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## Statement of Work

# Nuclear Thermal Propulsion (NTP) Reactor Interim Design


The INL is a U.S. Department of Energy National Laboratory
operated by Battelle Energy Alliance.

**Idaho National Laboratory**

| **NUCLEAR THERMAL PROPULSION (NTP) REACTOR INTERIM DESIGN** | Identifier: SOW-17948<br>Revision: 0<br>Effective Date: 12/16/2020 |
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## REVISION LOG

| Rev. | Date | Affected Pages | Revision Description |
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# Contents

# 1. INTRODUCTION

## 1.1 Background

Nuclear Thermal Propulsion (NTP) is an attractive in-space propulsion option for exploration missions to Mars and beyond. NTP offers a specific impulse ($I_{sp}$) roughly double that of the highest performing traditional chemical systems.

NTP offers significant advantages for operations in cislunar space and for human Mars missions. NTP could also enable science and exploration missions. NTP can reduce crew exposure to space radiation, microgravity, and other hazards. NTP enables abort modes not available with other architectures, including the ability to return to Earth anytime within three months of the Earth departure burn, and the ability to return immediately upon arrival at Mars.

To date, all nuclear propulsion system designs have derived from reactors fueled by Highly Enriched Uranium. A shift to Low Enriched Uranium (LEU)—defined as a concentration of lower than 20% 235 Uranium (U)—offers several potential advantages for any propulsion system development program. Security regulations for an LEU system would be less burdensome on the project budget and schedule.

Space nuclear propulsion is directly relevant to National Aeronautics and Space Administration's (NASA's) vision, mission, and long-term goal of expanding human presence into the solar system and to the surface of Mars because it provides the fastest trip time of all currently obtainable advanced propulsion systems. Fast trip times will safeguard astronaut health by reducing exposure to zero gravity and cosmic radiation and reduce risks associated with reliability uncertainties inherent in complex systems, as well as those associated with life-limited, mission-critical systems.

## 1.2 Purpose/Objectives

The main objectives of this Statement of Work (SOW) are:

- To mature a prototype reactor to a design level equivalent to 30% fidelity of the final design that demonstrates the design meets project requirements, is technically feasible, completes or identifies appropriate trades, determines performance and design margins for the reactor and subsystems, identifies cost and schedule to complete and test the prototype reactor, identifies risks, and the design and analyses are generally at a level to successfully conduct a 30% Design Review (30%DR), as defined in Appendix A.1; and

- To define the NTP engine system and subsystems fundamental operating and performance requirements and to produce a reactor design down to the subsystem level, including core and reactor subsystem mechanical design. The Subcontractor shall be responsible for refining the reactor subsystem operating and performance requirements that will be integrated with the system-level requirements and controlled by the NASA Systems Engineering and Integration (SE&I) team.

Secondary (follow-on options for information and context) objectives set forth by this SOW are:

- To develop and demonstrate the fuel fabrication process and the reactor fuel element (FE)/tie-tube moderator element (ME) design, or equivalent structures in particle bed or other reactor designs, and fabrication methods to meet the requirements for the reactor subsystem [e.g., thermochemical stability and mechanical integrity for anticipated reactor operating conditions; characterize the performance of full-scale prototype FE and ME to support fabrication technology development and reactor design; and verify fuel integrity in transient power conditions, including during startup, shutdown, normal power fluctuations during control element adjustments, and other potential unanticipated changes in the overall power or specific localized power profile of the reactor (e.g., reactivity insertion accidents.)]; and

- To verify and validate the physics (e.g., neutronics) and performance analytical models using a representative zero power critical assembly, or other type of experimental observation.

### 1.3 Anticipated Benefits

The initial (Phase-1) contract period will lead to the creation of an interim design package that can be used as the basis for future contract phases. These future contracts will produce detailed reactor designs that will culminate in the fabrication and test of demonstration units. Manufacturability and performance of these demonstration units will help mitigate the primary concerns of an in-space nuclear thermal propulsion system.

## 2. APPLICABLE CODES AND REFERENCES

- Executive Order 13834, “Efficient Federal Operations”
- NASA Data Procurement Document (DPD) for NTP Reactor Interim Design
- NASA Federal Acquisition Regulation (FAR) Supplement (NFS) 1852.235-73, “Final Scientific and Technical Reports”
- Space Launch System (SLS) Document, SLS-SPEC-159, Rev. G, “Cross-Program Design Specification for Natural Environments” (DSNE)
- Department of Energy (DOE) Standard Review Plan, “Lines of Inquiry for Design and Engineering Review of DOE Nuclear Facilities” (September 2018)

# 3. SCOPE

## 3.1 Work to be Performed

The Subcontractor shall develop a design of a nuclear thermal propulsion reactor system that has the following characteristics:

- The reactor shall use high assay low-enriched uranium (HALEU) fuel, or uranium fuel with lower levels of enrichment (i.e., U-235 enrichment <20%).
- The reactor shall be compatible with an engine system that uses hydrogen as a propellent.
- The reactor shall be capable of achieving a hydrogen outlet temperature of 2700K, which is consistent with a vacuum $I_{sp}$ of 900 sec.
- The reactor shall use a maximum hydrogen mass flow rate of 6.3 kg/s (13.9 lbm/s), which is consistent with a vacuum $I_{sp}$ of 900 sec and a thrust of 55.6 kN (12,500 lbf).
- The reactor design shall be scalable so that maximum hydrogen mass flow rate can increase up to 12.6 kg/s (27.8 lbm/s), which is consistent with a vacuum $I_{sp}$ of 900 sec and a thrust of 111.2 kN (25,000 lbf) with little or no additional technology development.
- The target mass for all reactor components inside, including the reactor pressure vessel, is 2,500 kg (5,500 lbm). The upper threshold for an acceptable reactor system mass is 3,500 kg (7,700 lbm).
- The reactor shall be capable of maintaining full power thrust for a goal of five hours and a threshold duration of two hours, capable of a minimum of five starts and five shutdowns.

The overall objective of the Phase-1 and future contract phases will be to develop detailed NTP reactor system designs and hardware that can be used in system testing. Phase-1 will focus on development of documentation that can be used to support a 30% design review. A Phase-2 contract focused on development of more detailed design information (i.e., review of a 90% design) and fabrication and testing of a portion of the reactor core using surrogate and nuclear materials may be implemented following the Phase-1 contract. A Phase-2 contract focused on fabrication of two prototype reactors that can be used in non-nuclear and nuclear testing to verify design analyses may be implemented following the Phase-1 contract.

The contract scope emphasis is for the development of a reactor system design that is innovative and capable of achieving the above performance characteristics with a reasonable degree of confidence, but also has a clear path to successful fabrication and testing. The reactor design shall take full advantage of design and fabrication experience achieved during past nuclear thermal propulsion technology development efforts, including past nuclear thermal propulsion technology development and terrestrial power technology development programs, where applicable, and have limited dependence on

low Technology Readiness Level (TRL) technologies. To the maximum extent possible, the design shall be based on systems and materials that have TRLs in the range of 4–6 (i.e., technology demonstration under laboratory conditions to technology prototype demonstration in a relevant environment).

Sections 3.1.1 – 3.1.10 to this SOW describe the Phase-1 contract scope, including deliverables; Section 3.1.11 describes the notional Phase-2 contract scope; and Section 3.1.12 describes the notional Phase-3 contract scope.

### 3.1.1 Propulsion Reactor 30% Design

The Subcontractor shall produce a propulsion reactor design that meets the entry criteria for a 30%DR as specified in Appendix A.1. The design shall include detailed descriptions of all major reactor system components and materials. The design shall target a hydrogen mass flow rate consistent with a vacuum $I_{sp}$ of 900 sec and a thrust of 55.6 kN (12,500 lbf), but it shall be scalable to a thrust of 111.2 kN (25,000 lbf) with little or no additional technology development.

In addition, an estimate of the minimum steady state thrust that can be achieved for a 900 sec $I_{sp}$ design but scalable to a thrust of 111.2 kN (25,000 lbf) with little or no additional risk or technology development shall also be provided.

Key performance parameters for the reactor design are shown in Table 3.1-1.

**Table 3.1-1.** Key Performance Parameters

| Parameter | Threshold | Goal |
|---|---|---|
| Hydrogen Outlet Temperature | 2700 K | * |
| Maximum Hydrogen Mass Flow Rate | 6.3 kg/s (13.9 lbm/s) | * |
| Mass | 3,500 kg | 2,500 kg |

* The threshold values for temperature and flow rate reflect the reactor operating level that will enable an engine thrust of 12,500 lbf and specific impulse of 900 seconds. There is no change to the goal flow rate from that specified in the threshold value, but a goal temperature can be any value greater than the threshold value.

A 30% Design Review shall be conducted near the end of the Phase-1 period of performance.

#### 3.1.1.1 Propulsion Reactor System Requirements Review (SRR)

The SRR examines the functional and performance requirements defined for the system, the preliminary project planning, and ensures that the requirements and the selected concept will satisfy the mission. In addition to deliverables described in other sections of this SOW, the Subcontractor shall deliver:

- Reactor Supportability Analysis (Data Requirements Description (DRD) SNP1LS-004)
- Systems Engineering Management Plan (DRD SNP1SE-001)
- Verification and Validation Planning (DRD SNP1VR-001).

#### 3.1.1.2 Propulsion Reactor 30% Design Review (30%DR)

The 30%DR demonstrates that the reactor design meets all system requirements with acceptable risk and within the cost and schedule constraints and establishes the basis for proceeding with detailed design. In addition to deliverables mentioned in other sections of this SOW, the Subcontractor shall deliver:

- Specification, Drawing, and Documentation Trees (DRD SNP1CM-009)
- Structural Strength and Fatigue Analysis Reports (DRD SNP1DE-010)
- Technical Performance Report (DRD SNP1MA-011)
- Materials Identification and Usage List (DRD SNP1MP-005)
- System Safety Plan (DRD SNP1SA-001)
- System Connectivity Diagrams and End-to-End Functional Schematics (DRD SNP1SE-009).

### 3.1.2 Interim Reactor Performance Analyses

The Subcontractor shall provide detailed thermal (in accordance with DRD SNP1DE-009, Thermal Design Data Book), structural (in accordance with DRD SNP1DE-007, Structural Dynamics Analyses, Loads, and Models Documentation), and neutronic modeling and simulation analyses developed to demonstrate the interim design's ability to meet or exceed the threshold performance requirements identified in Table 3.1-1. Estimates of excess reactivity during various stages of reactor operation, estimates of maximum temperatures, pressures, and stresses of key components, and discussion of margins shall be included in the analyses. The analyses shall also include a discussion of predicted reactor startup and shutdown neutronic, stress, and thermal transients, and any systems considered necessary for preventing inadvertent criticality during a launch accident (e.g., submersion criticality safety systems).

### 3.1.3 Reactor Manufacturing Plan

The Subcontractor shall provide a detailed manufacturing plan for fabricating and assembling the reactor that:

- Identifies the processes that will be used to fabricate the reactor prior to final build-to package release.
- Describes critical assembly processes including mounting and support of the core.
- Describes major steps in the reactor assembly process that will need to be followed in order to align core components.
- Identifies critical manufacturing processes that may be required and discusses maturity of the processes.
- Identifies required manufacturing and assembly facilities and identifies new facilities or equipment that will need to be built to support reactor manufacturing and assembly.
- Discusses availability of existing fabrication and assembly equipment and facilities.

### 3.1.4 Reactor Mass Estimate

The Subcontractor shall provide a detailed listing of the predicted masses of components included in the reactor design. The major reactor components that should be part of the mass estimate include:

- Reactor fuel materials
- Reactor moderator materials
- Other required core components such as insulator materials, structural support materials, hydrogen flow tubes, other
- Hydrogen inlet and outlet plenums
- Reflector
- Control drums
- In-core instrumentation and control systems
- Control drum drive mechanisms (if located inside the reactor pressure vessel)
- Pressure vessel
- Criticality safety systems (if included in design).

Options for reducing the estimated masses, while still achieving the threshold performance characteristics shown in Table 3.1-1, shall be discussed.

### 3.1.5 Reactor/Engine Interfaces

The reactor and engine interface shall be based on an expander cycle hydrogen flow design. The Subcontractor shall describe major interfaces between the reactor system

and engine system, and the description shall be consistent with expander flow cycle requirements. At a minimum, the description shall include discussion of the proposed hydrogen flow pathway through the reactor, major reactor design features that are required to establish and control hydrogen flow, an interim power balance, and discussion of turbopump and nozzle design requirements. The description shall also include a discussion of aspects of the hydrogen flow system that are most likely to cause issues with reactor operation and would therefore require testing to demonstrate acceptable performance.

### 3.1.6 Reactor Instrumentation and Control

The Subcontractor shall provide a description of the major sensors and data collection systems that will be incorporated in the interim reactor design. The description shall differentiate between sensors and data collection systems that shall be included in ground testing, flight testing, and mission operations. This activity also includes development of a study that uses design reactivity coefficients, control drum worths, predicted ranges of hydrogen flow, and other important reactivity variables to predict how reactor power will respond across the full range of expected operational conditions. The purpose of this analysis will be to provide information that supports development of a system that safely controls the reactor and engine systems when they are linked together.

This task is for development of the control algorithms and instrumentation concepts only, and not the specific reactor controller or engine controller. The algorithms should be of sufficient fidelity to be utilized in special test equipment (STE) used in the Phase-2 and Phase-3 contracts periods to control the test articles.

### 3.1.7 Propulsion Reactor Test Plan

The Subcontractor shall provide a detailed plan for integral and component-level testing of the reactor systems. The plan shall provide enough data to satisfy a NASA-integrated nuclear engine technical review, which includes the reactor and the non-nuclear engine components. An emphasis shall be placed on use of existing testing facilities, where possible, or relatively minor modifications to existing facilities, when required. Information about the availability of the proposed testing facilities during the time periods when components to be tested are expected to be available shall be included in the testing plan. Information about criticality control safety measures that will be incorporated in the prototype reactor design and testing procedures shall also be included in the testing plan.

### 3.1.8 Reactor Cost and Schedule Estimates

The Subcontractor shall provide detailed cost and schedule estimates for the reactor system design, fabrication, assembly, and testing activities. The cost estimate shall be based on the work breakdown structure defined in the Phase-1 contract. The estimate attributes shall include the following for each category:

- Materials
- Labor
- Facility
- Subcontracts to other suppliers.

The schedule estimate shall include major milestones, a critical path analysis, and estimates of float for all major manufacturing, assembly, and testing activities.

A demonstration of the Subcontractor's cost and schedule performance measurement and reporting system shall be performed in the Phase-1 contract period. The Subcontractor's cost and schedule performance shall be reported as specified in the Integrated Program Management Report (DRD SNP1MA-017).

### 3.1.9 Technology Readiness Assessment

The Subcontractor shall provide a technology readiness and advancement assessment of all major reactor system components. The assessment shall describe current component readiness and provide a plan for advancing component readiness to the level needed for a potential NTP reactor demonstration (TRL 6). Innovative reactor designs that meet or exceed performance goals are encouraged, but such designs must demonstrate an acceptable Advancement Degree of Difficulty and have a plan for rapidly demonstrating significant progress towards achieving TRL 6 for all major reactor system components. Major risks associated with technology advancement shall also be discussed in the assessment.

The Technology Readiness Assessment shall be a part of DRD SNP1DE-004, Reactor Development Plan.

### 3.1.10 Quality Assurance Plan

The Subcontractor shall provide a description of the proposed nuclear quality assurance requirements applied during fabrication and testing of the space reactor system. The intent of this activity is to begin the process of gathering industry input on necessary quality assurance requirements for fabrication and testing of space propulsion reactors. The activity is not meant to imply that quality assurance for space reactors will follow the same requirements that have been developed for terrestrial

reactors. However, the plan shall include a discussion of which, if any, terrestrial quality assurance requirements would be beneficial to space reactor development.

