis and test of the flight hardware that shows that all hazards are controlled or waivers have been approved detailing acceptable risk level.

The contractor shall develop procedures for crew tended, untended, and off-nominal operations with the input and approval of project and carrier representatives, including Flight Safety. The contractor shall deliver any hardware or software required for operations capability as identified in the Delivery Order, such as simulators or data processing equipment to support the mission.

The contractor shall conduct logistics support analyses to determine the support required for pre-flight, flight, on-orbit, return, and post-flight operations of hardware and software integrated in the project. Based on the logistics support analyses and other inputs, the contractor shall provide adequate flight and non-flight spares. The analyses shall include plans for the most efficient physical transfer of flight and non-flight items required supporting the project operations. The contractor shall provide the physical packaging, handling, storage, and transportation of all flight and non-flight items. The contractor shall ensure that the hardware and packaging comply with and satisfy all appropriate Department of Transportation regulations.

The contractor shall develop, in conjunction with specific users, all training materials for the project, including project-specific training unit development as defined in the Delivery Order. The contractor shall develop and support the installation of the project-training unit at the appropriate site for the vehicle and/or carrier, if applicable. The contractor shall work with the flight crew, and the vehicle and/or carrier training organization to develop the requirements for crew training, if applicable. These requirements will drive the design and development for the project training materials. The contractor shall implement the training requirements for the training sessions, for any computer-based training, for part-task trainers, and for on-orbit training. The contractor shall provide project hardware and software training for the appropriate personnel in the operational/functional limitations and capabilities of

the equipment for proper decision-making and development of operational procedures.

The contractor shall be responsible for all ground servicing at the launch site (e.g. KSC) to ensure the successful integration of all project hardware with the vehicle and/or carrier or transportation system. The contractor personnel shall actively participate in the launch processing team activities and shall add/modify requirements, concur on procedures, analyze data, make engineering recommendations and decisions required by conditions not within specifications. The contractor's launch site activities shall be in support of the hardware/software ground operations effort provided by NASA's launch site personnel. The contractor shall develop and implement launch site plans and procedures for the project hardware, support the development of the requirements for testing, servicing, and facility services required to process the hardware through pre-launch activities, monitor tests, evaluate test data, maintain records of the tests, and provide engineering expertise to resolve hardware/software problems, and ensure the project hardware has been properly tested. Following verification of flight readiness, the flight hardware and associated documentation shall be provided to the launch element manager for pre-flight processing and launch.

4.7.2. Reviews

The key reviews for the System Assembly, Integration & Test, and Launch phase are the System Acceptance Review (SAR), Operational Readiness Review (ORR), Flight Readiness Review (FRR) and the Phase 3 Safety Review. The SAR verifies the completeness of the specific end products in relation to their requirements and assesses compliance with stakeholder expectations. The SAR examines the system, its end products and documentation, and test data and analyses that support verification. The SAR (may also be designated a Pre-Ship Review) is a key decision point to authorize the shipment of the system to the designated operational facility or launch site.

The ORR examines the actual system characteristics and procedures used in the system's operation and ensures that all system and support (flight and ground) hardware, software, personnel, procedures, and user documentation accurately reflect the deployed state of the system. The FRR examines the system's readiness for a safe and successful flight or launch and for subsequent flight operations. It also ensures that all flight and ground hardware, software, personnel, and procedures are operationally ready.

The SAR, ORR and FRR are defined in NPR 7123.1A that includes the entrance and success criteria. Any tailoring of this review shall be called out in the Delivery Order. The Phase 3 Safety Review is dependent on the anticipated carrier/vehicle, such as the International Space Station and shall conform to that specific review boards requirements.

4.7.3. Documentation / Deliverables

The contractor shall develop the following set of documentation and deliverables for this project phase that consists of the following:

- Flight Hardware Units w/ Flight Software
- Qualification Hardware Units
- Spare Hardware
- Flight Support Equipment
- Ground Support Equipment
- Simulators
- Training Units
- Integrated Logistics Support Plan, per DID# OP-01: documents the project's ILS approach.
- Individual Item Verification Reports, per DID# V-03.
- Launch Site Operations and Test Procedures, per DID# OP-04.
- System Acceptance Review package, per DID# D-01: Charts that shows the system is ready for acceptance by the Government and open actions for launch.
- Operational Readiness Review package, per DID# D-01: Charts that show the system is ready for operations.
- Flight Readiness Review package, per DID# D-01: Charts that show that all items are closed and the system is ready for it flight/launch.
- Master Requirements and Verification Compliance Plan/Matrix per DID# V-01.
- Acceptance Data Package for the delivered hardware and software.
- Materials Identification and Usage List (Final), per DID# PA-06: Identify material usage and justify the use of non-A-rated materials (MUA) in space flight hardware.
- Software Design Document, per DID# D-06: The software design is documented that describes the interface design, data requirements and architectural design of the software.
- Certificate of Compliance, per the carriers requirements.
- Safety Hazard Reports (Final), per DID# PA-03: Includes verification of safety hazard controls.
- Phase 3 Safety Compliance Data Package, per DID# PA-05
- Software/Operator's Users Manual (Final), per DID# OP-02: Overall guide to using the software by the operator's during Operations
- Carrier/Vehicle specific Data Sets, per DID# R-03. Per integration template

schedule.

