

# ATTACHMENT A

## RAPID IV

## RFP

# STATEMENT OF WORK (SOW)

September 11, 2019

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# RAPID IV STATEMENT OF WORK

## 1.0 Introduction

This Statement of Work (SOW) describes the baseline set of requirements for the delivery of a spacecraft via the Rapid Spacecraft Acquisition (RSA) “Rapid IV” contract. The Rapid IV contract serves as a rapid and flexible means for the Government to acquire spacecraft and related components, equipment and services in support of the science and technology missions of the National Aeronautics and Space Administration (NASA). Under the contract, Rapid IV Contractors offer spacecraft and related services to be purchased via Government placed Delivery Orders (DO). The spacecraft designs, related items and services may be tailored, as needed, to meet the unique needs of each mission.

Specific mission requirements will be defined in the DO issued for each mission.

Rapid IV is a Multi-Agency Contract (MAC) and may be utilized by other United States Federal Government Departments and Agencies.

## 2.0 Scope

The Scope of Work encompasses all the required effort from receipt of a Rapid IV DO for a specific mission, through the development, shipment, launch and on-orbit checkout and acceptance of the spacecraft.

Each Rapid IV spacecraft is offered inclusive of the deliverables and services outlined in this SOW. The SOW and mission specific requirements for each mission shall be as defined in the DO issued for that mission. DOs will be issued by the Government in accordance with the ordering procedures contained in the contract. DOs for non-standard services may also be issued by the Government.

### 2.1 Contractor Definition and Responsibilities

For this document, “Contractor” refers to the spacecraft Contractor team to whom the core RSA contract and all subsequent delivery orders are awarded. In order to be considered a Contractor, the spacecraft Contractor must have performed two successful spacecraft developments in which they successfully performed all the work defined by this SOW inclusive of the following:

- a. design, build & test of the spacecraft
- b. integration and test (I&T) of the spacecraft payload-instrument(s)
- c. observatory (spacecraft plus payload) level testing
- d. shipment of the observatory to the launch site
- e. launch site support
- f. launch operations support

- g. on-orbit checkout of the spacecraft
- h. on-orbit checkout support for payload-instrument(s), and
- i. on orbit acceptance review

The Contractor is responsible for all of the aforementioned tasks on all subsequent delivery orders. The Contractor may not delegate the aforementioned tasks to their subcontractors, except for supplying subsystem parts and components. The Contractor should ensure that their subcontractors adhere to all Rapid IV safety and quality performance standards. The Contractor may only offer spacecraft that were developed and deployed by their company.

**3.0 Documents & Requirements**

**3.1 Applicable Documents**

These documents apply directly to the performance required, and contain provisions that constitute requirements of this SOW on the Rapid IV Contract DOs to the degree specified in Section 4.0. All mission specific applicable documents, including but not limited to those listed below, will be specified on each DO.

| <u>Document Title</u>                                       | <u>Doc #</u>       | <u>Rev:</u> |
|-------------------------------------------------------------|--------------------|-------------|
| AS9100 Quality System or ISO 9001 Quality Management System | AS9100/ISO9001     |             |
| Mission Assurance Requirements (MAR)                        | (Mission Specific) |             |
| Mission Spacecraft Performance Requirements                 | (Mission Specific) |             |
| Mission Operations Concept Document                         | (Mission Specific) |             |
| Instrument Interface Requirements                           | (Mission Specific) |             |
| Launch Vehicle Interface Requirements                       | (Mission Specific) |             |

**3.2 Reference Documents**

These documents contain information relating to the work required by this SOW on the Rapid IV Contract Delivery Orders. The mission specific reference documents will be specified on each DO.

| <u>Document Title</u> | <u>Doc #</u>       | <u>Rev:</u> |
|-----------------------|--------------------|-------------|
| (Mission Specific)    | (Mission Specific) |             |

**3.3 Requirements Precedence**

In the event of a conflict in requirements between this SOW and any other referenced document, the requirements of this SOW shall take precedence. Applicable documents take precedence over Reference documents.

## **4.0 Work to be Performed by the Contractor**

### **4.1 Standard Services**

For this contract, the effort to produce a Rapid IV Core Spacecraft and all mission-unique modifications required in the DO, developed in accordance with the related System Performance Verification Program Plan, as defined in the Contract, results in a product called the mission specific “Core Spacecraft.” \*

\* NOTE: Mission Specific Core Spacecraft is also referred to as the “mission spacecraft” in the RFP.

The effort to integrate one or more payload instrument(s) with the mission specific core spacecraft and successfully tested per the DO and System Performance Verification Program Plan results in a system called an “Observatory”. The Observatory shall then be qualified in accordance with the DO and System Performance Verification Program Plan to prepare it for launch and flight operations.

The integration of only one instrument shall be assumed in the baseline effort although more instruments may be required in a mission specific DO.

The complete set of technical requirements as contained in the DO shall be applicable to the Core Spacecraft and the Mission Specific Modifications.

The general term “spacecraft” is used to refer to both the Core Spacecraft and the Observatory.