### 3.1.11 PHASE-2: Surrogate Unit Cell Fabrication and Reactor Detailed Design

The scope described in this section will be initiated by the Battelle Energy Alliance, LLC (Contractor) as Phase-2 if at least one Subcontractor design package, discussed in Sections 3.1.1 through 3.1.10, meets Contractor design requirements. Scope for the Phase-2 contract shall not be priced as part of the Phase-1 contract proposal; a follow-on request for proposals will be issued by the Contractor to gather information about Phase-2 contract proposals. The notional timing for Phase-2 contract award would be approximately two months after the end of the Phase-1 contract for a performance period of 22 months. The following discussion is provided to help prepare for the Phase-2 contract proposal process. The Subcontractor is not required to address its approach to Phase-2 as part of the Phase-1 contract proposal but is not precluded from doing so.

The Subcontractor shall produce a detailed propulsion reactor design that meets the entry criteria for a 90% Design Package (90%DR) as described in the DOE Standard Review Plan: Lines of Inquiry for Design and Engineering Review of DOE Nuclear Facilities (September 2018). The design shall build on the 30%DR package submitted during the Phase-1 contract and shall include detailed descriptions of all major reactor system components and materials.

In addition to the 90%DR package, the Subcontractor shall fabricate a unit cell of the reactor core or propose fabrication of some other set of reactor core components that will demonstrate the ability to manufacture complex nuclear core components. The manufacturing test demonstrator shall include one or more FEs, one or more MEs (if a thermal reactor design is proposed), and any structural components needed to provide support to the core. The fabricated unit cell shall include all the proposed core geometries (e.g., number of hydrogen flow channels), it shall be built to at least one-half scale of the proposed design, and it shall represent the smallest portion of the proposed core design that has geometric symmetry with the remainder of the core. Reflectors and reactivity control devices do not need to be included in the fabricated unit.

The unit cell, or other prototype, shall be fabricated using processes that are the same as, or very similar to, the processes discussed in the proposed manufacturing plan. The steps, costs, and activity durations used to fabricate the unit cell shall be documented for use in validating information presented in the proposed manufacturing plan.

A nuclear test of the unit cell or other prototype shall be performed to demonstrate performance of the test unit in a combined effects environment. The testing shall demonstrate the test specimen’s ability to withstand Space Nuclear Propulsion (SNP)

prototypic temperatures and temperature ramp rates produced by fission heating during exposure to flowing hydrogen. Facilities that could host the unit cell test include the Transient Reactor Test facility at the Idaho National Laboratory, the High Flux Isotope Reactor at Oak Ridge National Laboratory, or another suitable test reactor, and the testing could be performed under a DOE authorization basis. The demonstration test shall be performed before the end of the Phase-2 contract period, assuming the selected test reactor can support the contracting schedule, or as soon as feasible after the end of the Phase-2 contract period if the test reactor cannot accommodate the contracting schedule. Non-nuclear testing of the unit cell could also be performed to demonstrate unit cell performance under operational conditions that cannot be tested using existing nuclear testing infrastructure. The unit cell or other prototype testing shall be included in the proposed test plan and cost and schedule estimates. A report detailing all important testing steps, data collected during the test(s), and conclusions developed from the test results shall be written and submitted to the Contractor as a contract deliverable.

### 3.1.12 PHASE-3: Unfueled and Fueled Reactor Prototype Fabrication

The scope described in this section will be initiated by the Contractor as Phase-3 if at least one Subcontractor 90%DR package discussed in Section 3.1.11 meets Contractor design requirements and fabrication and testing of the unit cell or other prototype are successful. Scope for the Phase-3 contract does not need to be priced as part of the Phase-1 contract proposal; a follow-on request for proposals will be issued by the Contractor to gather information about Phase-3 contract proposals. The notional timing for Phase-3 contract award would be approximately two months after the end of the Phase-2 contract for a period of performance of 18 months. The following discussion is provided to help prepare for the Phase-3 contract proposal process. The Subcontractor is not required to address its approach to Phase-3 as part of the Phase-1 contract proposal but is not precluded from doing so.

#### 3.1.12.1 Unfueled Reactor Prototype

The Subcontractor shall fabricate and assemble an unfueled prototype of the reactor system that includes natural or depleted uranium FEs and all other major components of the reactor fabricated out of design materials or surrogate materials that have physical properties similar to the design materials. The prototype shall be suitable for non-nuclear testing with flowing hydrogen and other gasses to support measurements of hydrogen pressures, structural integrity, vibrational properties, and other physical characteristics of the reactor system. Assembly of the prototype shall be documented, and a detailed assembly procedure shall be developed, to assist with communication of the reactor assembly process.

The unfueled reactor system prototype shall be fabricated using processes that are the same as, or very similar to, the processes discussed in the proposed manufacturing plan. The steps, costs, and activity durations used to fabricate the reactor prototype shall be documented for use in validating information presented in the proposed manufacturing plan.

Engine system components (e.g., turbopumps, nozzles, other) do not need to be included in the unfueled reactor prototype, but connections to these components shall be sized and positioned to be consistent with a viable 55.6 kN (12,500 lbf) thrust engine design.

Instrumentation and instrument connections shall be included at points within the reactor prototype to assist with prototype testing. The instruments shall be positioned in locations that will produce representative data for major system components and in locations that are predicted to have the most limiting physical characteristics. The instrumentation included in the prototype shall be suitable for measuring gas flow pressures and temperatures, and structural characteristics such as vibration.

The unfueled reactor prototype could be made from surrogate materials that have non-nuclear characteristics similar to the proposed core materials as long as the surrogate materials are suitable for use in testing at proposed operational temperatures and pressures. The testing shall be performed at one or more Contractor facilities, or with Contractor oversight at one or more Subcontractor facilities, and the testing description shall be included in an update to the test plan and cost and schedule estimates produced during the Phase-1 contract. A report detailing all important reactor prototype testing steps, data collected during the test(s), and conclusions developed from the test results shall be written and submitted to the Contractor as a contract deliverable.

At the Subcontractor's option, an interim fueled reactor prototype could be substituted for the unfueled prototype, so that the initial prototype will serve as a demonstration of all processes that will be used to manufacture the final fueled reactor prototype. Regardless of whether the interim reactor prototype is fueled or unfueled, the interim prototype could be used as a source of spare parts for the final fueled reactor prototype after the initial prototype has been inspected and tested in accordance with the proposed test plan.

#### 3.1.12.2 Fueled Reactor Prototype

The Subcontractor shall fabricate and assemble a reactor prototype fueled with HALEU that includes all elements of the reactor contained within the reactor pressure vessel. The fueled reactor prototype shall be suitable for use in nuclear

testing of the reactor designed for demonstration of the ability to control the reactor under a variety of normal operation and accident conditions.

The fueled prototype shall be similar in design and manufacturing to the unfueled reactor prototype that will also be produced during the Phase-3 contract period. Once again, the reactor system prototype shall be fabricated using processes that are the same as, or very similar to, the processes discussed in the proposed manufacturing plan. The steps, costs, and activity durations used to fabricate the reactor prototype shall be documented for use in validating information presented in the proposed manufacturing plan.

Engine system components (e.g., turbopumps, nozzles, other) do not need to be included in the fueled reactor prototype, but connections to these components shall be sized and positioned to be consistent with a viable 55.6 kN (12,500 lbf) thrust engine design.

Instrumentation and instrument connections shall be included at points within the reactor prototype to assist with prototype testing. The instruments shall be positioned in locations that will produce representative data for major system components, and in locations that are predicted to have the most limiting physical characteristics. The instrumentation included in the prototype shall be suitable for measuring gas flow pressures and temperatures, and structural characteristics such as vibration.

The fueled reactor prototype shall be made from materials specified in the reactor design, and it shall be suitable for use in nuclear testing at proposed operational temperatures and pressures. Non-nuclear testing of the prototype could also be performed to demonstrate reactor performance under operational conditions that cannot be tested using existing nuclear testing infrastructure. The testing shall be performed at one or more Contractor facilities under a DOE authorization basis. The testing and modifications to existing Contractor facilities required to support the prototype testing shall be included in an update to the test plan and cost and schedule estimates produced during the Phase-1 contract period. A report detailing all important reactor prototype testing steps, data collected during the test(s), and conclusions developed from the test results shall be written and submitted to the Contractor as a contract deliverable.

The fueled reactor prototype is intended to be integrated into an engine system for demonstration.

## 3.2 Work Excluded

Development of the Reactor to Engine System Interface Control Document (ICD) will be led by the Government. The ICD will be incorporated into this SOW as Attachment A,

via future revision. The Subcontractor will be given an opportunity to provide comments and recommended changes to the ICD during the performance of the Phase-1 contract.

### 3.3 Requirements

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### 3.4 Place of Performance

Work may be performed at the Subcontractor's facility with periodic reporting at the Contractor or at NASA facilities. Work that must be accomplished at the Contractor's facilities shall be documented in a negotiated Government Task Agreement. Specific tasks that are negotiated to be performed by DOE laboratories or NASA field centers may be performed at those sites, in accordance with the Organizational Conflict of Interest (OCI) Mitigation Plan in Attachment C.

### 3.5 Interfaces

DOE laboratories and NASA field centers are not permitted to team with private sector companies to perform the scope of work under this contract; however, DOE and NASA may perform specific tasks, in accordance with the OCI Mitigation Plan in Attachment C.

### 3.6 Miscellaneous

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## 4. DELIVERABLES

The Subcontractor shall be responsible for both performance-based deliverables and routine deliverables, briefings, and reports, as shown in Tables 4.1-1 and 4.1-2, respectively. Performance-based deliverables are key products unique to this contract. Routine deliverables are standard reporting products, data packages, and meeting notes.

**Table 4.1-1.** Performance-Based (PB) Deliverables—Phase-1 Period

| Product # | Deliverable | Description |
|---|---|---|
| PB.1 | Operational Concept and Requirements Document Comments | Subcontractor comments to the NASA-provided preliminary versions of the NTP Reactor/Engine Concept of Operations, requirements, and Engine ICD. Includes known changes to the proposed operational concept and requirements. |
| PB.2 | NTP Reactor SRR Data Package | Subcontractor delivers all information required to satisfy SRR Entrance Criteria as defined in Appendix A.2. |
| PB.3 | Prototype Reactor Development Schedule | Refined preliminary development schedule from post-30%DR reactor Authority to Proceed (ATP) through first non-nuclear demonstration of the prototype Reactor. |

| Product # | Deliverable | Description |
|---|---|---|
| PB.4 | Estimated Prototype Reactor Cost | Estimated cost from post-30%DR reactor ATP through first non-nuclear demonstration of the prototype Reactor. |
| PB.5 | NTP Reactor 30%DR Data Package | Subcontractor delivers all information required to satisfy 30%DR Entrance Criteria as defined in Appendix A.1. |
| PB.6 | Draft Phase-2 SOW | Draft SOW for teammates from post-30%DR through detailed design (90%DR). Includes Core Unit Cell Fabrication and Test. SOW includes milestones and deliverables. |
| PB.7 | Final Report | Report(s) summarizing the work done in this Phase-1 period, in the format required by the Technology Demonstration Mission Office. The Subcontractor shall present a summary of the activities associated with the design and testing activities performed during the Phase-1 period of performance. Results and observations throughout the performance period shall also be included. |

**Table 4.1-2.** Routine (R) Deliverables, Briefings and Reports—Phase-1

| Product # | Deliverable | Description |
|---|---|---|
| R.1 | Quarterly Project Status/Technical Briefings | The Subcontractor shall provide a quarterly project and technical briefing summarizing the major accomplishments for the previous quarter and the plans for the upcoming quarter. The program's technical and schedule status are defined. Areas of concern, issues, and/or risks are highlighted, and recovery plans defined. |
| R.2 | Quarterly Technical Reports | The Subcontractor shall provide quarterly updates regarding the technical progress of the program. These reports are delivered in a format consistent with the Final Report. |
| R.3 | Monthly Progress/Status Reports | The Subcontractor shall provide monthly status reports summarizing the major accomplishments for the previous month and the plans for the upcoming month. The status of the program's technical and schedule progress is provided. Areas of concern, issues, and/or risks shall be highlighted, and recovery plans defined. These reports are delivered in format defined by Idaho National Laboratory (INL). The Subcontractor shall deliver the report within 7 days of the end of the month. |
| R.4 | Bi-weekly Telecons | The Subcontractor shall document a summary of participation in bi-weekly telecons with the customer (INL and NASA). Technical discussions, programmatic status and any associated issues shall be highlighted. The Subcontractor shall deliver the report within 7 days of the telecon and include in the report in the Monthly Progress/Status Report. |
| R.5 | Program Review Presentation/Meeting Results | The Subcontractor shall deliver presentation materials presented at the performance-based and routine reviews. |
| R.6 | Participation in Government-led Working Groups | The Subcontractor shall document the activities associated with the Government working group meetings performed during the Phase-1 period of performance. |

# 5. SCHEDULE AND MILESTONES

The schedule for contract milestones is shown in Table 5.1-1. The referenced SOW section is listed, along with a summary of the event criteria and/or deliverables.

**Table 5.1-1.** Contract Milestones Schedule (MS)

| Milestone Name | Reference (SOW Section/DRD) | Event Criteria / Deliverable | Date (ATP + months) |
|---|---|---|---|
| MS 1 | | The Subcontractor shall provide comments to the initial INL/NASA Concept of Operations, System Level Requirements, and Design & Construction Standards Applicable DRDs. | ATP + 1 |
| MS 2 | SOW Appendix A.2 | The Subcontractor shall conduct a SRR per the instructions in Appendix A.2. | ATP +2 |
| MS 3 | | DRDs: Routine Deliverables (Quarterly, Final Report Outline), SRR discrepancy closure / plans. | ATP + 3 |
| MS 4 | SOW 3.1.8 | Quarterly / Midpoint Status Review, DRD Status, DRDs: Reactor Schedule, Reactor Cost Estimate | ATP + 6 |
| MS 5 | | DRDs: Routine Deliverables (Quarterly, Final Report Status) | ATP + 9 |
| MS 6 | SOW 3.1.1, Appendix A.1 | The Subcontractor shall conduct a 30%DR per the instructions in Appendix A.1. | ATP + 11 |
| MS 7 | | Final Report, 30%DR discrepancy closure / plans. | ATP + 12 |

# 6. COMPLETION CRITERIA AND FINAL ACCEPTANCE

The Contractor and NASA will review and approve products produced from Subcontractor's compliant performance of this SOW and the contract of which it is a part. In general, final acceptance of work products will be issued by the Contractor. Acceptance notifications may become part of the SNP project record maintained by NASA.

# 7. APPENDICES

**Appendix A.1 – 30% Design Review**

**Appendix A.2 - Systems Requirements Review (SRR) Criteria**

**Appendix B – Technology Readiness Level (TRL) Definitions**

**Appendix C – Reactor Design Constraints and Requirements**

# 8. ATTACHMENTS

**Attachment A - Reactor to Engine System Interface Control Document (ICD)** This document will be delivered to the Subcontractor(s) at ATP.

**Attachment B - Data Procurement Document (DPD), including Data Requirements Descriptions**

**Attachment C - Organizational Conflict of Interest (OCI) Mitigation Plan**

# Appendix A.1

## 30% Design Review

The Phase-1 contract will end with a 30%DR, as described in the following section. The Subcontractor performance at 30%DR will be a significant part of the selection criteria for Phase-2.

Blended DOE 30%DR and NASA Technology Development (TD) Preliminary Design Review (PDR) methodology will be used with tailored Entrance and Success Criteria as shown in Table A.1-1. The 30%DR demonstrates that the interim design meets all system requirements with acceptable risk and within the cost and schedule constraints, as well as establishes the basis for proceeding with detailed design. It will show that the correct design option has been selected, interfaces have been identified, and verification methods have been described.

System Requirements Review (SRR)

In advance of the 30%DR, a tailored SRR will be conducted approximately 2 months after ATP. The SRR examines the functional and performance requirements defined for the system, the preliminary project planning, and ensures that the requirements and the selected concept will satisfy the mission. See Appendix A.2—System Requirement Review (SRR) Criteria for more information.