4.8. OPERATIONS & SUSTAINMENT

During this phase, the contractor shall support on-orbit integration activities, hardware and software sustaining engineering, flight and data reduction, equipment real-time operations, and data reduction. The outcome of the Operations and Sustainment phase is to operate the project equipment in accordance with the goals and requirements of the project. The performance standard for successful completion of this work element occurs upon achieving the full success criteria for the project as described in the Engineering/Science Requirements Document, or equivalent. The NASA development phases are defined in 7120.5D for Space Flight Systems. The following sections are provided to emphasis the key areas of activities that will be defined in a Delivery Order for the Operations and Sustainment phase of the project:

4.8.1. Key Activities

The contractor shall be responsible for the real-time operations and any supporting activities of the project equipment in conjunction with the vehicle and/or carrier operations per the Delivery Order. The contractor shall provide trained staff for mission support console operations. Appropriate personnel shall be on console when the project equipment is active or other planned operations are being performed. The contractor shall be responsible for on-console support of on-orbit installation & set-up, check-out and verification of the project equipment hardware and software, if applicable; the planning and scheduling of all project equipment on-orbit operations; obtaining or requesting all necessary ground and on-orbit resources; and implementing and following the planned project equipment operations. The contractor shall be prepared to respond to crew and ground team communications, and off-nominal situations. The contractor shall develop procedures to resolve on-orbit problems or anomalies.

The contractor shall provide mission operations support including coordination of real-time project requirements with the PI, the vehicle and/or carrier, and other appropriate entities; acquire and process real-time data according to pre-determined requirements; support the correlation of data with mission events; provide appropriate personnel to support on-console mission operations and data analysis at the carrier's control center; preparation of data products for data dissemination including general and specific mission summary reports; preparation of unique data analysis reports for the project; maintain engineering/scientific information databases; and participate in working group interchanges as defined in the Delivery Order.

The contractor shall be responsible for ground installation & set-up, check-out and verification of the project equipment hardware and software, if applicable; the planning and scheduling of all hardware/software ground operations; and

implementing and following the planned operations.

The contractor shall conduct appropriate analyses, data evaluations, and ground tests to maintain the on-orbit system. This includes the tracking of limited life items for safety and/or mission assurance reasons; incorporating upgrades as required; standard reporting of the on-orbit project equipment performance; developing trend analyses using on-orbit systems reports and other available data; and implementing the project maintenance plan designed to maintain the full operational capability of the equipment.

4.8.2. Reviews

The key reviews for the Operations and Sustainment phase is the Post-Launch Assessment Review (PLAR) and the Critical Event Readiness Review (CERR). The PLAR is a post-deployment evaluation of the readiness of the system to proceed with full, routine operations. The CERR confirms the project's readiness to execute the mission's critical activities during flight operation.

The PLAR and CERR are defined in NPR 7123.1A that includes the entrance and success criteria. Any tailoring of this review shall be called out in the Delivery Order.

4.8.3. Documentation / Deliverables

The contractor shall develop the following set of documentation and deliverables for this project phase:

- Flight Safety Package (updated)
- As-Built Documentation (updated)
- On-Orbit Verification and Validation Reports (DID# V-03)
- Mission Status Reports
- Anomaly Resolution Procedures
- Data Analysis Reports

4.9. CLOSEOUT

During this phase, the contractor shall support the return of data and any returned samples and/or hardware. Also, the contractor shall determine what items need to be archived and which items need to be disposed from the project.

4.9.1. Key Activities

The contractor shall complete analysis and archive mission and science data, archive project data and documentation, document lessons learned, implement the

Decommissioning/Disposal Plan, and dispose all project assets.

4.9.2. Reviews

The key review for the Closeout phase is the Decommissioning Review (DR). The DR confirms the decision to terminate or decommission the system and assesses the readiness of the system for safe decommissioning and disposal of system assets.

The DR is defined in NPR 7123.1A that includes the entrance and success criteria. Any tailoring of this review shall be called out in the Delivery Order.

4.9.3. Documentation / Deliverables

The contractor shall develop the following set of documentation and deliverables for this project phase:

- Decommissioning Plan (DID# OP-10)
- Lessons Learned
- Property Disposition paperwork