#### **4.1.1 Core Spacecraft**

The Contractor shall develop, implement, integrate, and test a Core Spacecraft that is ready for payload integration, as well as satisfy all related requirements of Section 4.3., Standard Services Implementation. The Core Spacecraft and its development shall conform to the applicable: a) Spacecraft Performance Specification, b) System Performance Verification Program Plan, and c) Project Control Plan provided by the Contractor with the Rapid IV Core Spacecraft proposal and incorporated in the Rapid IV contract. If applicable, the Core Spacecraft may be modified per Section 4.1.3, Mission Specific Modifications.

#### **4.1.2 Reserved**

#### **4.1.3 Mission Specific Modifications**

In order to meet the unique requirements of a DO for a specific mission, the Contractor may modify their Rapid IV Core Spacecraft. These modifications shall be applied as necessary for the adaptation of the Rapid IV Core Spacecraft and implementation effort under the contract, to meet the requirements of the mission specific DO. The extent of the modifications may include, but are not limited to, the addition of performance parameters; changes to any performance parameter; changes to System Performance Verification Program Plan, and Launch Site Operations and Test Plan; the addition of new specifications, requirements, analyses, tests, reports, hardware, software or support; adaptation of baseline hardware or software configurations; changes to baseline schedules, reviews, funding profiles, and milestones; and the

modification of the contract deliverable items list. This results in a Mission Specific Core Spacecraft. It is expected that in some cases the extent of modifications required to meet the specific mission requirements may be extensive.

#### **4.1.4 Mission Observatory**

The Contractor shall integrate the mission payload-instrument(s) with the mission specific core spacecraft, qualify the resulting Observatory, ship the Observatory to the launch site, provide launch support and flight operations support, perform on-orbit spacecraft checkout, support instrument/payload checkout, conduct on-orbit acceptance review, and satisfy all of the requirements of Section 4.3.

#### **4.1.5 Instrument-Payload Development**

For this contract and all subsequent delivery orders, the Contractor is not responsible for payload-instrument development.

### **4.2 Non-Standard Services**

The Government may issue non-standard service DOs or issue non-standard service tasks or study tasks under an existing DO. The Contractor shall provide all personnel, facilities, materials, and other resources needed to perform non-standard services as ordered under this contract.

Acceptance criteria for Non-Standard Services will be specified in the associated DO.

#### **4.2.1 Mission Specific Non-Standard Services**

Non-standard services ordered under this section shall be directly related to a specific mission under an existing DO. The services ordered and the applicable requirements will be described in the mission specific Request for Offer (RFO) and resulting DO.

Non-standard services may be ordered for the following types of efforts:

- a) Special Studies;
- b) Analyses;
- c) Contractor-provided Mission Operations and/or Network Services including, but not limited to, control and operation of the spacecraft via control centers, flight software maintenance, networks, and/or data processing and storage facilities;
- d) Additional services and facilities in support of a Government Resident Office; and,
- e) Anomaly support after on-orbit acceptance of the spacecraft.
- f) Flight software maintenance after on-orbit acceptance

#### **4.2.2 Non-Mission Specific, Non-Standard Services**

Non-standard services ordered under this section are independent of any mission specific DO, but may address issues associated with possible future missions. The services ordered and applicable requirements will be described in an RFO and the resulting DO.

These DOs may be issued for the following types of efforts:

A. Studies and analyses related to a core spacecraft or to a potential mission spacecraft, which include, but are not limited to: performance capability, modeling parameters, modifications, launch vehicle compatibility, instrument interface and compatibility, integration and testing, launch support and on-orbit checkout.

B. Tasks, including but not limited to: core spacecraft design envelope enhancement, core spacecraft modifications, verification testing, core spacecraft technology update feasibility, and the definition, review and update of processes.

#### **4.2.3 Non-Mission Specific Hardware**

The Government may order flight systems and/or components at a level below an integrated spacecraft, which meet requirements specified in a Non-Mission Specific DO. The flight systems and/or components shall be accompanied with all documentation (e.g. analysis, certifications, and data) that are specified in the Non-Mission Specific DO.

### **4.3 Standard Services Implementation**

This section describes the effort required of the Contractor upon receipt of a DO for Standard Services.

The Contractor shall provide all facilities, services, personnel and other resources necessary for the implementation of all efforts necessary to meet the mission specific DO requirements.

Acceptance criteria will be specified in the Mission Specific DO.

#### **4.3.1 Program Management**

The Contractor shall provide a Program Management (PM) function that is responsible for control and coordination of all activities on each mission specific DO. The PM function shall serve as the central point of contact with the Government for information for all activities under the DO.

The Contractor shall provide to the Government a Project Management Plan consistent with CDRL 21.

##### **4.3.1.1 Government Insight and Surveillance**

The Contractor's PM function shall provide to the Government reporting and real-time insight into program status, as well as, technical and programmatic performance information on all of the Contractor's responsibilities and activities performed under the DO.

Insight is defined as the understanding necessary to knowledgeably concur with the Contractor's actions through watchful observation, inspection, or review of program events, documents, meetings, tests, audits, hardware, etc., without approval/disapproval authority.