**Assume the following for configuration-controlled data as indicated in the entrance and success table:**

| | |
|---|---|
| **D** | Rough draft version |
| **P** | Preliminary version |
| **B/L** | Baselined version |
| **UPD** | Update expected (data expected to evolve throughout formulation and implementation) |
| **I** | Initial version |
| **F** | Data is expected to exist in its final form |
| **SUM** | Summarizes results of previous review or some other process |
| **Plan** | Captures work planned for following phases |

**Table A.1-1.** 30% Design Review Criteria.

| 30% Design Review | |
|---|---|
| **Entrance Criteria** | **Success Criteria** |
| 1. Successful completion of the previously planned milestone reviews, including all lower-level reviews, and responses has been made to all SRR discrepancies or a timely closure plan exists.<br>2. A preliminary agenda, success criteria, and charge to the board have been agreed to by the technical team, Project Manager, and review chair prior to the 30%DR.<br>3. The programmatic products listed below have been made available to the cognizant participants prior to the review:<br>a. P—International agreements<br>b. I—Environmental Compliance Documentation<br>c. Plans to respond to regulatory requirements, as required.<br>d. P—TD Project Plan<br>e. SUM—Documentation of performance against plans for work to be accomplished during next implementation phase, including performance against baselines and status/closure of formal actions from previous reviews.<br>f. P—Schedule, work breakdown structure and allocation of resources<br>g. D—Disposal plan<br>h. D—Decommissioning Plan<br>i. P—Integration Plans<br>4. The following technical products, for both hardware and software systems elements, have been made available to the cognizant participants prior to the review:<br>a. P—Interim design that can be shown to meet requirements and key technical performance measures.<br>b. UPD—Trending information on the mass margins, power margins, and closure of review actions (Request for Actions (RFA), Review Item Discrepancies (RID), and/or Action Items)<br>c. Subsystem design specifications with supporting trade-off analyses and data, as required, that are ready to be baselined after review comments are incorporated.<br>d. Applicable technical plans as defined in DPD.<br>e. Applicable standards that have been identified and incorporated.<br>f. Preliminary Engineering drawing tree.<br>g. Interface control documents that are ready to be baselined after review comments are incorporated.<br>h. P—Implementation Plans<br>i. P—V&V plans<br>j. P—Operations Plans<br>k. Technical resource utilization estimates/margins. | 1. Top-level requirements—including technology demonstration success criteria, Technical Performance Measures (TPMs), and any sponsor-imposed constraints—are agreed upon, finalized, stated clearly, and are consistent with the 30% design.<br>2. The flow down of verifiable requirements is complete and proper or, if not, an adequate plan exists for timely resolution of open items. Requirements are traceable to mission goals and objectives.<br>3. The program cost and schedule are credible and within program constraints and ready for commitment.<br>4. The interim design is expected to meet the requirements at an acceptable level of risk.<br>5. Definition of the technical interfaces (both external entities and between internal elements) is consistent with the overall technical maturity and provides an acceptable level of risk.<br>6. Any required new technology has been developed to an adequate state of readiness, or back-up options exist and are supported to make them viable alternatives. Any required new technology has been developed to an adequate state of readiness, or backup options exist and are supported to make them a viable alternative.<br>7. The project risks are understood and have been credibly assessed, and plans, a process, and resources exist to effectively manage them.<br>8. Safety and Mission Assurance (SMA) have been adequately addressed in interim designs and any applicable SMA products as defined in DPD meet requirements, are at the appropriate maturity level for this phase of the program's life-cycle and indicate that the program safety/reliability residual risks will be at an acceptable level.<br>9. Adequate technical and programmatic margins (e.g., mass, power, memory) and resources exist to complete the development within budget, schedule, and known risks.<br>10. The operational concept is technically sound and includes the flow down of requirements for its execution.<br>11. Technical trade studies are mostly complete to sufficient detail and remaining trade studies are identified, plans exist for their closure, and potential impacts are understood.<br>12. The program/project has demonstrated compliance with applicable INL, NASA and implementing Center requirements, standards, processes, and procedures.<br>13. To Be Determined (TBD) and To Be Resolved (TBR) items are clearly identified with acceptable plans and schedule for their disposition.<br>14. Preliminary analysis of the primary subsystems has been completed and summarized, highlighting performance and design margin challenges. |

| 30% Design Review | |
|---|---|
| Entrance Criteria | Success Criteria |
| | 15. Appropriate modeling and analytical results are available and have been considered in the design.<br>16. Heritage designs have been suitably assessed for applicability and appropriateness.<br>17. Manufacturability has been adequately included in design. |

**Table A.1-2.** 30%DR Product Maturity Post Review.

| 30%DR Product Maturity Post Review |
|---|
| Review Programmatic Products:<br>a. B/L—International agreements<br>b. Final —Environmental Compliance Documentation<br>c. B/L—Project Plan<br>d. SUM—Documentation of performance against plans for work to be accomplished during next implementation phase, including performance against baselines and status/closure of formal actions from previous review.<br>e. B/L—Schedule, work breakdown structure and allocation of resources<br>f. P—Decommissioning Plan<br>g. P—Disposal Plan<br>h. B/L-Integration Plans<br>Technical Products:<br>a. B/L—Interim Design Documentation<br>b. UPD—Trending information on the mass margins, power margins, and closure of review actions (RFA, RID, and/or Action Items)<br>c. UPD—Stakeholders and expectations<br>d. UPD—Concept documentation<br>e. UPD—Cost and schedule for technical implementation<br>f. UPD—Requirements<br>g. UPD—Required leading indicators<br>h. B/L—Interface Definitions<br>i. B/L-Implementation Plans<br>j. B/L—V&V plans<br>k. B/L—Operations Plans |

Table notes:

1. RFAs are typically questions or issues documented by independent reviewers from a chartered standing review board or independent review team that are chartered for the full lifecycle of the project.

2. RIDs are typically potential design issues documented by project subject matter experts. Corrective action must be developed for all RIDs approved by the Project Manager.

*Results of Review*

The design-to-baseline is approved upon a successful completion of the 30%DR. A successful review result also authorizes the project to proceed into implementation and toward final design.

In the case of the Phase-1 contract, a successful review will make the Subcontractor eligible for an Phase-2 award. Review discrepancies (i.e., RFAs, RIDs, and/or other documented actions related to review findings) should be addressed by the Subcontractor before the end of the Phase-1 period of performance. Review discrepancies that are not closed by the end of the Phase-1 period of performance can be addressed in the Subcontractor's Phase-2 contract proposal.

# Appendix A.2

## Systems Requirements Review (SRR) Criteria

The SRR Entrance and Success Criteria are shown in Table A.2-1. The product maturity in the Entrance Criteria is indicated by the letter(s) at the front of the deliverable items.

**Assume the following for configuration-controlled data as indicated in the entrance and success table:**

| | |
|---|---|
| **D** | Rough draft version |
| **P** | Preliminary version |
| **B/L** | Baselined version |
| **UPD** | Update expected (data expected to evolve throughout formulation and implementation) |
| **I** | Initial version |
| **F** | Data is expected to exist in its final form |
| **SUM** | Summarizes results of previous review or some other process |
| **Plan** | Captures work planned for following phases |

**Table A.2-1.** System Requirements Review Entrance and Success Criteria.

| System Requirements Review (SRR) | |
|---|---|
| Entrance Criteria | Success Criteria |
| 1. RESERVED<br>2. A preliminary agenda, success criteria, and charge to the board have been agreed to by the technical team, Project Manager, and review chair prior to the SRR.<br>3. The programmatic products listed below have been made available to the cognizant participants prior to the review:<br>a. D—Project Plan<br>4. The following technical products, for both hardware and software systems elements, have been made available to the cognizant participants prior to the review:<br>a. P—Systems Engineering Management Plan (SEMP)<br>b. P—Requirements for system being reviewed are ready to be baselined after the review and preliminary allocation to the next lower-level system has been performed.<br>c. Updated parent requirements.<br>d. Initial document tree. | 1. The functional and performance requirements defined for the system are responsive to the parent requirements and represent achievable capabilities.<br>2. The maturity of the requirements definition and associated plans is sufficient to begin interim design.<br>3. The project utilizes a sound process for the allocation and control of requirements throughout all levels, and a plan has been defined to complete the definition activity within schedule constraints.<br>4. Interfaces with external entities and between major internal elements have been identified.<br>5. Preliminary approaches have been determined for how requirements will be verified and validated.<br>6. Major risks have been identified and technically assessed, and viable mitigation strategies have been defined.<br>7. The program/project has demonstrated compliance with applicable Department of Energy and NASA requirements, standards, processes, and |

| System Requirements Review (SRR) | |
|---|---|
| **Entrance Criteria** | **Success Criteria** |
| e. Verification and validation approach.<br>f. Preliminary Minimum Operational Performance Standards (MoPs) and Technical Performance Measurement (TPMs)<br>g. Other specialty discipline analyses, as required<br>Logistics documentation (e.g., preliminary maintenance plan).<br>h. Preliminary engineering development assessment and technical plans to achieve what needs to be accomplished in the next phase. | procedures.<br>8. TBD and TBR items are clearly identified with acceptable plans and schedule for their disposition. |

| SRR Product Maturity Post Review |
|---|
| Programmatic Products: |
| P—Schedule, work breakdown structure, and allocation of resources. |
| Technical Products: |
| B/L—Requirements |
| UPD—Stakeholders and expectations |
| UPD—Concept documentation |
| UPD—Cost and schedule for technical implementation |

# Appendix B

## Technology Readiness Level (TRL) Definitions

See NASA Procedural Requirement (NPR) 7123.1 “NASA Systems Engineering Processes & Requirements,” Appendix E—Technology Readiness Levels.

# Appendix C

## Reactor Design Constraints and Requirements

The purpose of this Appendix is to define the technical design constraints and requirements for a nuclear reactor subsystem for a subscale NTP System. The design constraints and requirements specified below are considered sufficient to inform the content of the Request for Proposal (RFP) proposal response. Additional fidelity in the technical requirements will be provided at the ATP as a government-controlled reactor specification and a reactor/engine interface document. Proposal teams selected for Phase-1 contract ATP shall develop their respective concept-specific reactor subsystem specifications (ref. DRD CM-005, *Reactor Subsystem Specification*) to document compliance with the government documents, which will be baselined at the SRR at ATP plus 2 months.

### Subscale Reactor Subsystem Design Constraints

The following design constraints are considered to be established attributes to be reflected in the reactor design. Compliance with these constraints is considered absolute and not subject to deviation or exemption.

- NTP Reactor (NTPR) Propellant - The NTPR shall be compatible with an engine system that uses hydrogen as a propellant.
- NTPR Fuel - The NTPR shall use HALEU fuel or uranium fuel with levels of U-235 enrichment less than 20%.

### Subscale Reactor Subsystem Requirements

The following requirements are considered to be sufficient to inform the content of the Request for Proposal (RFP) response to be reflected in the proposer's reactor design. Deviations or exemptions to these requirements are allowed if compelling rationale is provided and accepted, but compliance is considered to be a criterion for proposal selection.

- NTPR Exit Temperature - The reactor shall be capable of achieving a hydrogen outlet temperature of 2700 K, which is consistent with a vacuum $I_{sp}$ of 900 sec.
- NTPR Hydrogen Mass Flow Rate—The reactor shall use a maximum hydrogen mass flow rate of 6.3 kg/s (13.9 lbm/s), which is consistent with a vacuum $I_{sp}$ of 900 sec and a thrust of 55.6 kN (12,500 lbf).
- NTPR Life, Accumulated Operational Time—The NTPR shall be capable of maintaining a nominal operating power level for a minimum of two hours accumulated operational time after acceptance and delivery with a goal of five hours accumulated operational time.

- NTPR Life, Operational Cycles—The NTPR shall be capable of a minimum of five starts and five shutdowns.
- NTPR Start—The NTPR shall perform a controlled start upon command to operational power levels.
- NTPR Shutdown—The NTPR shall perform a controlled shut-down upon command from any power level.
- NTPR Mass—The target mass for all reactor components inside, and including the reactor pressure vessel, is 2,500 kg (5,500 lbm). The upper threshold for an acceptable reactor system mass is 3,500 kg (7,700 lbm).
- NTPR Performance and Natural Environments—The NTPR shall meet all functional and performance requirements defined herein within the range of natural environmental conditions to accommodate applicable mission parameters as specified in the Space Launch System (SLS)-SPEC-159, Cross-Program Design Specification for Natural Environments (DSNE).
- NTPR Performance and Induced Environments—The NTPR shall meet all functional and performance requirements during and after exposure to the launch vehicle induced environments as specified in Table E.1-1, Induced Environments.

**Table E.1-1.** Induced Environments

| EVENT | Range Time (secs) | Longitudinal Static Acceleration (g) ** | Longitudinal Vehicle Dynamics (g) | Lateral Vehicle Dynamics (g) * |
|---|---|---|---|---|
| Ignition, 1st Stage | T-4 to T-0 | 1.0 | 0 | 0 |
| Release Lift-Off | T-0 to T+10 | 1.4 | ±2.25 (3–35 Hz) | ±1.5 (0.1–15 Hz) |
| 1st Stage Steady State | T+10 to T+65 | 1.4–2.0 | ±0.3 (3–35 Hz) | ±0.3 (0.1–15 Hz) |
| Mach 1 (Transonic) | T+65 to T+75 | 2.0–2.2 | ±0.3 (3–35 Hz) | ±0.3 (0.1–15 Hz) |
| Max Q | T+75 to T+85 | 2.2–2.4 | ±0.3 (3–35 Hz) | ±0.3 (0.1–15 Hz) |
| Max Acceleration | T+150 to T+160 | 5.0–5.2 | ±0.3 (3–35 Hz) | ±0.3 (0.1–15 Hz) |
| Cutoff / 1st Stage Separation | T+160 to T+165 | 0 | ±2.25 (3–35 Hz) | ±0.3 (0.1–15 Hz) |
| Ignition 2nd Stage | T+170 | 0.75 | SMALL | SMALL |
| Boost 2nd Stage | T+170 to T+470 | 1.5 | SMALL | SMALL |

* Lateral static acceleration 1.0 g

** Includes weight effect of 1.0 gRationale: Depending on the launch vehicle used to insert the reactor into the target operational orbit, the reactor will have to meet this requirement. The reactor must be able to function nominally after exposure to these environments. Until a launch vehicle is selected, the induced environments specified for the 75K Nuclear Engine for Rocket Vehicle Application (NERVA) engine are replicated for this requirement. (Ref.: AGC Data Item C002-CP090290-F1, Performance/Design and Product Confirmation Requirements for Engine, NERVA, 75K, Full Flow, 15 Dec 1969.)