The Government will define the specific insight that it requires in each mission specific DO. Should the Government identify non-compliance with requirements, a difference in interpretation of test results or in requirements, the Government will take action to ensure compliance.

The Contractor shall notify the Government Contracting Officer, the Government resident office or the appropriate Government operations organization or personnel of meetings, reviews, operations or tests in sufficient time to permit meaningful Government participation.

The Contractor shall grant access for NASA mission assurance and other representatives to conduct audits, assessments, or surveys upon notice or as otherwise requested by the Government. The Contractor shall supply documents, records, equipment, and a work area within the Contractor's facilities.

In addition to any other Government on site auditing functions, the Contractor shall provide full time office space for a minimum of two Government project representatives from six months after the award of a DO until three months after delivery and acceptance of product.

#### **4.3.1.2 RESERVED**

#### **4.3.1.3 Documentation**

As a mission baseline, the Contractor shall develop, produce, deliver, and maintain all documentation required by the Rapid IV Contract Data Requirements List (CDRL). CDRL items shall be delivered in accordance with Rapid IV CDRL Table 1 and SOW Data Item Descriptions. Each specific mission will identify the CDRLs they require in the mission specific CDRL defined in the DO.

All efforts, including the performance of tests and analyses not otherwise explicitly stated in other parts of the SOW, but determined jointly by the Contractor and the Government to be mission critical, shall be performed and documented by the Contractor.

All documentation, data and analyses generated for, or applicable to, the DO effort, shall be made available to the Government upon request at the Contractor's facility.

#### **4.3.1.4 Spacecraft Project Reviews**

The Contractor shall conduct reviews and provide for timely reporting of project status to the Government. This shall include discussions on problem areas and timely transfer of technical information to the Government, including progress and status on achieving major project milestones and materials required by the Government for systems review and evaluation. The baseline set of reviews stated within may be modified to meet the needs of each specific mission and will be defined in the mission specific DO.

##### **4.3.1.4.1 Project Monthly Status Reviews (MSRs)**

Program MSRs shall be conducted at the Contractor's facility.

At a minimum, the Contractor shall present the following information at the Program MSRs:

1. Status of work being performed including appropriate schedule progress and metrics;
2. Milestone Monitoring - The Contractor shall report on the progress made toward accomplishing each of the planned project milestones. Each report shall include a listing of major accomplishments and a discussion of any problems associated with each milestone as well as their resolution;

3. Changes to design parameters such as weight, power profile, communications, system performance, etc.;
4. Resource allocations and margins (e.g. telemetry, commands, power, weight, data storage, processor capability, etc.);
5. Status of technical issues;
6. Descriptions and status of technical problems and the resolutions;
7. Subcontract technical performance; and
8. Performance assurance status including non-conformance and failure report dispositions.

**4.3.1.4.2 Spacecraft (S/C) Systems Reviews**

The Contractor shall provide technical and management support to certify the Core Spacecraft and Observatory readiness at the following baseline set of spacecraft systems reviews:

| Spacecraft Systems Reviews *                                     | Length (Days) | Location              | CDRL Deliverable |
|------------------------------------------------------------------|---------------|-----------------------|------------------|
| S/C Systems Requirements and Systems Definition Review (SSR/SDR) | 2             | Contractor’s Facility | CDRL 20A         |
| S/C Preliminary Design Review (PDR)                              | 3             | Contractor’s Facility | CDRL 20B         |
| S/C Critical Design Review (CDR)                                 | 3             | Contractor’s Facility | CDRL 20C         |
| Instrument Integration Readiness Review (IIRR)                   | 2             | Contractor’s Facility | CDRL 20D         |
| Observatory Pre-Environmental Review (PER)                       | 2             | Contractor’s Facility | CDRL 20E         |
| Observatory Pre-Shipment Review (PSR)                            | 2             | Contractor’s Facility | CDRL 20F         |
| Observatory Acceptance Review (OAR)                              | 1             | Contractor’s Facility | CDRL 20G         |

\* This list of systems reviews and their requirements may be modified to meet the needs of each specific mission and will be defined in each mission specific DO.

The Contractor shall host and provide data for these reviews.

The Government will chair these reviews and provide Requests for Action (RFAs) to the Contractor for response. The PDR, CDR, PER and PSR will be additionally attended by a Government Integrated Independent Review Team (IIRT). The Contractor shall provide to the Government, for approval, formal responses to all RFAs.

Unless otherwise stated herein or in the CDRL, the Contractor shall provide CDRL submissions to the Government 14 calendar days before the associated review where that CDRL is required per CDRL Table 1.

Each review shall be considered complete when: (1) the Government chairperson for the review provides notice that the criteria for successful completion have been satisfactorily met; (2) all RFAs deemed ‘critical’ by the chairperson have been closed to the Government’s satisfaction and (3) all CDRLs required at or prior to that review have been delivered and found to be

acceptable by the Government. Acceptance by the Government may require that all CDRL item modification recommendations resulting from Government “Review” or required for Government “Approval” have been incorporated by the Contractor. The criticality of RFA’s will be determined and documented by the review chairperson when submitted to the Contractor.

**The above reviews shall form the baseline set of project contract milestones as called out in Sections H.9 (Performance-Based Payment Events and Completion Criteria) and H.10 (Acceptance and Final Payment) of the Contract.** These milestones will be modified as needed for each mission specific DO.

**4.3.1.4.3 Mission Reviews**

In addition to the above reviews, the Contractor shall provide support to various mission reviews. As a baseline, support of the following mission reviews shall be assumed:

| Mission Reviews *               | Length (Days) | Location        |
|---------------------------------|---------------|-----------------|
| Mission Operations Review (MOR) | 2             | Government Site |
| Flight Operations Review (FOR)  | 2             | Government Site |
| Flight Readiness Review (FRR)   | 1             | Launch Site     |

\* A list of reviews and requirements will be specified in each mission specific delivery order.

The purpose of the MOR is for the Government project to provide to the Government Integrated Independent Review Team (IIRT) a comprehensive status of the project’s mission operations planning, including a breakdown of requirements to the various elements and plans for verification and validation of those requirements.

The purpose of the FOR is for the Government project to present to the IIRT the state of readiness of the Flight Operations Ground Systems to support prelaunch, launch and flight operations.

The purpose of the FRR is for the Government project to provide to the launch management the state of readiness for all flight and ground systems to support launch and operations. The FRR is used to determine the final go/no-go decision for proceeding with the launch countdown.

Coordination of these Mission Reviews and of Mission Systems Design Reviews, such as Mission PDR and Mission CDR, shall be as indicated in the DO.

**4.3.1.5 Engineering Change Proposals, Deviations and Waivers**

In accordance with CDRL 12, Engineering Change Proposals (ECP), Deviations and Waivers, the Contractor’s PM function shall be responsible for the timely reporting, submission and negotiation with the Government on all Class 1 ECPs, Deviations and Waivers.

**4.3.2 Systems Engineering**

The Contractor shall perform the necessary systems engineering required to ensure that the core spacecraft, options, and modifications meet all of the performance, interface, and implementation requirements of the mission specific DO.

The Contractor shall supply to the Government a Systems Engineering Plan consistent with the CDRL 22.

The systems engineering effort shall include the analyses and flow-down of technical requirements and allocation of system budgets for the Core Spacecraft, Core Spacecraft options, and mission specific modifications, as well as requirements for GSE and communications links. The effort shall also include definition and maintenance of all interface documents, verification of all defined and derived requirements, technical risk evaluations, system design tradeoff analyses, orbital performance analysis, flight software requirements analysis (see Section 4.3.6, Flight Software) and lower level requirements (e.g. subsystem, components, assemblies, parts).

#### **4.3.2.1 Requirements Analyses and Allocations**

The Contractor shall conduct complete analyses of the mission requirements which fully establish, define, maintain and control system budget allocations.

An appropriately updated index of analyses and allocations shall be maintained by the Contractor. The results of all analyses shall be made available by the Contractor for Government review at each subsequent monthly status review.

#### **4.3.2.2 Interface Definition, Verification and Control**

The Contractor shall specify all interfaces not explicitly defined by the Government. These interfaces shall be defined, documented, verified and controlled for the duration of the DO, by the Contractor.

External interfaces, models, and analysis shall be documented in accordance with CDRL 6. Telemetry and command requirements shall be documented in accordance with CDRL 5.

##### **4.3.2.2.1 Spacecraft/Payload-Instrument Interface**

The Contractor shall document and maintain all design interface information between the spacecraft and the Government provided payload-instrument(s). The Contractor shall prepare the Instrument Interface Control Documents (IICD), as defined in CDRL 2, and shall be responsible for its maintenance and configuration management.

The Government and the Contractor will have signature approval on the IICD.

The Contractor shall provide analytical models and shall perform all analyses and tests required to ensure proper electrical, mechanical, thermal, and operational compatibility between the Core Spacecraft and the Government provided payload-instrument(s).

##### **4.3.2.2.2 Observatory/Ground Operations Interface - Mission Specific**

The Contractor shall participate in the preparation and maintenance of the Flight Operations Ground System Interface Control Document (OPS-ICD). The Contractor shall submit Flight Operations Ground System Interface documentation as defined in CDRL 7.

**The responsibility for writing, configuration management, and gaining approval of the OPS-ICD shall reside with the Government.**

A flight operations readiness end-to-end interface verification test of the Observatory to the Flight Operations Ground System shall be performed by the Contractor prior to the final flight mate to the launch vehicle. The test shall demonstrate commanding and telemetry capability between the Observatory and the Mission Operations Control Center. The Contractor shall perform all analyses and tests required to ensure proper operational compatibility between the Observatory and the Government provided Flight Operations Ground Systems. The Contractor shall develop, maintain and provide all technical and programmatic documentation required to ensure successful operation of the Observatory, including the required data outlined in CDRL 17, Spacecraft Operations Description Manual and CDRL 16, Flight Operations Support Plan.