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DATA PROCUREMENT DOCUMENT
NO.: SNP1
ISSUE: Final

**02986312**

CONTRACT/RFP

**NA**

EXHIBIT NUMBER

**Attachment B**

ATTACHMENT NUMBER

**Nuclear Thermal Propulsion (NTP) Reactor Interim Design**

PROJECT/SYSTEM

***DATA PROCUREMENT DOCUMENT (DPD)***

**Battelle Energy Alliance, LLC**

CONTRACTOR

**December 16, 2020**

DATE

National Aeronautics and
Space Administration

MSFC - Form 3461 (Rev)

National Aeronautics and Space Administration

# *DOCUMENT CHANGE LOG*

DATA PROCUREMENT

DOCUMENT NO.: SNP1

Issue: Final

| INCORPORATED REVISIONS<br>OUTSTANDING REVISIONS | AS OF: | SUPERSEDING: | PAGE: |
|---|---|---|---|

| AUTHORITY | PORTION AFFECTED - PAGE NO./NO. | | | | REMARKS |
|---|---|---|---|---|---|
| (DPD Revision) | INTRO | SGR | DRL | DRD | |
| | | | | | |

| National Aeronautics and Space Administration<br><br>**PAGE REVISION LOG** | | | DATA PROCUREMENT<br>DOCUMENT NO. SNP1<br>ISSUE: Final |
|---|---|---|---|
| NOTE: The current revision is denoted by a vertical line in the outer margin adjacent to the affected text. | AS OF: | SUPERSEDING: | PAGE: |

INSERT LATEST REVISED PAGES. DISCARD SUPERSEDED PAGES.

| ITEM | PAGE | STATUS | ITEM | PAGE | STATUS |
|---|---|---|---|---|---|
| | | | | | |

1.0 INTRODUCTION

1.1 Scope: Subject to the Rights in Data clause (refer to the Battelle Energy Alliance, LLC (BEA) Form PROC-207, General Provisions for Acquisition of Professional/Consulting Services Fixed Price/Fixed Rate, dated May 2020 and the requirements of Contract No. DE-AC07-0514517 between BEA and the U.S. Department of Energy for management and operation of the Idaho National Laboratory and any successor thereto (M&O Contract), this Data Procurement Document (DPD) sets forth the data requirements in each Data Requirements Description (DRD) and shall govern that data required by the DPD for the contract. The Subcontractor shall furnish data defined by the DRDs listed on the Data Requirements List (DRL) by category of data, attached hereto, and made a part of this DPD. Such data shall be prepared, maintained, and delivered in accordance with the requirements set forth within this DPD. References to Contracting Authority, Contracting Officer or Contracting Officer's Representative within this document shall be construed to mean BEA's Procurement Agent, whether called a Contract Specialist, Procurement Specialist, or another name.

1.2 DPD Description: This DPD consists of a Document Change Log, a Page Revision Log, an introduction, DPD maintenance procedures, a DRL, and the DRDs.

1.2.1 Reserved

1.2.2 Data Requirements List (DRL): Throughout the performance of the contract, the DRL provides a listing by data category of the data requirements of the DPD.

1.2.3 Data Requirements Descriptions (DRDs)

1.2.3.1 Each data requirement listed on the DRL is given complete definition by a DRD. The DRD prescribes content, format, maintenance instructions, and submittal requirements.

1.2.3.2 For the purpose of classification and control, DRDs of this DPD are grouped into the following broad functional data categories:

| CATEGORY SYMBOL | DESCRIPTION |
|---|---|
| CM | Configuration Management |
| DE | Design and Development Engineering |
| LS | Logistics/Support |
| MA | Management |
| MP | Materials and Processes |
| OP | Mission Operations |
| QE | Quality Engineering |
| RM | Reliability and Maintainability |
| SA | Safety |
| SE | Systems Engineering |
| SW | Software |
| VR | Verification |

1.2.3.3 The symbols representing these data categories form part of the prefix of the DRD identification number. The first numerical characters reflect the DPD number.

1.2.3.4 To facilitate the usage and maintenance of the DPD, the DRDs have been sectionalized in accordance with the above data categories.

1.2.3.5 The DRDs are filed by data category and are in alpha-numeric sequence as listed on the DRL page (or pages) that precedes the DRDs.

1.2.4 Document Change Log (DCL) and Page Revision Log (PRL): The Document Change Log chronologically records all revision actions that pertain to the DPD. The Page Revision Log describes the current revision status of each page of the DPD and thus, at all times, provides its exact configuration.

1.2.5 DPD Maintenance Procedures: Maintenance procedures define the detailed methods to be employed in maintaining the DPD. Detailed maintenance procedures are specified in paragraph 3.0 of this DPD.

1.3 Data Types for Contractual Efforts: The types of data and their contractually applicable requirements for approval and delivery are:

| TYPE | DESCRIPTION |
|---|---|
| 1* | All issues and interim changes to those issues require written approval from the requiring organization before formal release for use or implementation. |
| 1a | For Type 1 data issues submitted to Contracting Authority in support of design review activities (e.g. 30%DR, 90%DR), draft versions of this data shall be submitted as necessary to support the review. Upon completion of design review Pre-Board/Board activities, the Subcontractor shall submit updated documentation per Contracting Officer letter, to include the incorporation of Review Item Discrepancies (RIDs), for processing by Contracting Authority as described in the above paragraph describing Type 1 data issues. |
| 2* | Contracting Authority reserves a time-limited right to disapprove in writing any issues and interim changes to those issues. The Subcontractor shall submit the required data to Contracting Authority for review not less than 30 calendar days** prior to its release for use. The Subcontractor shall clearly identify the release target date in the "submitted for review" transmittal***. If the data is unacceptable, Contracting Authority will notify the Subcontractor within 30 calendar days** from the date of submission, regardless of the intended release date***. The Subcontractor shall resubmit the information for reevaluation if disapproved. The submittal is considered approved if the Subcontractor does not receive disapproval or an extension request from Contracting Authority within 30 calendar days**. |
| 2a | For Type 2 data issues submitted to Contracting Authority for Design Reviews (e.g., 30%DR, 90%DR) draft versions of data shall be submitted as necessary to support the review. Following the completion of design review Pre-Board/Board activities, the Subcontractor shall submit updated documentation per Contracting Officer letter, to include the incorporation of RIDs, for processing as described in the above paragraph describing Type 2 data issues. |
| 3 | These data shall be delivered by the Subcontractor as required by the contract and do not require Contracting Authority approval. However, to be a satisfactory delivery, the data shall satisfy all applicable contractual requirements and be submitted on time. |
| 4 | These data are produced or used during performance of the contract and are retained by the Subcontractor. They shall be delivered only when Contracting Authority |

requests in writing and shall be delivered in accordance with the instructions in the request. The Subcontractor shall maintain a list of these data and shall furnish copies of the list to Contracting Authority when requested to do so.

5 These data are incidental to contract performance and are retained by the Subcontractor in those cases where contracting parties have agreed that formal delivery is not required. However, the Contracting Officer or the Contracting Officer's Representative shall have access to and can inspect this data at its location in the Subcontractor's or teammate's facilities, or in an electronic database accessible to the Contracting Authority.

* Note: Type 1 and Type 2 data may be placed under Contracting Authority configuration management control when designated by Contracting Authority. CM control requires the Subcontractor to submit Type 1 and Type 2 data updates through Engineering Change Proposals (ECPs).

** Note: This time limit may be tailored for individual DPDs to meet the requirements of the procuring activity.

***Note: If the Subcontractor does not identify a release target date, or if the intended release date is shorter than 30 calendar days from the date of submission, the 30 calendar days review cycle stands (or the tailored Type 2-time limitation for the specific procurement).

2.0 RESERVED

3.0 DPD MAINTENANCE PROCEDURES

3.1 Contracting Authority-Initiated Change: New and/or revised data requirements shall be incorporated by contract modification to which the new or revised portion of the DPD shall be appended. The Subcontractor shall notify the Contracting Officer in the event a deliverable data requirement is imposed and is not covered by a DRD, or when a DRD is changed by a contract modification and for which no revision to DPD is appended. In such cases, the Subcontractor shall submit the requested changes to Contracting Authority for approval. See paragraph 3.3.1 for change procedures.

3.2 Subcontractor-Initiated Change: Subcontractor-proposed data requirements, or proposed changes to existing requirements shall be submitted to Contracting Authority for approval.

3.3 DPD Change Procedures

3.3.1 Changes to a contractual issue of this DPD shall be identified by Contracting Authority on the Document Change Log and Page Revision Log. The actual revised material on the DPD page shall be identified by placing a heavy vertical line in the margin extending the entire length of the change. In addition, the numerical control number of the contractual direction authorizing the change shall be placed adjacent to the vertical revision line. These revision identifiers shall be used to reflect the current revision only; any previous symbols on a page shall be deleted by the current revision.

3.3.2 The date of the contractual direction paper, e.g., Change Order, Supplemental Agreement, or Contracting Officer's letter shall be entered under the "Status" column of the Page

Revision Log adjacent to the affected page or DRD number, and in the “as of” block. The date that was in the “as of” block shall be entered in the “Superseding” block.

3.3.3 The Document Change Log entitled “Incorporated Revisions” shall be changed to indicate the number, portions affected, and associated Supplemental Agreement number, if applicable.

3.3.4 The Document Change Log entitled “Outstanding Revisions” is changed periodically to indicate outstanding Change Orders and Contracting Officer notification letters.

3.4 DPD Reissues

3.4.1 When conditions warrant, the DPD shall be reissued by Contracting Authority and shall supersede the existing DPD in its entirety. Reissues shall be issued by contractual direction.

3.4.2 All revision symbols (vertical lines and contractual direction control numbers) shall be removed from all pages; revision dates shall remain in the Date Revised block on DRDs that have been revised. The issue symbol, which shall commence with "A" and progress through "Z," shall be entered in the DPD identification block of each DRD page of the DPD.

**Nuclear Thermal Propulsion Reactor – Preliminary Design**
**Data Requirements List**

| DRD | DATA TYPE | TITLE |
|---|---|---|
| CM – Configuration Management | | |
| SNP1CM-005 | 1 | Reactor Subsystem Specification |
| SNP1CM-009 | 3 | Specification, Drawing, and Document Trees |
| | | |
| DE – Design and Development Engineering | | |
| SNP1DE-001 | 3 | Reactor Subsystem and Component Test Plans |
| SNP1DE-004 | 2 | Reactor Development Plan |
| SNP1DE-005 | 2 | Structural Assessment Plan |
| SNP1DE-007 | 3 | Structural Dynamics Analyses, Loads, and Models Documentation |
| SNP1DE-009 | 3 | Thermal Design Data Book |
| SNP1DE-010 | 3 | Structural Strength and Fatigue Analysis Reports |
| SNP1DE-011 | 4 | Reactor Subsystem and Component Test Reports |
| SNP1DE-012 | 2/3 | Reactor Systems and Component Analyses and Critical Math Models |
| | | |
| LS – Logistics Support | | |
| SNP1LS-003 | 2 | Reactor Supportability Plan |
| SNP1LS-004 | 3 | Reactor Supportability Analysis |
| | | |
| MA – Management | | |
| SNP1MA-004 | 2 | Work Breakdown Structure (WBS) and WBS Dictionary |

| | | |
|---|---|---|
| SNP1MA-006 | 2/3 | Risk Management Plan and Risk Management Reports |
| SNP1MA-011 | 3 | Technical Performance Report |
| SNP1MA-016 | 3 | Final Report |
| SNP1MA-017 | 3 | Integrated Program Management Report |
| | | |
| MP – Materials and Processes | | |
| SNP1MP-003 | 3 | Manufacturing and Assembly Plan |
| SNP1MP-005 | 3 | Materials Identification and Usage List (MIUL) |
| | | |
| OP – Mission Operations | | |
| SNP1OP-003 | 2 | Reactor Operations Concept Document |
| | | |
| QE – Quality Engineering | | |
| SNP1QE-002 | 2 | Quality Assurance Plan |
| | | |
| SA – Safety | | |
| SNP1SA-001 | 2 | System Safety Plan (SSP) |
| | | |
| SE – Systems Engineering | | |
| SNP1SE-001 | 2 | Systems Engineering Management Plan |
| SNP1SE-002 | 3 | Reactor Design Definition Document |
| SNP1SE-004 | 2 | Interface Definition Documentation (IDD) |
| SNP1SE-005 | 3/2 | Instrumentation Program and Command List |
| SNP1SE-006 | 2 | Mass Properties Control Plan |
| SNP1SE-007 | 3 | Mass Properties Report |
| SNP1SE-009 | 3 | System Connectivity Diagrams and End-to-End |
| | | |
| SW – Software | | |
| RESERVED | | |
| | | |
| VR – Verification | | |
| SNP1VR-001 | 2 | Verification/Validation Planning |

<u>The following DRDs will be required in the Phase-2 and Phase-3 contract periods</u>

| | | |
|---|---|---|
| XXXXCM-010 | 3 | Product Definition Data and Associated Lists |
| XXXXDE-003 | 2 | Electromagnetic Environmental Effects (E3) Control Plan |
| XXXXDE-013 | 2 | Electrical, Electronic, and Electromechanical Nonstandard Parts Approval Request |
| XXXXDE-014 | 2 | Electrical, Electronic, and Electromechanical (EEE) Parts Control Plan |
| XXXXDE-015 | 4/2 | As-Designed EEE Parts List |
| XXXXMP-006 | 2/3 | Material Usage Agreements (MUAs) |
| XXXXQE-001 | 2 | Software Assurance Plan |
| XXXXSA-002 | 2 | Safety, Health, and Environmental (SHE) Plan |
| XXXXSE-001 | 2 | Systems Engineering Management Plan |
| XXXXSE-003 | 3 | Avionics Systems Functional Decomposition |
| XXXXSE-008 | 3 | Electrical Power and Energy Management Report |

| | | |
|---|---|---|
| XXXXSW-001 | 3/2 | Software Requirements Specification |
| XXXXSW-002 | 3/2 | Software Data Dictionary |
| XXXXSW-003 | 2 | Software Configuration Management Plan |
| XXXXSW-004 | 2 | Software Maintenance Plan |
| XXXXSW-005 | 2 | Software Development Plan |
| XXXXSW-007 | 3 | Software and Programmable Devices Design Description |
| XXXXSW-008 | 3 | Software Test Plan |
| XXXXSW-012 | 3 | Software Metrics Report |
| XXXXVR-002 | 2 | Verification Data |
| XXXXVR-003 | 2 | Verification Compliance Reports |

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1CM-005**
3. **DATA TYPE**: 1
4. **DATE REVISED**:
5. **PAGE**: 1/1
6. **TITLE**: Reactor Subsystem Specification
7. **DESCRIPTION/USE**: To document the performance, functional, operational, and physical design requirements and design standards of the reactor subsystem and the associated top-level verification requirements.
8. **OPR**: N/A
9. **DM**: N/A
10. **DISTRIBUTION**: Per Contracting Officer's letter
11. **INITIAL SUBMISSION**: Baseline delivery at System Requirements Review (SRR).
12. **SUBMISSION FREQUENCY**: Update for 30% Design Review (30%DR) and as required thereafter to reflect changes.
13. **REMARKS**: None
14. **INTERRELATIONSHIP**: SOW section 3.1.1
15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Reactor Subsystem Specification provides the performance, functional, physical characteristics, and operational requirements, and design standards provided consistent with the established customer requirements. Associated top-level verification methods, requirements, and success criteria are provided for all design requirements.

15.2 **REFERENCE DOCUMENTS**:

| | |
|---|---|
| TBD | SNP Subscale Reactor Requirements Document |
| MIL-STD-961 | *Defense and Program – Unique Specifications Format and Content* |

15.3 **CONTENTS**: The Reactor Subsystem Specification shall be prepared as directed by the Contracting Authority, traceable to the SNP Subscale Reactor Requirements Document Sections 3 and 4 and using the standards of MIL-STD-961 as guidelines.

15.4 **FORMAT**: The format shall be in accordance with the instructions in MIL-STD-961. Format may deviate from the guidance in MIL-STD-961 based on mutual agreement between Contracting Authority and Subcontractor.

15.5 **MAINTENANCE:** Changes shall be incorporated by complete reissue consistent with the submission schedule. When the specification is placed under Contracting Authority configuration control (Type 1), proposed changes shall be submitted through the formal Engineering Change Proposal (ECP) process.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1CM-009**
3. **DATA TYPE**: 3
4. **DATE REVISED:**
5. **PAGE**: 1/1
6. **TITLE**: Specification, Drawing, and Document Trees
7. **DESCRIPTION/USE**: A specification tree is a generation breakdown of the specifications with interrelationships, as applicable, to the contract configuration items. A drawing tree is a generation breakdown of the engineering drawings that depicts the allocation of requirements of the contract configuration item specification. A document tree is an illustration of hierarchical interrelationships between programmatic documents.
8. **OPR**: N/A
9. **DM**: N/A
10. **DISTRIBUTION**: Per Contracting Officer's letter
11. **INITIAL SUBMISSION**: Specification and document trees – with 30% Design Review (30%DR) data package. Drawing trees – With 90% Design Review (90%DR) data package.
12. **SUBMISSION FREQUENCY**: Specification and document trees updated for 30% Design Review (30%DR). Document tree update as necessary.
13. **REMARKS**:
14. **INTERRELATIONSHIP**: SOW section 3.1.1.2, Attachment A.1, Table A.1-1
15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Specification, Drawing and Document Trees depicts the hardware and software configuration items in top-down or generation breakdown form. Document trees depict the hierarchical relationships of programmatic documents.