The Government and the Contractor will have signature approval on the OPS-ICD.

#### **4.3.2.2.3 Observatory/Launch Vehicle Interface**

The Contractor shall participate in the preparation and maintenance of the Observatory-to-Launch Vehicle Interface Control Documents (LV-ICD). The Contractor shall submit Launch Vehicle documentation in accordance with CDRL 8. The Government and the Contractor will have joint signature approval on the LV-ICD.

**The responsibility for writing, configuration management, and gaining approval of the LV-ICD shall reside with the Government.**

A flight ready mechanical fit check and an electrical interface verification test of the Spacecraft to the launch vehicle interface shall be performed by the Contractor prior to the final flight mate to the launch vehicle interfaces. The mechanical fit check and electrical interface verification test shall be performed at the Contractor's location prior to shipment to the launch site.

**The Government, or launch service provider, will supply a test payload attach fitting (or other deployment mechanism) which simulates the launch vehicle side of the interface.**

The Contractor shall provide the analytical models and shall perform all analyses and tests required to ensure proper electrical, mechanical, thermal, and operational compatibility between the Observatory and the Government provided launch vehicle and launch vehicle environments.

**The Government, through the launch service provider, will provide for three (baseline) cycles of Coupled Loads Analysis.**

The Contractor shall develop, maintain and provide all technical and programmatic documentation required to ensure a successful launch activity, including documentation in accordance with CDRL 14, Observatory Launch Site Operations and Test Plan, and CDRL 15, Observatory Launch Site Operations and Test Procedures.

#### **4.3.2.3 Design and Performance Verification Analyses**

The Contractor shall perform and document all analyses of the data and information from the design, qualification testing, acceptance testing, compatibility testing and on-orbit testing of the Contractor's hardware and software that are required to ensure that the program shall meet its specifications and objectives.

#### **4.3.3 Safety and Mission Assurance Management**

The Contractors baseline spacecraft design and associated services shall comply with the requirements of a quality management system that meets the intent of SAE AS9100D Quality Systems - Aerospace - Model for Quality Assurance in Design, Development, Production, Installation and Servicing or an ISO 9001 Quality Management System, or equivalent that encompasses all flight hardware, software, and GSE.

The Contractor shall provide to the Government a Systems Assurance Plan consistent with CDRL 23.

The Government reserves the right to impose other safety and mission assurance standards as mission-specific requirements to meet the needs of a specific mission. These unique requirements will be documented in the mission-specific delivery order.

##### **4.3.3.1 EEE As Built Parts List (ABPL)**

The Contractor shall maintain a program for Electrical, Electronic, Electro-Mechanical (EEE) parts control and supply As Built Parts List (ABPL) information per CDRL 9 to the Government. This requirement shall include subcontracted components parts.

##### **4.3.3.2 Failure Modes and Effects Analysis (FMEA) and Critical Items List (CIL)**

The Contractor shall perform a FMEA and prepare and maintain a CIL for severity categories 1, 1R, and 1S per CDRL#10.

##### **4.3.3.3 Non-Conformance and Failure Reports**

Once the subsystem components begin acceptance testing, a system of written Non-Conformance Reports (NCRs), in accordance with company standards, will be used through launch and in-orbit acceptance. The NCRs will be written for any departure from design, function, performance, testing, or handling requirements that might affect the proper function of the flight system or ground support systems that interface with the flight system. Failure reports shall include risk rating of the problem in order to identify significance. The Contractor shall describe their NCR system in their Systems Assurance Plan.

##### **4.3.3.4 Contamination/Cleanliness Control Program**

The Contractor shall prepare and implement a contamination control program per CDRL 11 and shall monitor for contamination in all areas of the flight hardware development and use and verify the cleanliness of the flight hardware.

##### **4.3.3.5 Orbital Debris Analysis Report**

The Contractor shall assess the potential for spacecraft orbital debris generation and shall assess methods for debris mitigation. The results of this assessment will be reported in accordance with CDRL 19, Orbital Debris Assessment.

#### **4.3.4 Spacecraft Systems Implementation**

The Contractor shall develop and implement a Spacecraft/Observatory Performance Integration and Test Plan in accordance with CDRL 4.

The Contractor shall develop and provide a Spacecraft/Observatory Performance Verification Matrix in accordance with CDRL 3.

##### **4.3.4.1 Core Spacecraft**

The Contractor shall produce and verify the performance of a core spacecraft that meets all of the requirements, specifications, and interfaces defined in the mission specific DO and the mission specific Core Spacecraft Performance Specification (CDRL 1).

##### **4.3.4.2 Core Spacecraft Interface Simulator**

The Contractor shall provide a Core Spacecraft Interface Simulator(s) for use by mission elements for interface verification of the instruments. This Interface Simulator need not be mission specific but may be adaptable by the Contractor to meet the requirements of the mission specific DO. The Contractor shall make the Spacecraft Interface Simulator available to the Instrument supplier as required to support the DO mission schedule for the Instrument development.