15.2 **REFERENCE DOCUMENTS**: None

15.3 **CONTENTS**: The Specification, Drawing, and Document Trees shall consist of an indentured or generation breakdown listing of all specifications, drawings, or documents applicable to a configuration item or items. Document trees shall consist of an illustrated hierarchical schematic of programmatic planning documents.

15.4 **FORMAT**: Subcontractor format is acceptable.

15.5 **MAINTENANCE**: Changes shall be incorporated by complete reissue.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1DE-001**
3. **DATA TYPE**: 3
4. **DATE REVISED:**
5. **PAGE**: 1/1
6. **TITLE**: Reactor Subsystem and Component Test Plans
7. **DESCRIPTION/USE**: To provide all details, objectives, and requirements necessary to define and implement a test series at the subsystem and component level. A series is defined as a set of tests with a unique objective and at a specific facility with unique requirements.
8. **OPR**: N/A
9. **DM**: N/A
10. **DISTRIBUTION**: Per Contracting Officer's letter
11. **INITIAL SUBMISSION**: The preliminary submission date of the subsystem and component test plans to be deliverable at the 30% Design Review (30%DR).
12. **SUBMISSION FREQUENCY**: Final submission of the subsystem and component test plans to be deliverable 30 days before start of each test series.
13. **REMARKS**: None
14. **INTERRELATIONSHIP**: DRD SNP1DE-011, *Reactor Subsystem and Component Test Reports* and SOW section 3.1.7
15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: Each Reactor Subsystem and Component Test Plan will serve as the test requirements document and describe reactor subsystem and component test activities required for verification of functional, performance, and operational requirements.

15.2 **REFERENCE DOCUMENTS**: None

15.3 **CONTENTS**: The two-tier delivery of the Reactor Subsystem and Component Test Plans allows for the evolutionary development of the final plan:

a. Preliminary Reactor Subsystem and Component Test Plans shall include the series-specific test scope, top-level milestones, test objectives and rationale, test article architecture, and facility identification.
b. Final Reactor Subsystem and Component Test Plans shall include updated and expanded information including the series-specific test scope, required milestones, test objectives and rationale, test article architecture, instrumentation requirements, data acquisition requirements, facility requirements, fluid requirements, participant roles and responsibilities experiment design (including a test matrix identifying test article configurations, test parameters, test durations, and number of tests), success criteria, data format requirements, and a discussion of how the test data will be interpreted to satisfy the test objectives.

15.4 **FORMAT**: Subcontractor format is acceptable.

15.5 **MAINTENANCE**: Changes shall be incorporated by change page or complete reissue.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1DE-004**
3. **DATA TYPE**: 2/2a
4. **DATE REVISED:**
5. **PAGE**: 1/2

6. **TITLE**: Reactor Development Plan

7. **DESCRIPTION/USE**: To establish and delineate a cohesive approach for developing the reactor subsystem.

8. **OPR**: N/A

9. **DM**: N/A

10. **DISTRIBUTION**: Per Contracting Officer's letter

11. **INITIAL SUBMISSION**: As part of the System Requirements Review (SRR) data package

12. **SUBMISSION FREQUENCY**: 30% Design Review (30%DR) and 90% Design Review (90%DR); final no later than 90% Design Review (90%DR). Update as required.

13. **REMARKS**:

14. **INTERRELATIONSHIP**: SOW section 3.1.3

15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Reactor Development Plan covers all design activities, analyses, and trade studies, and component selection activities inherent in the development of the reactor.

15.2 **REFERENCE DOCUMENTS**: None

15.3 **CONTENTS**: The Reactor Development Plan shall provide a detailed overview of the logic flow and overall approach, which the developer will use in developing the reactor. It provides a detailed summary of the rationale supporting architecture ground rules, design decisions, and hardware selections, which are in place prior to initial submission. It describes the trade studies, which shall be completed to address the trade space, success criteria, and decision date. It also provides an analysis plan that describes: (a) the scope and objectives of each planned analysis or model (i.e., what will be analyzed and the analytical results being sought), (b) the method to be used in the analysis effort, (c) how the results will be used in the development process, and (d) how the models have been (or will be) validated. The development plan also describes any planned alternate technology evaluations, including the success criteria, the approach used for the evaluation, and the dates at which a "go/no-go" decision will be made. This plan shall present a component procurement schedule, indicating planned dates for specification releases, procurement awards, and Subcontractor design reviews.

The development plan shall address the following items (developed to a sufficient level to provide supporting data that schedules, budgets, and requirements can be met and to provide out year planning):

a. Qualification and certification requirements.
b. Development test plans at subsystem and component levels.
c. Hardware flow path with respect to manufacturing and assembly logistics.
d. Assembly planning and checkouts.

15.3 **CONTENTS (CONTINUED)**:

e. Analysis tools and analysis tool certification.
f. Approach for Subcontractor control and support of team members.
g. Technology Readiness Assessment.

15.4 **FORMAT**: The Reactor Development Plan shall be presented as a narrative document with numbered paragraphs and illustrations in Subcontractor's document format. The document shall be submitted both in electronic and hardcopy format.

15.5 **MAINTENANCE**: Changes shall be incorporated by change page or complete reissue.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1DE-005**
3. **DATA TYPE**: 2/2a
4. **DATE REVISED**:
5. **PAGE**: 1/2
6. **TITLE**: Structural Assessment Plan
7. **DESCRIPTION/USE**: To enable the Contracting Authority to assure compliance with requirements for strength and fatigue analyses, tests, and structural assessment.
8. **OPR**: N/A
9. **DM**: N/A
10. **DISTRIBUTION**: Per Contracting Officer's letter
11. **INITIAL SUBMISSION**: As part of the System Requirements Review (SRR) data package
12. **SUBMISSION FREQUENCY**: As part of the 30% Design Review (30%DR) and 90% Design Review (90%DR) data packages, update as required
13. **REMARKS**: None
14. **INTERRELATIONSHIP**: SOW section 3.1.2
15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Structural Assessment Plan describes Subcontractor compliance with requirements for strength and fatigue analyses, tests, and structural assessment.

15.2 **REFERENCE DOCUMENTS**:

| | |
|---|---|
| NASA-STD-5001 | *Structural Design and Test Factors for Safety for Space Flight Hardware* |
| NASA-STD-5005 | *Ground Support Equipment* |
| NASA-STD-5012 | *Strength and Life Assessment Requirements for Space Propulsion System Engines* |
| MSFC-HDBK-505B | *Structural Strength Program Requirements* |
| ANSI/AIAA S-80 | *Space Systems – Metallic Pressure Vessels, Pressurized Structures, and Pressure Components* |

**NOTE: Reference Table 1 for applicability information.**

15.3 **CONTENTS**: The Structural Assessment Plan shall be prepared in accordance with the applicable structural requirements documents (see Table 1) referenced in section 15.2 and describe how the Subcontractor intends to comply with the structural strength program requirements. The plan shall identify the organization responsible for the structural analyses, tests, and assessment tasks; define satisfactory results; and include a schedule for completion. The plan shall distinguish between flight and development hardware, identify components that require design verification tests and proof tests, specify appropriate test levels and environments, and state the means of correlating test data with analyses.

15.4 **FORMAT**: Subcontractor format is acceptable. The plan shall be available in an electronic database.

15.5 **MAINTENANCE**: Changes shall be incorporated by change page or complete reissue.

**Table 1 – Applicability Information**

| Structural System | Applicable Requirement* | Comments |
|---|---|---|
| Space Propulsion System Engines | NASA-STD-5012 | This document is only applicable to liquid fueled engines. |
| Ground Support Equipment | NASA-STD-5005 | This document is only applicable to ground support equipment. |
| Metallic Pressure Vessels, Pressurized Structures and Components | ANSI/AIAA S-80 | This document is only applicable to metallic pressure vessels. |
| Vehicles, Payloads, and Other Hardware | MSFC-HDBK-505B or NASA-STD-5001 | These documents are applicable to vehicles, payloads, and other hardware not listed above. |

* Project specific structural assessment plans shall address additional requirements and special provisions.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1DE-007**
3. **DATA TYPE**: 3
4. **DATE REVISED**:
5. **PAGE**: 1/2

6. **TITLE**: Structural Dynamics Analyses, Loads, and Models Documentation

7. **DESCRIPTION/USE**: To define the structural dynamics analyses, loads, and models to be used for the design of the flight or test article and its associated equipment.

8. **OPR**: N/A 9. **DM**: N/A

10. **DISTRIBUTION**: Per Contracting Officer's letter

11. **INITIAL SUBMISSION**: With 30% Design Review (30%DR) data package

12. **SUBMISSION FREQUENCY**: As part of the 90% Design Review (90%DR) data package

13. **REMARKS**: Reference is made to NASA-HDBK-7005, *Dynamic Environmental Criteria* and ED21-02-022, *Transportation and Handling Limit Load Accelerations*

14. **INTERRELATIONSHIP**: SOW section 3.1.2

15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Structural Dynamics Analyses, Loads, and Models Documentation defines the structural dynamics analyses, loads, and models to be used for the design of the flight article and its associated equipment. Develop in coordination with SNP Reactor Subsystem Requirements Document.

15.2 **REFERENCE DOCUMENTS**: None

15.3 **CONTENTS**: The Structural Dynamics Analyses, Loads, and Models Documentation shall consist of:

Structural Dynamic Analyses Reports – These reports shall describe the structural dynamic response, loads analyses, and environmental analyses conducted on the flight article, its systems, subsystems, and components to calculate stresses and/or to identify operational limits and restrictions. Assumptions, boundary conditions, applied environments for response analyses, rationale, appropriate results, Campbell or resonance diagrams for normal modes, characterized modal parameters for response analyses, plots of modes, and proper coordinate system reference of models shall be provided.

Environments used for response analyses shall include all vibration and mechanical induced environments including transients, pressure fluctuations due to flow induced vibrations, cross correlated pressure measurements that occur during the combustion process and vibroacoustic phenomena. Vibroacoustic environments to be used for range safety, transportation, hardware qualification, and workmanship screening shall also be provided.

Loads – A structural loads data book shall be generated and kept current and approved by INL/NASA. All significant loads encountered during the service life, from manufacturing to the end of service, static, dynamic, steady state, and transient loads shall be documented. Load combinations which occur simultaneously shall be defined.

15.3 **CONTENTS (CONTINUED)**:

Models – The structural math models used for loads and dynamics response analyses shall be documented and available upon request. Verification of models shall be included in the documentation. Model description shall indicate pertinent modeling parameters, model display, material properties used, and type of model. A list and scope of the structural math models shall be proposed by the Subcontractor and approved by INL/NASA.

15.4 **FORMAT**: For reports and data book, electronic Subcontractor format is acceptable. For models, either ANSYS, NASTRAN .bdf or MSC/PATRAN .db format is preferred with electronic delivery.

15.5 **MAINTENANCE**: Changes shall be incorporated by complete reissue.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1DE-009**
3. **DATA TYPE**: 3
4. **DATE REVISED**:
5. **PAGE**: 1/2
6. **TITLE**: Thermal Design Data Book
7. **DESCRIPTION/USE**: The Thermal Design Data Book, (TDDB) evolves as the design matures and eventually documents all details of the reactor thermal design. It becomes a comprehensive source of information for all aspects of the thermal design, analysis, test, and verification. The customer shall use this data as the primary source to review and evaluate the thermal design for approval to proceed to the next development phase.
8. **OPR**: N/A
9. **DM**: N/A
10. **DISTRIBUTION**: Per Contracting Officer's letter
11. **INITIAL SUBMISSION**: With 30% Design Review (30%DR) data package
12. **SUBMISSION FREQUENCY**: Update as required for 90% Design Review (90%DR) and any following major design reviews as part of the submitted data package. Additional updates shall be provided as necessary to capture significant thermal design or analytical changes.
13. **REMARKS**: Documents referenced in the TDDB shall already be available to the purchasing agency or provided as an appendix or separate document.
14. **INTERRELATIONSHIP**: SOW section 3.1.2
15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The TDDB describes the thermal requirements, design requirements, thermal interfaces, materials, thermal properties and system architecture.

15.2 **REFERENCE DOCUMENTS**: None

15.3 **CONTENTS**: The TDDB shall include the following:

The TDDB shall be a compilation of reactor design criteria, thermal environments, materials and material properties, a summary of component thermal response and thermal protection (TPS) design thickness to meet requirements. Detailed thermal analysis assumptions (properties, environments and geometries), thermal model general descriptions and thermal analysis results shall be documented in separate reports but listed as references in the TDDB. The purpose of the TDDB shall be to present, in abridged form, information from these detailed analytical reports necessary for the reader to understand the thermal response of the reactor subjected to induced thermal environments for a design mission trajectory.

Material thermal physical properties to be documented shall include temperature dependent density, conductivity, and specific heat. Material thermal physical properties shall be documented in a subsection of the TDDB reserved for thermal physical properties data.

15.3 **CONTENTS (CONTINUED)**:
References to the natural and induced environments used shall be documented. Provide the thermal model(s) and any necessary associated files in electronic format. Reference will be made to any Computer Aided Design (CAD) drawings used in thermal modeling. Provide drawings of hardware as implemented in thermal models.

15.4 **FORMAT**: Subcontractor format is acceptable.

15.5 **MAINTENANCE**: Changes shall be incorporated by change page or complete reissue.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1DE-010**
3. **DATA TYPE**: 3
4. **DATE REVISED**:
5. **PAGE**: 1/2

6. **TITLE**: Structural Strength and Fatigue Analysis Reports

7. **DESCRIPTION/USE**: To provide component strength and fatigue analysis and a structural analysis database used for development of the flight article.

8. **OPR**: N/A

9. **DM**: N/A

10. **DISTRIBUTION**: Per Contracting Officer's letter

11. **INITIAL SUBMISSION**: As part of the 30% Design Review (30%DR) data package

12. **SUBMISSION FREQUENCY**: As part of the 90% Design Review (90%DR) data package

13. **REMARKS**: None

14. **INTERRELATIONSHIP**: SOW section 3.1.1.2

15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Structural Strength and Fatigue Analysis Reports provide a strength and fatigue analysis and a structural analyses database. Strength and fatigue analyses are documented to demonstrate that strength and fatigue requirements have been met. Preliminary strength and fatigue analyses shall assure the structural integrity of major structural elements and the credibility of weight calculations. Analyses provided in support of the 90%DR shall substantiate the structural integrity of detailed parts and provide the basis for approval of drawings. Analyses provided in support of certification shall fully substantiate the structural integrity of each detailed part in its final design configuration. Analyses provided in support of flight hardware shall be updated for the "as-built" configuration.

15.2 **REFERENCE DOCUMENTS**: None

15.3 **CONTENTS**: The report shall document strength and fatigue analyses for structural flight components and provide a structural analyses database for the flight hardware. These analyses shall verify the capability of the hardware to withstand worst case design loads. The strength and fatigue analyses reports shall identify such items as geometric description of each component, drawing or part number, identification of all applied loads, type of material and applicable strength and fatigue allowables, environments and effects, proper identification of reference inputs into the analyses, and a summary of calculated margins of safety and life predictions. An automated procedure shall be established to calculate margins for all structures and components. When loads from a new load cycle are provided, they shall be used to automatically determine new margins of safety. Effects of structural design changes shall be incorporated into this procedure so that margins of safety for the "as-built" configuration may be accurately calculated.

15.3 **CONTENTS (CONTINUED):**
When computer analyses, including finite element analyses are used, deliverable information shall include a description of the analyses with applicable geometry, dimensions, loads, other boundary conditions, annotated input data file(s), plots of model geometry, and results. This information shall be sufficient to recreate the analysis if necessary. Computer programs, data inputs, and data outputs utilized in these analyses must be documented and available to the Contracting Authority upon request.

15.4 **FORMAT**: Subcontractor format is acceptable. Reports shall be available in an electronic database.

15.4 **MAINTENANCE**: Changes shall be incorporated by change page or complete reissue.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1DE-011**
3. **DATA TYPE**: 4
4. **DATE REVISED:**
5. **PAGE**: 1/1

6. **TITLE**: Reactor Subsystem and Component Test Reports

7. **DESCRIPTION/USE**: To document the as-run test matrix, test procedures, as-built test article, test results, data analysis, and conclusions of the reactor subsystem and component test programs.

8. **OPR**: N/A

9. **DM**: N/A

10. **DISTRIBUTION**: Per Contracting Officer's letter

11. **INITIAL SUBMISSION**: As requested.

12. **SUBMISSION FREQUENCY**: As requested.

13. **REMARKS**: None

14. **INTERRELATIONSHIP**: SOW Appendix E

15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Reactor Subsystem and Component Test Reports covers test activities required for development, qualification, acceptance, and certification. The data from the tests are used for project risk mitigation and verification of function, performance, and operation. These reports provide the complete record of the test activities and provide the data upon which formal requirement verification and validation records are developed.

15.2 **REFERENCE DOCUMENTS**:

| | |
|---|---|
| AIAA G-054-2003e | *AIAA Guide to Assessing Experimental Uncertainty - Supplement to S-071A-1999 (G-054-2003e)* |
| ASME PTC 19.1 | *Test Uncertainty, Instruments and Apparatus* |

15.3 **CONTENTS**: The Reactor Subsystem and Component Test Reports shall include a detailed as-built test article description; the as-run test matrix (including test article configurations, test parameters, test durations, and number of tests) with detailed rationale for all deviations from the planned matrix; detailed descriptions of the instrumentation and data acquisition systems; detailed descriptions of as-built test setup; detailed presentation of test results, including a detailed assessment showing how the results have satisfied each objective enumerated in the test plan; and test conclusions. Quantitative test data shall be presented with the associated experimental uncertainty, as determined using the methods provided in ASME PTC 19.1 and AIAA G-054-2003e.

15.4 **FORMAT**: Subcontractor format is acceptable, however all charts, data plots, and graphics must be explained in narrative form.

15.5 **MAINTENANCE**: Changes shall be incorporated by change page or complete reissue.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1DE-012**
3. **DATA TYPE**: 2 (for CMMs), 3 (for other models and analyses)
4. **DATE REVISED**:
5. **PAGE**: 1/1

6. **TITLE**: Reactor Subsystem Analyses and Critical Math Models

7. **DESCRIPTION/USE**: To provide reactor subsystem and component-level performance, dispersions analyses and element and system trade studies. This shall include critical math models used in the integration of the reactor and the NTP subscale engine.

8. **OPR**: N/A

9. **DM**: N/A

10. **DISTRIBUTION**: Per Contracting Officer's letter

11. **INITIAL SUBMISSION**: As part of 30% Design Review (30%DR) data package

12. **SUBMISSION FREQUENCY**: As part of the 90% Design Review (90%DR) data packages. Periodically as significant changes and updates occur; periodically as necessary to support technical interchange meetings requested by INL/NASA.

13. **REMARKS**: None

14. **INTERRELATIONSHIP**: SOW section 3.1.1.2

15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Reactor Subsystem Analyses and Models covers the performance of the reactor subsystem.

15.2 **REFERENCE DOCUMENTS**: None

15.3 **CONTENTS**: The Reactor Subsystem Analyses and Critical Math Models shall be made to predict the performance of the components and reactor subsystem from beginning of development life to termination of the reactor life cycle. Analysis shall include consideration of the reactor subsystem and component performance uncertainties, other propulsion operation and duty cycle. Analytical processes shall be described, analysis inputs identified, and analysis results reported. Nominal and contingency performance shall be described. Design trade studies shall be documented and include a description of what was traded, selection criteria and weighting, and the result of the trade.

15.4 **FORMAT**: Subcontractor shall conform to delivery media formats and electronic data formats per Contracting Officer approval.

15.5 **MAINTENANCE**: Changes shall be incorporated as required by change page or complete reissue. Generic model updates require Contracting Authority approval.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1LS-003**
3. **DATA TYPE**: 2/2a
4. **DATE REVISED**:
5. **PAGE**: 1/2
6. **TITLE**: Reactor Supportability Plan
7. **DESCRIPTION/USE**: To describe the maintenance and support concepts and provide the requirements and plans for program supportability. This includes plans for hardware processing and estimation of logistics support resources. This plan will define the support concept that will be used to meet the life-cycle cost and availability requirements for the reactor.
8. **OPR**: N/A
9. **DM**: N/A
10. **DISTRIBUTION**: Per Contracting Officer's letter
11. **INITIAL SUBMISSION**: Draft at System Requirements Review (SRR)
12. **SUBMISSION FREQUENCY**: Baselined with 30% Design Review (30%DR); update as necessary
13. **REMARKS**: The following documents may be used as guides:

| | |
|---|---|
| NPD 4200.1 | *Equipment Management* |
| NPD 6000.1 | *Transportation Management* |
| NPD 8800.14 | *Policy for Real Property Management* |
| NPG 6000.1 | *Requirements for Packaging, Handling and Transportation for Aeronautical and Space Systems Equipment and Associated Components* |

14. **INTERRELATIONSHIP**: SOW section 3.1.8
15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Reactor Supportability Plan identifies the maintenance and support concepts and the needs, requirements, and plans for implementing these concepts for the system's operational life.

15.2 **REFERENCE DOCUMENTS**:

| | |
|---|---|
| NPD 7500.1 | *Program and Project Logistics Policy* |
| NPR 6000.1 | *Requirements for Packaging, Handling, and Transportation for Aeronautical and Space Systems, Equipment, and Associated Components* |

15.3 **CONTENTS**: The Reactor Supportability Plan shall adhere to the applicable requirements of NPD 7500.1 and include as a minimum the following elements:

a. Supportability organization, responsibilities, and interfaces with reliability, maintainability, and design engineering.
b. Maintenance and support concept:
    1. Maintenance levels and maintenance sites.
    2. Maintenance functions per level.
    3. Maintenance environment (i.e., organization and resources available at each level/site).
    4. Repair/sparing policy.
    5. Maintenance packaging approach.
    6. Maintenance item selection criteria.
c. Support plans, policies and criteria:
    1. Facility plan.
    2. Personnel and training plan.
    3. Test and support equipment plan.
    4. Supply support plan.
    5. Packaging, handling, storage and transportation plans.
    6. Provisioning plans.
    7. Computer services plan.
    8. Plan for major contingencies, i.e., launch scrub and abort.
    9. Planned upgrades (e.g., obsolescence) planning.
    10. Standardization/commonality policy.
    11. Technical data/database documentation criteria and management.
    12. Post-production support (i.e., performance evaluation, sustaining engineering).
    13. Training policies.

15.4 **FORMAT**: Subcontractor format is acceptable.

15.5 **MAINTENANCE**: Changes shall be incorporated by complete reissue.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1LS-004**
3. **DATA TYPE**: 3
4. **DATE REVISED**:
5. **PAGE**: 1/2
6. **TITL**E: Reactor Supportability Analysis

7. **DESCRIPTION/USE**: To perform analysis to support the design-for-supportability process and to determine the estimated total resources necessary to support the maintenance of the flight system over its operational life. Data generated will be used as inputs for assessments and development of reactor life-cycle cost and availability requirements.

8. **OPR**: N/A
9. **DM**: N/A

10. **DISTRIBUTIO**N: Per Contracting Officer's letter

11. **INITIAL SUBMISSIO**N: Conceptual-level analyses sufficient to support Architecture supportability trades shall be submitted at System Requirements Review.

12. **SUBMISSION FREQUENCY**: Updates shall reflect the most current design information and shall be submitted with major program reviews, 30% Design Review (30%DR), 90% Design Review (90%DR).

13. **REMARKS**: The following documents shall be used as guides:

| | |
|---|---|
| NPD 7500.1 | *Program and Project Logistics Policy* |
| NPD 8720.1 | *Reliability and Maintainability Program Policy* |
| MIL-HDBK-502 | *Acquisition Logistics* |
| MIL-PRF-49506 | *Logistics Management Information* |

14. **INTERRELATIONSHIP**: SOW section 3.1.1.1

15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Supportability Analysis will address the total support resources required for the maintenance and operation of the reactor subsystem over its operational life.

15.2 **REFERENCE DOCUMENTS**: None

15.3 **CONTENTS**: The Reactor Supportability Analysis shall provide information under the following categories:

a. Reliability Centered Maintenance Analysis Results.
b. Maintenance Task Analysis Results.
c. Maintenance Packaging Analysis Results.
d. Repair Level Analysis Results.
e. Test and Support Equipment Needs or Requirements.
f. Facility Needs or Requirements.
g. Manpower, Personnel and Training Needs or Requirements.
h. Provisioning and Supply Support Analysis Results.
i. Standardization/commonality analysis results.
j. Packaging, handling, stowage and transportation needs or requirements.

15.3 **CONTENTS (CONTINUED)**:

k. Post-production support (e.g., fielding, performance evaluation, sustaining engineering) requirements results.
l. Technical data, documentation, and database needs or requirements.

15.4 **FORMAT**: Subcontractor format is acceptable.

15.5 **MAINTENANCE**: Changes shall be incorporated by change page or complete reissue.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.: SNP1MA-004**
3. **DATA TYPE**: 2
4. **DATE REVISED:**
5. **PAGE**: 1/2

6. **TITLE**: Work Breakdown Structure (WBS) and WBS Dictionary

7. **DESCRIPTION/USE**: To establish a product-oriented framework for reporting program cost, schedule, and technical performance. To provide a basis for uniform planning, reporting status, program visibility, and assignment of responsibilities.

8. **OPR**: N/A
9. **DM**: N/A

10. **DISTRIBUTION**: Per Contracting Officer's letter.

11. **INITIAL SUBMISSION**: Authority to Proceed (ATP) plus 60 days.

12. **SUBMISSION FREQUENCY**: Update as required.

13. **REMARKS**: NPD 7120.4 (Current Revision), *Program/Project Management*, NPR 7120.5 (Current Revision), *NASA Program and Project Management Processes and Requirements*, and MIL-HDBK-881, *Department of Defense Handbook Work Breakdown Structure*, shall be used as guides in the preparation of the WBS and the WBS dictionary.

14. **INTERRELATIONSHIP**: SOW section 3.1.8

15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Work Breakdown Structure (WBS) establishes a product-oriented logical subdivision of hardware, software, services, facilities, etc., that make up the total project scope of work. The WBS Dictionary provides a narrative description of the tasks and effort to be performed in each WBS element.

15.2 **REFERENCE DOCUMENTS**: None

15.3 **CONTENTS**: The WBS and WBS Dictionary are two distinct project documents used for defining the approved project scope of work. The contents of each document are detailed in the following paragraphs:

a. WBS – A logical, hierarchical display of the subdivision of all project work to be completed. The WBS shall include the approved element title and element number.

b. WBS Dictionary – The WBS dictionary shall describe and document the work content of every WBS element and relevant efforts associated with each element (e.g., design, development, and manufacturing). The WBS dictionary shall be arranged in the same order as the contract WBS.

The WBS dictionary shall include the following for each WBS element:

1. WBS element title.
2. WBS element code.
3. WBS element content description (including quantities, relevant associated work, and contract end items where applicable).
4. WBS Index.

15.3 **CONTENTS (CONTINUED)**:

5. SOW paragraph number.
6. Specification (number and title) associated with the WBS element (if applicable).
7. Contract line item associated with the WBS element.
8. Date, revision number, revision authorization and approved changes.
9. Contract Identification Number.
10. Budget and reporting number (i.e., Charge Code).

15.4 **FORMAT**: Subcontractor format is acceptable.

15.5 **MAINTENANCE**: Changes shall be incorporated by change page or complete reissue.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.: SNP1MA-006**
3. **DATA TYPE**: 2/3
4. **DATE REVISED**:
5. **PAGE**: 1/2

6. **TITLE**: Risk Management Plan and Risk Management Reports

7. **DESCRIPTION/USE**: To provide the Subcontractor and the Contracting Authority a baseline document for planning, management, control, and implementation of the Subcontractor's risk management program. To implement a continuous risk management process that is consistent with the Contracting Authority provided guidelines. To develop and maintain risk management waterfall charts per the attached example.

8. **OPR**: N/A

9. **DM**: N/A

10. **DISTRIBUTION**: Per Contracting Officer's letter

11. **INITIAL SUBMISSION**: Draft Risk Management Plan and waterfall charts with the proposal. Population and maintenance of the Risk Management database to begin no later than 30 days after Authority to Proceed (ATP).

12. **SUBMISSION FREQUENCY**: An updated Risk Management Plan shall be provided no later than 30 days after ATP for baselining (Type 2). Following baselining, the Risk Management Plan shall be updated as necessary to incorporate a continuous risk management philosophy.

    The Risk Management Database will be updated as required to reflect current status and will be accessible to the Contracting Authority. The Risk Management Reports shall be submitted monthly. Changes in the assessment of risk for a particular task shall be reported to the Contracting Authority within 2 business days of the change.

13. **REMARKS**: The Risk Management Plan shall be data type 2. All other submissions are type 3.

14. **INTERRELATIONSHIP**: SOW section 1.2

15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Risk Management Plan addresses how risk management requirements are to be implemented throughout the program's life cycle. The Risk Management Report provides a status of risk mitigation plans and activities and is an output of the Risk Management Database.

15.2 **REFERENCE DOCUMENTS**:

MWI 7120.6 *Marshall Work Instructions – Program/Project Risk Management*

15.3 **CONTENTS**:

The Risk Management Plan shall specify how the Subcontractor will satisfy the risk management requirements. The plan shall specify how the Subcontractor will document risk management activities and how the Subcontractor will communicate risk issues and concerns to the Contracting Authority.

15.3 **CONTENTS (CONTINUED)**:

The Risk Tracking Report shall be an output of the risk management database. The Risk Tracking Report shall contain the following data:

1. Current assessment of risk as a combination of the likelihood of occurrence and the consequences of occurrence. The likelihood and consequences of occurrence must be scored from 1 to 5 with 5 being the highest likelihood or most severe consequence.
2. Status of all risk mitigation plans and metrics.
3. Summary of risk analyses.
4. Summary of risk mitigation activity and progress including objective evidence of exit criteria accomplishments.
5. Technology Readiness Level (TRL) progression chart. The TRL progression chart is generated in the same manner as the Risk Waterfall chart except that TRL replaces Risk as the Y axis label. TRL shall increase from the top of the chart to the bottom.
6. Documentation of replanning activities that result from unsuccessful mitigation plans and risk acceptance/closures.

15.4 **FORMAT**: Subcontractor format for report is acceptable as documented in approved Risk Management Plan.

15.5 **MAINTENANCE**: Changes shall be incorporated by change page or complete reissue.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1MA-011**
3. **DATA TYPE**: 3
4. **DATE REVISED**:
5. **PAGE**: 1/2
6. **TITLE**: Technical Performance Report
7. **DESCRIPTION/USE**: To provide data for the assessment of the design, development, test, evaluation, and related integration for the system and its elements.
8. **OPR**: N/A
9. **DM**: N/A
10. **DISTRIBUTION**: Per Contracting Officer's letter
11. **INITIAL SUBMISSION**: Authority to Proceed (ATP) plus 60 days
12. **SUBMISSION FREQUENCY**: Submit monthly summary at Monthly Performance Review (MPR) and full report at major reviews; per Contracting Authority direction.
13. **REMARKS**: Reference is made to NPD 7120.4B, *Program/Project Management* and NPR 7120.5, *NASA Program and Project Management Processes and Requirements*. These documents shall be used as guides in preparation of the Technical Performance Report.
14. **INTERRELATIONSHIP**: SOW Attachment A, Table A.1-1, and SOW section 3.1.1.2
15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Technical Performance Report presents a comparison of the expected performance and physical characteristics with the contractually specified values. It is the basis for reporting established milestones and describes progress toward meeting the technical requirements.