##### **4.3.4.3 Core Spacecraft Integration and Test**

The Core Spacecraft design shall be verified by a combination of demonstration, inspection, analyses and test utilizing, as needed, Contractor supplied engineering models, prototypes, proto-flight or heritage flight hardware and software.

Prior to instrument integration, the Contractor shall integrate and test all Core Spacecraft to payload-instrument interface hardware and software. The Core Spacecraft shall undergo a comprehensive test that verifies, to the fullest technically practical extent, the necessary functionality and, performance to demonstrate readiness for observatory level integration.

The Core Spacecraft shall be tested with calibrated and maintained GSE.

The Contractor shall run compatibility testing with the flight operations ground control system as defined in the DO.

##### **4.3.4.4 Observatory Integration and Test**

To the extent defined in the mission specific DO, the Contractor shall plan and conduct integration of the Core Spacecraft and payload instrument(s) to form an Observatory. The Contractor shall coordinate plans and procedures for Instrument Integration with the Instrument representative.

The Contractor shall plan, manage, and execute Observatory level interface verification, system test, environmental test, and support mission payload specific tests as defined in the DO. The Contractor's integration and test program shall include at a minimum:

- 1) Electrical interface testing performed prior to integration of any assembly, component or subsystems into the next higher assembly. At a minimum, pin out configuration, impedance and signal characteristics shall be verified.
- 2) Performance testing performed immediately prior to and immediately after the environmental test program. Performance testing shall verify 100% functionality of all components including redundant systems (if applicable).
- 3) Electromagnetic Compatibility Environmental testing, appropriate for the Core Spacecraft offer, shall be performed to demonstrate self-compatibility of the spacecraft and instrument-payload and compatibility with the launch vehicle and launch site as defined by the applicable specifications for each.
- 4) Thermal vacuum environmental testing, appropriate for the offered spacecraft that demonstrates all spacecraft and payload components function properly over the full range of the flight operational environments.
- 5) An appropriate set of environmental tests to verify spacecraft and its components performance given the expected structural loads and appropriate exposure limits of vibro-acoustic, sine vibration and mechanical shock, and pressure profiles induced during all phases of the mission.
- 6) An end-to-end test shall be conducted with the spacecraft flight operations control center to verify spacecraft compatibility with operations ground system software and hardware.

At no time shall any test, functional or environmental, expose the payload-instrument to environments, signals, loads or other conditions that exceed the limits specified in the Contractor's Instrument Interface Control Document (CDRL 2).

The Contractor shall submit for Government approval a written justification for each analysis that the Contractor plans to perform in lieu of testing and each environmental test or environmental exposure level that the Contractor does not plan to perform.

#### **4.3.4.5 Core Spacecraft/Observatory Storage**

The Contractor shall provide appropriate ground storage for the Core Spacecraft, prior to delivery or instrument integration, and for the Observatory prior to shipment to the launch site, for the time specified in the DO. This activity shall encompass storage, in-storage maintenance, and post-storage activities necessary to bring the Core Spacecraft or Observatory to pre-storage state of readiness. This shall include, but not be limited to, the storage and maintenance of spare parts and GSE. The Contractor shall submit storage related documentation in accordance with CDRL 13. The storage period shall be delineated in the DO. The baseline storage requirement is 0 (zero) days. However, all preparations to perform such storage situations should be included.

#### **4.3.4.6 Shipment of the Core Spacecraft or Observatory and Ground Support Equipment**

The Contractor shall be responsible for the shipment of the Core Spacecraft and Observatory between the places of manufacture, integration and test, storage and launch operations. The Contractor shall provide for all appropriate shipping containers, vehicles, and handling equipment. The Contractor shall provide for the shipment of necessary GSE required to support the Core Spacecraft/Observatory during each phase of assembly, integration and test and launch preparation. Shipping and Handling plans shall be documented in accordance with CDRL 13.

#### **4.3.5 Launch Operations Support**

The Contractor shall provide launch support of the completed Observatory. This shall include launch vehicle interface definition, design verification and management, Observatory launch preparation and launch support. The Government will make the final go/no-go decision for launch. The baseline launch support activity shall include the following efforts:

1. **Launch Site Safety** - Prior to shipment of the Observatory and associated equipment to the launch site, the Contractor shall prepare and provide Observatory related safety documentation as required by the launch site safety and launch range organizations. The Contractor shall submit the Missile Safety Prelaunch Safety Package (MSPSP) as included in the CDRL 8 documents. The Government will provide to the Contractor launch site related information for all Government Furnished Equipment, including the payload-instrument(s), for inclusion in the MSPSP.
2. **Launch Operations Planning** - This effort requires the development and maintenance of interfaces with all entities that play a role in Observatory launch. This involves coordinating, planning and performing all tasks which are necessary to implement a successful launch. The Contractor shall provide technical and management support of meetings to define launch related interfaces.
3. **Launch Simulations** - This effort encompasses the conduct, analyses and evaluation of pre-launch training and launch readiness simulations (through orbit insertion). Two launch simulation tests plus one on-stand (spacecraft mated to the launch vehicle) launch rehearsal shall be conducted.
4. **Pre-launch Integration and Test** - The Contractor shall perform all tasks necessary to integrate, test and prepare the Observatory for launch at the launch site. Hazardous test procedures and other required safety related deliverable documentation shall be provided to the launch range safety.
5. **Launch Operations** - The Contractor shall provide all required integration, safety, and engineering support to process the Observatory through the ground processing facilities, launch site facility and on the launch vehicle. The Contractor shall support the actual launch and post-launch orbit insertion. The Contractor shall perform Observatory initialization, deployments and preparation for on-orbit performance verification testing. All activity will be under Government direction from launch through separation of the Observatory from the launch vehicle.