15.2 **REFERENCE DOCUMENTS**: None

15.3 **CONTENTS**: The Technical Performance Report shall identify specific reactor technical parameters that are considered critical. These items shall include critical requirements such as those identified in the contract end item specification(s). The provisions for measurement and tracking each parameter may include items such as:

a. Specification requirements and approved changes.
b. Program events significant to the achievement of the end value.
c. Conditions of measurement.
d. Current measurement values.
e. Predicted value of end product.

Identify variances from the approved technical requirements where adjustments are not made, if such variances will cause the performance of critical items to fall below the established minimum values.

In critical areas, analyze variances exceeding the tolerances to determine causes and assess the impact of changes on measurement control parameters, interface requirements, schedule, and cost, as appropriate. In instances of impact to the Subcontractor, the Subcontractor's evaluation shall be obtained.

For identified performance deficiencies, procedures for developing recovery plans shall be specified that identify appropriate implications.

15.4 **FORMAT**: Subcontractor format is acceptable. Quantitative measurements shall be utilized to determine program success. These reports shall be maintained electronically.

15.5 **MAINTENANCE**: None required

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1MA-016**
3. **DATA TYPE**: 3
4. **DATE REVISED**:
5. **PAGE**: 1/1

6. **TITLE**: Final Report

7. **DESCRIPTION/USE**: To provide a summary of the results of the entire contract effort, including recommendations and conclusions.

8. **OPR**: N/A 9. **DM**: N/A

10. **DISTRIBUTION**: Per Contracting Officer's letter. In addition to the final report submitted to the Contracting Officer, the Subcontractor shall concurrently provide to the Center STI/Publication Manager and the NASA Center for AeroSpace Information (CASI) a copy of the letter transmitting the final report to the Contracting Officer. The copy of the letter shall be submitted to CASI at the following address: Center for AeroSpace Information (CASI); Attn: Acquisitions Collections Development Specialist; 7121 Standard Drive; Hanover, Maryland 21076-1320

11. **INITIAL SUBMISSION**:

12. **SUBMISSION FREQUENCY**: 30 days after completion of contract

13. **REMARKS**:

14. **INTERRELATIONSHIP**: SOW Table 4.1-1

15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Final Report summarizes the results of the entire contract work.

15.2 **REFERENCE DOCUMENTS**:

NFS 1852.235-73 *Final Scientific and Technical Reports*

15.3 **CONTENTS**: The Final Report shall be prepared and submitted in accordance with NFS 1852.235-73. The Final Report shall contain the information required by NFS 1852.235-73. The Final Report shall summarize the results of the entire contract, including recommendations and conclusions based on the experience and results obtained. The Final Report shall include tables, graphs, diagrams, curves, sketches, photographs, and drawings in sufficient detail to explain comprehensively the results achieved under the contract. The Final Report shall include a completed report documentation page (Standard Form 298) as the final page, per NFS 1852.235-73(c).

15.4 **FORMAT**: Subcontractor format is acceptable for the text of the report. The final page of the report shall be in accordance with Standard Form 298. The report shall be provided in both hardcopy and electronic versions. Electronic format shall be in accordance with NFS 1852.235-73.

15.5 **MAINTENANCE**: None required.

**DATA REQUIREMENTS DESCRIPTION (DRD)**

1. **DPD NO.**: SNP1 **ISSUE**: Standard
2. **DRD NO.**: **SNP1MA-017**
3. **DATA TYPE**: 3
4. **DATE REVISED**:
5. **PAGE**: 1/5

6. **TITLE**: Integrated Program Management Report (IPMR)

7. **DESCRIPTION/USE:** To communicate program cost and schedule information between the Subcontractor and INL/NASA. It may also be tailored for use on intra-government work agreements. It consists of seven formats that provide program managers information to: (1) integrate cost and schedule performance data with technical performance measures, (2) identify the magnitude and impact of actual and potential problem areas causing significant cost and schedule variances, (3) forecast schedule completions, and (4) provide valid, timely program status information to higher management.

   a. Format 1 defines cost and schedule performance data by product-oriented Work Breakdown Structure (WBS).

   b. Format 2 defines cost and schedule performance data by the Subcontractor's organizational structure (e.g., Functional or Integrated Product Team (IPT)).

   c. Format 3 defines changes to the Performance Measurement Baseline (PMB).

   d. Format 4 defines staffing forecasts.

   e. Format 5 is a narrative report used to provide the required analysis of data contained in Formats 1-4 and 6.

   f. Format 6 defines and contains the Subcontractor's Integrated Master Schedule (IMS).

8. **OPR:** N/A
9. **DM:** N/A

10. **DISTRIBUTION:** Per Contracting Officer's letter

11. **INITIAL SUBMISSION:** Preliminary IMS (Format 6) is due with proposal. The first submission (Formats 1-6) is due between 60 and 90 calendar after the Authority to Proceed (ATP); pending Contracting Authority approval

12. **SUBMISSION FREQUENCY:** Monthly for Formats 1-6 by the 12th working day after the close of the Subcontractor's accounting month.

13. **REMARKS:** The IMS (Format 6) will be baselined after ATP as agreed to by both parties and not to exceed 90 days after ATP. Reference is made to NPR 7120.5 (Current Revision), *NASA Space Flight Program and Project Management Requirements*, NPR 7120.7 (Current Revision), *NASA Information Technology and Institutional Infrastructure Program and Project Management Requirements*, NPR 7120.8, (Current Revision), *NASA Research and Technology Program* and *Project Management Requirements, NASA Schedule Management Handbook* (Current Revision) and *NASA IPMR Data Requirements Description (DRD) Implementation Guide* available at https://www.nasa.gov/evm These documents shall be used as guides in preparation of the IPMR.

14. **INTERRELATIONSHIP:** SOW section 3.1.8

15. **DATA PREPARATION INFORMATION:**

15.1 **SCOPE:** The Integrated Program Management Report (IPMR) is the primary means of communicating cost and schedule performance and project health information between the Subcontractor and INL/NASA.

15.2 **REFERENCE DOCUMENTS/CLAUSES:**

DI-MGMT-81861 Data Item Description: Integrated Program Management Report (IPMR) (latest version) (Available at: https://www.acq.osd.mil/evm/#/policy-guidance/dids-cdrls-standards)

15.3 **CONTENTS:** All IPMR Formats (Formats 1-7) are required. The IPMR shall include all data pertaining to all authorized contract work, including both priced and unpriced effort that has been authorized at a not-to- exceed amount in accordance with the Contracting Officer's direction. The Subcontractor shall provide monthly IPMRs per DI-MGMT-81861 (latest version) except as modified in this section.

a. Format 1 Instructions: Provide reporting at level 3, except for high cost or high-risk items per the DRD STD/MA-WBS, Contract Work Breakdown Structure and include General and Administrative (G&A) and Cost of Money (COM) as non-add.

b. Format 2 Instructions: Use organizational categories, e.g. IPT or functional organization including each Subcontractor with EVMS flow-down (NFS 1852.234-2) and each major vendor separately as a non- add item.

c. Format 3 Instructions: Significant differences (absolute values exceeding ±5%) between the PMB at the beginning and end of each specified period shall be explained in Format 5. Use quarterly periods for Block 6, columns (10) through (11), yearly periods for columns (12) through (13), and the remainder of the contract for column (14).

d. Format 4 Instructions: Significant changes that require explanations in Format 5 are those that change the absolute value of the projected total staff-months at completion of any organizational or functional category by more than ±5%. Use quarterly periods for Block 5, columns (10) through (11), yearly periods for columns (12) through (13), and the remainder of the contract for column (14).

e. Format 5 Instructions: The reporting level identified above is the level where variance reporting thresholds are applied. Variance analysis shall be required for:

1. Three largest current cost variances exceeding ± 5% and ± $50K.
2. Three current schedule variances exceeding ± 5% and ± $50K.
3. Three largest cumulative cost variances exceeding ±10% and ± $100K.
4. Three largest cumulative schedule variances exceeding ± 10% and ± $100K.
5. Three largest variances at completion exceeding ± $250K and other cost and schedule variances or technical performance issues that are causing or are likely to cause significant schedule delays or cost overruns.

**15. DATA PREPARATION INFORMATION (CONTINUED)**

The required narrative explanations and variance thresholds will be reviewed periodically and may be adjusted by contract modification with no change in contract price. All reportable WBS variance narratives shall adequately address the root cause of the variance; adequately discuss any schedule variance in terms of float and impact to the program critical path, if any, and quantitatively explain the causes that account for at least 70% of the variance exceeding the threshold. If there are no changes to the reportable element problem analysis, expected impacts, or corrective action status, then specify "no changes since the last reported analysis" and reference the IPMR date when the narrative was initially reported.

Schedule Analysis (See Format 6 Instructions below). Include the results of the Schedule Risk Assessment (SRA) when performed within the reporting month. The SRA report is in Subcontractor format and includes assumptions; probability of result to the specified target; analysis of results; actions taken as a result of the analysis; and results, if any, of the steps taken. Discuss changes to the schedule based on the results of the SRA. A SRA shall be conducted prior to an Integrated Baseline Review (IBR), System Requirements Review (SRR), 30% Design Review (30%DR) and 90% Design Review (90%DR). It shall also be conducted before implementing an Over Target Baseline/Over Target Schedule (OTB/OTS) and a Single Point Adjustment. The SRA report is in Subcontractor format and includes assumptions; probability of result to the specified target; analysis of results; actions taken as a result of the analysis; and results, if any, of the steps taken. Discuss changes to the schedule and most likely EAC based on the results of the SRA. Critical and driving path analysis should also include identification and analysis of the primary critical path and all near (secondary) critical paths whose total slack (float) values are within 10 working days or less of the primary critical path. The analysis shall be submitted in a waterfall format and organized in a manner such that the path with the least amount of slack is delineated first and followed by each successive path according to total slack values. When driving path analysis is desired, the specified project milestones and/or major project events are to be identified for Subcontractor reporting. **NOTE:** If driving paths are identified through the use of assigned task constraints (limited or fixed start/finish dates) within the IMS, then it should be removed from the IMS after identification/explanation of driving path is complete. Constraints that are left within the IMS unnecessarily will hinder or prevent accurate project critical path identification and analysis.

Provide the results of the monthly schedule health analysis as discussed in Format 6 instructions. Reconciliation between the 533M/533Q, DRD STD/MA-FMR, and the IPMR (Formats 1-4) shall be included.

In some cases, additional variance analysis is required to cover emerging trends. In this case, the supplier will be required to report additional variances for a time period of 6 months or less.

## 15. DATA PREPARATION INFORMATION (CONTINUED)

f. **Format 6 Instructions:** The IMS shall include all discrete work at a minimum. The Subcontractor and teammates (if any) data shall be consistent, statused monthly and based on the same cutoff date to enable a realistic critical path. The WBS in the IMS shall be consistent with the Format 1 WBS structure.

**Summary Master Schedule:** The schedule shall include a top-level Gantt chart summary arranged by WBS and that reflects all contract and controlled milestones, major program/project phases (i.e. design, fabrication, integration, assembly, test, etc.) and all end item deliveries. It shall reflect either by manual creation or by automated summarization, a vertically integrated rollup of intermediate and detailed schedule data.

**Detailed Schedules:** The detailed schedules shall contain vertical and horizontal integration at the task/milestone level of detail (vice the work package/planning package level) to provide better definition in task sequence and greater accuracy in critical path identification.

**IMS Fields:** Additional IMS fields required in the schedule are WBS, LOE identification, responsible organization, and planning package identification. A field identifying critical path is not required. The WBS in the IMS shall be consistent with the EVMS WBS within the Format 1. If the IMS WBS field is not directly related, then a user-defined WBS field traceable to the EVMS WBS must be added (see DI- MGMT-81861 paragraph 3.7.1. IMS Requirements).

**Relationships/Dependencies:** All discrete tasks/milestones except for the start and end of the contract or for interim receipt and delivery events to/from external entities shall have at least one predecessor and successor.

**Level of Effort (LOE) in the Schedule:** If LOE tasks are excluded from the schedule, the Subcontractor must clearly document within the System Description how the LOE efforts are planned and measured.

**Schedule Margin:** If schedule margin is included in the IMS, it must be as a defined task and clearly labeled as “Schedule Margin” or “Schedule Reserve.” The number of schedule margin tasks should be minimal with most of the margin duration placed as the last task before the ending contract event or the end item delivery. Other acceptable locations for placing smaller amounts of schedule margin are prior to high-level project milestones, such as 30% Design Review (30%DR), 90% Design Review (90%DR), System I&T Complete, etc.

**15. DATA PREPARATION INFORMATION (CONTINUED)**

In addition to the native IMS file, the Subcontractor shall provide the IMS discussion and analysis as required in Format 5 (see DI- MGMT-81861 paragraph 3.7.1. IMS Discussion and Analysis) to include the results of the Subcontractor's internal health analysis. This analysis shall include counts for the following schedule assessment indicators: 1) the total number of tasks, milestones and non-detail (e.g., summary, hammock, rollup, etc.) activities contained in the schedule, 2) the number of completed tasks and milestones, 3) the number of tasks and milestones to be completed, 4 ) the number of tasks and milestones that have no predecessor and/or no successor relationships and document why, 5) the total number of tasks and milestones that have a total float (slack) value greater than 25% of the remaining duration of the total program/project schedule, 6) the total number of non-detail (e.g., summary, hammock, rollup, etc.) activities that have assigned predecessor or successor logical relationships, 7 ) the total number of tasks and milestones that have constraint (forced or fixed) dates, and 8) provide explanations and corrective actions.

15.4 **FORMAT:** Subcontractor formats can be substituted for IPMR formats whenever they contain all the required data elements at the specified reporting levels in a form suitable for Contracting Authority management use. The IPMR shall be submitted electronically. IPMR formats shall be completed according to the instructions outlined in DI-MGMT- 81861 (latest version). The UN/CEFACT XML file must be reported at the control account level. Report Formats 1-3 and 7 by dollars, Format 4 by full-time equivalents. Formats 1-4 will also be submitted in human readable formats such as word processor, spreadsheet or PDF file. Format 5 shall be submitted in Subcontractor native format. The basis for variance analysis is in dollars. Format 6 shall be submitted in the Subcontractor's native schedule electronic file format and the UN/CEFACT XML. IPMRs required from Subcontractors shall also be provided electronically using the same instructions and electronic formats stated above.

15.5 **MAINTENANCE:** Change shall be incorporated by complete reissue.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1MP-003**
3. **DATA TYPE**: 3
4. **DATE REVISED**:
5. **PAGE**: 1/3
6. **TITLE**: Manufacturing and Assembly Plan
7. **DESCRIPTION/USE**: To establish the requirements for the Manufacturing and Assembly Plan so that the program can scope the entire magnitude of the task to be accomplished and provide technically sound, efficient, and cost-effective plan of action to ensure projected schedules can be maintained. The plan shall define the make-or-buy process, including objectives, criteria, management, logic, and results.
8. **OPR**: N/A
9. **DM**: N/A
10. **DISTRIBUTION**: Per Contracting Officer's letter
11. **INITIAL SUBMISSION**: Preliminary draft no later than two weeks prior to Systems Requirements Review (SRR)
12. **SUBMISSION FREQUENCY**: Baseline at 30% Design Review (30%DR), update at 90% Design Review (90%DR)) and as required.
13. **REMARKS**: None
14. **INTERRELATIONSHIP**: SOW section 3.1.3
15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Manufacturing and Assembly Plan is applicable to hardware developer(s), Subcontractor(s), and vendor(s).