#### **4.3.6 Flight Software**

The Contractor shall treat the software component of firmware, which consists of computer programs and data loaded into a class of memory which cannot be dynamically modified by the computer during processing (e.g. programmable read-only memories, programmable logic arrays, digital signal processors, etc.) as software for the purposes of this SOW.

##### **4.3.6.1 Flight Software Requirements, Development, Verification, and Testing**

The Contractor shall perform all analyses and systems engineering required to allocate and identify software requirements, and to develop the necessary design specifications. Software requirements traceability to Rapid IV Core Spacecraft and subsystem requirements shall be provided. The Contractor shall also describe the documentation system, source code generation and use, and the methods of maintaining equipment in accordance with CDRL 16, Flight Operations Support Plan.

Requirements, design, and code walkthroughs or inspections shall be conducted at the Contractor's facility at the appropriate points in the software developmental life-cycle to ensure the validity of the requirements, design, and source code. These walkthroughs or inspections shall be open to Government participation. The coding, debugging, developer testing efforts, walkthroughs results and programmer's notes shall be documented and made available at the Contractor's facility for Government review.

##### **4.3.6.2 Flight Software Maintenance**

The Contractor shall maintain the Mission Spacecraft/Observatory flight software (FSW), along with the environments and emulators necessary to develop and verify the FSW, until on-orbit acceptance of the spacecraft.

This requirement may be modified by the DO to require Contractor maintenance of FSW through completion of the mission life. The Contractor shall obtain Government approval before suspending software maintenance operations.

The Contractor shall retain FSW documentation for the complete software lifecycle development until the end of the mission life. This documentation will be used for maintenance of the system and shall be accessible to the Government for review until the end of the mission life.

##### **4.3.6.3 Flight Software Development & Maintenance System (SDMS)**

The Contractor shall provide the necessary ground based hardware, software, procedures, documentation and services to maintain the FSW after on-orbit acceptance. This hardware, software, procedures, and documentation shall be referred to as the Software Development and Maintenance System (SDMS). The SDMS shall contain the hardware platform(s) and software used in development of the FSW, including all simulators, emulators, compilers, debuggers, linkers, test software and procedures/scripts used for test. The SDMS shall contain all tools and utilities required to format executable code for uplink to the spacecraft.

The SDMS shall be delivered in place at the Contractor's facility and operated from there through spacecraft acceptance. The Contractor shall work with the Government in the design

development of the communications links between the SDMS and the Flight Operations Ground Systems.

The Contractor shall maintain a ground reference image of the FSW in use on the spacecraft at the time of spacecraft acceptance. The DO may specify alternate terms for the location and operation of the SDMS.

#### **4.3.6.4 Software Quality Assurance**

The Contractor shall prepare and implement a Software Quality Assurance Plan covering all software used for the Spacecraft/Observatory development.

#### **4.3.6.5 Software Verification and Validation**

The Contractor shall provide all the resources necessary to verify and validate all the software developed for the Core Spacecraft and shall document their process in a Flight Software Verification and Validation Plan.

#### **4.3.7 Flight Operations Interfaces and Support**

Under the baseline effort, the Government will provide the Flight Operations Ground Systems and personnel. The Contractor shall provide support to Flight Operations personnel as indicated below.

The mission specific DO may require that the Contractor provide the systems and personnel to support the Flight Operations through the end of the mission life.

##### **4.3.7.1 Flight Operations Ground System Interface Definition**

The Contractor shall provide Observatory compatibility with the Flight Operations Ground Systems as specified in the mission specific DO.

The Contractor shall work closely with the Government mission engineers to perform communications, command, control and operational requirements trade analyses.

The Contractor shall provide all necessary interfaces to the ground systems as defined in the Observatory requirements documents contained in the mission specific DO. This shall include all necessary system documentation, interface control document inputs, databases and test efforts.

##### **4.3.7.2 Spacecraft Operations Description Manual**

The Contractor shall provide to the Government a Spacecraft Operations Description Manual per CDRL 17 to support the launch and early orbit operations and checkout. The manual shall be of sufficient detail to provide a basis for troubleshooting and isolating spacecraft anomalies by the flight operations team. The manual shall include written and diagrammatic descriptions of the flight hardware, flight component box interfaces and software functionality. Instrument sections will be provided by the Government.

#### 4.3.7.3 Training and Support for Flight Operations Team

The Contractor shall provide support to the mission flight operations team for training and preparations for on-orbit operations and anomaly resolution.

#### 4.3.7.4 On-Orbit Performance Verification

The Contractor shall perform an on-orbit performance verification program confirming that the Observatory performance is in accordance with the mission requirements, the Core Spacecraft Performance Specification (CDRL 1) and interface specifications.

At a minimum, this shall include:

1. Observatory On-Orbit Checkout:

The Contractor shall provide support to the Government in the preparation of on-orbit test and verification procedures. The Contractor shall verify the post-launch performance and state-of-health of the Observatory. To the extent possible, the proper function and performance of all systems shall be verified. The Government will provide payload-instrument performance evaluation support.

2. Observatory to Flight Operations Ground Systems Interface Verification:

This effort shall be performed by the Contractor after the Observatory on-orbit performance and state-of-health have been confirmed. The test shall verify proper operations of the interfaces between the Observatory and Flight Operations Ground System and assure that necessary calibrations are accomplished.

3. OAR and Presentation Package (Reference Section 4.3.1.4.2 and CDRL 20G):

The completed OAR Presentation review package shall summarize the on-orbit Observatory performance through in-orbit checkout. The presentation results shall be used to determine initial mission success and final payment milestone completion status.

In association with the OAR, the Contractor shall provide to the Government an acceptable End Item Acceptance Data Package in compliance with CDRL 18.

#### 4.3.7.5 Support for On-Orbit Operations Anomaly Resolution

The Contractor shall provide support to resolve all on-orbit Observatory anomalies and shall support the resolution of on-orbit anomalies until the end of mission life or as defined in the DO. *The DO may be modified to extend the mission life.*

Baseline support shall be through the period of on-orbit operations verification testing, instrument activation and calibration, on-orbit acceptance and handover to the flight operations team.

*After on-orbit acceptance, in the event of an Observatory anomaly, the Government will modify the DO to address each specific anomaly. (reference Section 4.2.1)*

#### **4.4 Mission Specific Options**

To be specified in the mission specific DO.

*Mission specific options can include, but are not limited to, pre-planned adjustments to the project plan due to changes of the instrument-payload delivery date and adjustments in the timing of the planned launch opportunity.*

**5.0 Government Furnished Equipment (GFE) List**

Mission unique GFE will be specified in each mission specific DO.

| Item # | Deliverable                     | Qty |
|--------|---------------------------------|-----|
| 1      | Mission Flight Instrument (TBD) | 1   |
| 2      | (Mission Unique)                |     |
| ...    |                                 |     |
| n      | (Mission Unique)                |     |

**6.0 Mission Unique Deliverables List**

Mission unique deliverables will be specified in each mission specific DO.

| Item # | Deliverable            | Qty |
|--------|------------------------|-----|
| 1      | Spacecraft/Observatory | 1   |
| ...    |                        |     |
| n      | (Mission Unique)       |     |

**7.0 SOW Acronyms List:**

|         |                                                               |
|---------|---------------------------------------------------------------|
| A/R     | As Required                                                   |
| CDR     | Critical Design Review                                        |
| CDRL    | Contract Data Requirements List                               |
| DID     | Data Item Description                                         |
| DO      | Delivery Order                                                |
| EMC     | Electromagnetic Compatibility                                 |
| EMI     | Electro-Magnetic Interference                                 |
| ESD     | Electrostatic Discharge                                       |
| FSW     | Flight Software                                               |
| GFE     | Government Furnished Equipment                                |
| GSE     | Ground Support Equipment                                      |
| I&T     | Integration and Test                                          |
| ICD     | Interface Control Document                                    |
| IRD     | Interface Requirements Document                               |
| IDIQ    | Indefinite Delivery Indefinite Quantity                       |
| IICD    | Instrument ICD                                                |
| IIRR    | Instrument Integration Readiness Review                       |
| LV      | Launch Vehicle                                                |
| LV-ICD  | Launch Vehicle Interface Control Document                     |
| MAIP    | Mission Assurance Implementation Plan                         |
| MAR     | Mission Assurance Requirements                                |
| MSPSP   | Missile System Prelaunch Safety Package                       |
| MSR     | Monthly Status Review, Program                                |
| NASA    | National Aeronautics and Space Administration                 |
| OAR     | Observatory Acceptance Review                                 |
| OPS-ICD | Flight Operations Ground System ICD                           |
| PDR     | Preliminary Design Review                                     |
| PER     | Pre-Environmental Review                                      |
| PI      | Principal Investigator                                        |
| PSR     | Pre-Ship Review                                               |
| RF      | Radio Frequency                                               |
| RFP     | Request for Proposal                                          |
| RFO     | Request for Offer (Request for Proposal for a Delivery Order) |
| S/C     | Spacecraft                                                    |
| S&MA    | Systems Safety and Mission Assurance                          |
| SDMS    | Software Development & Maintenance System                     |
| SOW     | Statement of Work                                             |
| SPS     | Systems Performance Specification                             |
| SRR     | (Spacecraft) Systems Requirements Review                      |
| TBD     | To Be Determined/Defined                                      |
| TO      | Task Order                                                    |