15.2 **REFERENCE DOCUMENTS**:

| | |
|---|---|
| MSFC-STD-506 | *Standard, Materials and Processes Control* |
| MSFC-SPEC-250 | *Protective Finishes for Space Vehicle Structures and Associated Flight Equipment, General Specification for* |
| MSFC-SPEC-445 | *Adhesive Bonding, Process and Inspection, Requirements for* |
| MSFC-STD-506 | *Standard, Materials and Processes Control* |
| MAPTIS-II database | Electronic Materials Selection List for MSFC Space Hardware Systems available @ http://maptis.nasa.gov/ |
| JSC SP-R-0022A | *General Specification, Vacuum Stability Requirements of Polymeric Materials for Spacecraft Applications* |
| MSFC-STD-246 | *Standard Design and Operational Criteria of Controlled Environmental Areas* |
| MSFC-SPEC-1238 | *Thermal Vacuum Bakeout Specification for Contamination Sensitive Hardware* |
| MSFC-SPEC-1443 | *Outgassing Test for Non-Metallic Materials Associated with Sensitive Optical Surfaces in a Space Environment* |
| MPR 5340.1 | *Controlled Work Area, Clean Room and Flow Bench Operations* |
| MIL-STD-1246 | *Product Cleanliness Levels and Contamination Control Program* |
| ASTM E595 | *Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment* |

15.3 **CONTENTS**: This plan shall define the objective, methods, and procedures to be used in the manufacture and assembly of the deliverable hardware. Specifically, the plan shall contain:

a. Organization – A description of the manufacturing and assembly organizations and policies.
b. Controls – A description of the controls to be used by the fabrication and assembly organization for procurements, inspection and testing, nonconformance reporting, material control, configuration control, manufacturing and assembly documentation shall be defined.
c. Procured Assemblies – Identify the major components and assemblies to be procured rather than manufactured and/or assembled in-house, long lead time procurements, and risks associated with sole or proprietary sources.
d. Producibility Plan – The plan shall define the producibility analysis process to be used in the development of deliverable hardware.
e. Manufacturing and Assembly Flow – The methods, procedures, and operations of control points used to plan, manufacture, and monitor the fabrication and assembly of the deliverable hardware shall be defined.
f. Critical Items – All processes, methods, facilities, tooling, or skills critical to success shall be identified. New, unique, or unfamiliar processes shall be identified with rationale explaining why these procedures are to be used. Critical manufacturing processes shall be identified and maturity of the process discussed.
g. Schedules – The development and maintenance of manufacturing and assembly schedules showing milestones and completion dates necessary to ensure that deliverable end items shall be met.
h. Capabilities and Facilities – The facilities and capabilities required for fabrication, manufacturing, and assembly shall be described. New facilities or equipment needed to be built to support reactor manufacturing and assembly shall be identified. Availability of existing fabrication and assembly equipment and facilities shall be discussed.
i. Materials and Processes (M&P) Selection, Implementation, and Control – Provide definition of the objectives, procedures, logic, and management controls of the hardware developer's, i.e., Subcontractor's, M&P selection, implementation, verification, and control program; and the hardware developer's interfaces with the procuring activity necessary. The plan shall describe the hardware developer activities involved in the identification, evaluation, documentation, and reporting of materials and processes usage in space flight hardware, support hardware, and ground support equipment. The necessary interfaces with procuring activity in the operation of this plan shall be defined. The method for materials control and verification of Subcontractors and vendors shall be included in the hardware developer's plan.
    1) Hardware Developer's Organization – Authority shall be assigned to an individual or group who shall be responsible for review and approval of all M&P specified prior to release of engineering documentation.
    2) Materials and Processes Identification – Identification and documentation of the M&P used, both in the original design and in any changes.

**15.3 CONTENTS (CONTINUED):**

3) Usage Evaluation – Documentation of M&P used in accordance with the Material and Process Identification and Usage List (MIUL) requirements of MSFC-STD-506 and the comparison of test data to selection requirements.
4) Testing – Logic, procedures, and data documentation for any proposed test program to support materials screening and verification testing.
5) Material Usage Agreement (MUA) Procedures – Logic, procedures and documentation involved in documenting and approving materials/processes as indicated in MSFC-STD-506 shall be defined, including those that do not meet the established requirements but are proposed for use due to lack of replacement materials/processes or other considerations.
6) New Technology – Identify areas of new test technology or technique improvement for consideration.
7) Approved Materials List (AML) – Hardware developer shall issue and maintain an Approved Materials List from which all materials, including fasteners, shall be selected. The selection of materials shall be based on consideration of cost, availability, reliability, and compatibility with the hardware environment.
8) Approved Processes List (APL) – Hardware developer shall issue and maintain an Approved Processes List from which all processes shall be selected.
9) Corrosion Prevention, Control and Protective Finish Plan – Describing the process for corrosion prevention, control and protective finish.
10) Forging Plan – A forging plan shall be developed showing locations and numbers of specimens to be excised from the first production equivalent size forging, including production forging verification and control measures.
11) Casting Plan – Hardware developer shall issue and maintain a casting plan in accordance with MSFC-STD-506 showing locations and numbers of specimens to be excised from the first production equivalent size casting, including production casting verification and control measures.
12) Adhesive Control and Operator Certification Plan – Hardware developer shall issue an adhesive control plan and adhesive bonding operator certification plan as described in MSFC-SPEC-445.
13) Review Procedures – Assessment and status of materials and processes to permit evaluation of a given design or configuration at hardware milestone reviews.

j. Contamination Control: Provide definition and implementation measures to assess for contamination control from design, through manufacturing, assembly, test, transportation and engine system integration such that environments, materials, and processes do not adversely affect hardware system life or performance. Provide definition for control and implementation measures for all stages of development and use, including 1) molecular and particulate contamination control requirements and how those requirements will be implemented; and 2) specific procedures for controlling, monitoring, verifying and reporting cleanliness and other production environment standards at all project phases as required by MPR 5340.1 and MSFC-STD-246.

15.4 **FORMAT**: Subcontractor format is acceptable and shall be consistent with contents of paragraph 15.3 of this DRD.

15.5 **MAINTENANCE**: Changes shall be incorporated by change page or complete reissue.

**DATA REQUIREMENTS DESCRIPTION (DRD)**

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1MP-005**
3. **DATA TYPE**: 3
4. **DATE REVISED**:
5. **PAGE**: 1/2

6. **TITLE**: Materials Identification and Usage List (MIUL)

7. **DESCRIPTION/USE**: The MIUL is an electronic searchable parts list or separate electronic searchable materials identification and usage list. The MIUL identifies all Material and Processes (M&P) usages contained in the end item, excluding piece part electronics, for evaluation of the acceptability of M&P selected and utilized.

8. **OPR**: N/A 9. **DM**: N/A

10. **DISTRIBUTION**: Per Contracting Officer's letter

11. **INITIAL SUBMISSION**: As part of the 30% Design Review (30%DR) data package

12. **SUBMISSION FREQUENCY**: As-designed MIUL – at Hardware Acceptance Review; As-built MIUL updates – prior to Flight Readiness Review (FRR)

13. **REMARKS**: None

14. **INTERRELATIONSHIP**: SOW Attachment A, Table A.1-1; and SOW section 3.1.1.2

15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The MIUL will be documented in an electronic searchable parts list or separate electronic searchable MIUL. The procedures and formats for documentation of materials and processes usage will depend upon specific hardware but shall cover the final design. The system used shall be an integral part of the engineering configuration control/release system. A copy of the stored data shall be provided to Contracting Authority in a form compatible with the Materials and Processes Technical Information System (MAPTIS) available at https://maptis.nasa.gov/.

15.2 **REFERENCE DOCUMENTS**:

NASA-STD-6016 *Standard Manned Spacecraft Requirements for Materials and Processes*

15.3 **CONTENTS**: The parts list or MIUL shall identify the following applicable information:

a. Detail drawing and dash number.
b. Next assembly and dash number.
c. Change letter designation.
d. Drawing source (Subcontractor or vendor).
e. Material form.
f. Material manufacturer.
g. Material manufacturer's designation.
h. Material specification.
i. Process specification.
j. Environment.
k. Weight.
l. Material code.

15.3 CONTENTS (CONTINUED):

m. Standard/commercial part number.
n. Subcontractor.
o. System.
p. Subsystem.
q. Maximum temperature.
r. Minimum temperature.
s. Fluid type.
t. Surface Area.
u. Associate Subcontractor number.
v. Project.
w. Document title.
x. Criticality.
y. Line number.
z. Overall evaluation.
aa. Overall Configuration test.
bb. Maximum pressure.
cc. Minimum pressure.
dd. Test MUA Document.
ee. Cure codes.

15.4 **FORMAT**: Subcontractor format is acceptable. However, Subcontractor format for electronic submittal of MIUL data shall be compatible with the NASA Materials and Processes Technical Information System (MAPTIS) database.

15.5 **MAINTENANCE**: Subcontractor updates to the MIUL shall be submitted to Contracting Authority for approval. Complete reissue of the document is not required.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1OP-003**
3. **DATA TYPE**: 2/2a
4. **DATE REVISED**:
5. **PAGE**: 1/2
6. **TITLE**: Reactor Operations Concepts Document
7. **DESCRIPTION/USE**: To describe the operational concepts for the reactor subsystem. To provide guidance to the reactor developers as to how the reactor is to be used, operated, and maintained in a given environment so that their specifications, designs, development, integration, and tests will accommodate overall reactor project goals, missions, and operational philosophy.
8. **OPR**: N/A
9. **DM**: N/A
10. **DISTRIBUTION**: Per Contracting Officer's letter
11. **INITIAL SUBMISSION**: As part of System Requirements Review (SRR) data package
12. **SUBMISSION FREQUENCY**: Update with the 30% Design Review (30%DR) and beyond that as required.
13. **REMARKS**: The following documents may be used as reference documents:

| | |
|---|---|
| SPP-6105 | *NASA Systems Engineering Handbook* |
| IEEE Std 1220-1994 | *Institute of Electrical Engineers (IEEE) Trial-Use Standard for Application of the Systems Engineering Process* |
| EIA 632 | *Electronics Industries Alliance (EIA) Standard: Processes for Engineering a System* |
| NPG 7120.5 | *NASA Procedures and Guidelines, NASA Program and Project Management Processes and Requirements* |
| MPG 7120.1 | *Program and Project Planning* |
| ANSI/AIAA-G043-1992 | *Guidance for Preparation of Operational Concept Documents* |

14. **INTERRELATIONSHIP**: SOW Table 4.1-1

15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Reactor Operations Concepts Document describes the desired operational system characteristics and concepts of the SNP subscale engine reactor, and how it is envisioned to integrate into the overall NTP subscale engine system.

15.2 **REFERENCE DOCUMENTS**: None

15.3 **CONTENTS**: The Reactor Operations Concepts Document shall provide guidance to the reactor developers on how the reactor is to be used, operated, and maintained in a given environment so that their designs, development, integration, and tests will accommodate SNP project goals, missions, and operational philosophy. The document shall describe the SNP project vision of the "*what, where, when, who, and why"* of reactor operations.

a. The Reactor Operations Concepts Documents (OCD) shall address, as a minimum, the following:
    1. Overview of the reactor and supporting systems.
    2. Description of operations concepts and scenarios for:
        (a) Manufacturing and Assembly.
        (b) Test.
        (c) Transportation and Handling.
        (d) Ground Operations.
b. Description of the operational environment.
c. Roles and Responsibilities.
d. Maintainability, supportability, Integrated Logistics Support (ILS) and sustaining engineering concepts.
e. Description of the capabilities and interfaces of the reactor operations systems and supporting infrastructure.
f. Description of operational goals, trades considered, issues, assumptions and constraints.
g. Analysis of operational effects on existing facilities, processes, organizational structures, and procedures.
h. Other items to provide additional understanding of the overall reactor concept of operations.

NOTE: It is expected that the depth and breadth of information contained in the OCD will increase over time and with subsequent deliveries.

15.4 **FORMAT**: Subcontractor format is acceptable.

15.5 **MAINTENANCE**: Changes shall be incorporated by change page or complete reissue.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1QE-002**
3. **DATA TYPE**: 2/2a
4. **DATE REVISED**:
5. **PAGE**: 1/3

6. **TITLE**: Quality Assurance Plan

7. **DESCRIPTION/USE**: The Quality Assurance Plan defines the objectives, responsibilities, and methods to be used for overall system safety program conduct and control. It describes the integration of quality assurance provisions into the total program based on early implementation, planned certification review/process, and total program life cycle support.

8. **OPR**: N/A

9. **DM**: N/A

10. **DISTRIBUTION**: Per Contracting Officer's letter

11. **INITIAL SUBMISSION**: At System Requirements Review (SRR)

12. **SUBMISSION FREQUENCY**: Update as required. The Quality Assurance Plan shall be updated to be kept current with program status.

13. **REMARKS**: A Department of Energy (DoE)-equivalent plan may be substituted if a rationale for the plan substitution is provided and accepted. This Quality Assurance Plan may be incorporated in more comprehensive safety and mission assurance plans or other general program plans provided the system safety data elements remain identifiable and completely reflect the requirements of this DRD. Reference is made to the following documents:

| | |
|---|---|
| NASA-STD-8739.8 | *NASA Software Assurance Standard* |
| NPD 8700.1A | *NASA Policy for Safety and Mission Success* |
| ANSI/ISO/ASQ Q9001-2000 | *American National Standard Quality Management Systems Requirements* |

14. **INTERRELATIONSHIP**: SOW section 3.1.10

15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Quality Assurance Plan shall be consistent with the status of the program's technical development providing a description of the quality assurance program necessary to support the total program life cycle. The plan will include detailed task requirements for the quality assurance task as tailored for this program. It will address requirements for safety organization participation in design, safety, and readiness reviews.

15.2 **REFERENCE DOCUMENTS**: None

15.3 **CONTENTS**: The Quality Assurance Plan shall:

a. Identify, as applicable, the specific quality activities (implementation) related to the design and development, procurement of materials/subcomponents, fabrication, test, shipping, flight operations, refurbishment, and reuse to ensure the quality of the items delivered. The plan shall reference the Subcontractor's quality manual and procedures as necessary to fully describe the Subcontractor quality system. The Plan shall include the following: An identification of each Quality task to be accomplished under the QA Program (e.g. Subcontractor monitoring, allocations process, etc.), a detailed description of how each quality task will be performed or complied with, and, the procedures (where existing procedures are applicable) to evaluate the status and control of each task.

b. Address each quality element of ANSI/ISO/ASQ Q9001-2000 supplemented by AS 9100, to describe the philosophy and approach for implementation. (Note: if the Subcontractor has not implemented ANSI/ISO/ASQ Q9001-2000 at ATP, then the quality plan shall be updated to comply with ANSI/ISO/ASQ Q9001-2000 within three years of ATP.) This may be satisfied by reference in the quality plan to the Subcontractor's existing quality manual provided a copy of the manual is delivered with the quality plan and the attendant procedures are available for review.

c. As a minimum, the subparagraphs below must be addressed by the quality plan and details of responsibilities and controls must be included to adequately describe the specific quality assurance activities related to hardware being procured by the program:
   1. Customer quality requirements – include hardware specific quality requirements imposed by contract or component/equipment specification (i.e., traceability requirements, specific inspection points, specific quality activities).
   2. Responsibilities – describe which Subcontractor organizations will perform the applicable quality activities below.
   3. Article, Material, and Service Controls – describe the level of article, material, and service control including traceability requirements invoked by the Subcontractor for the articles, materials, and/or services used in or performed as part of the hardware design and maintenance criteria, including how quality is ensured for each material, part, assembly, and/or service performed.
   4. Procurement – include the procurement quality requirements for all materials/parts/components the Subcontractor purchases and the level of control exercised over the suppliers (how are suppliers approved and monitored, how are supplier non-conformances monitored, etc.)
   5. Milestone Reviews – describe how the Subcontractor's quality system will support milestone reviews.
   6. Configuration Assurance – describe how the configuration of the hardware build is compared and verified to the approved design baseline drawings and specifications. Describe how the configuration of Government Furnished Property/Equipment is maintained.
   7. Special Process Controls – describe special process controls implemented for in-house processes and, if applicable, for sub-tier supplier processes.

15.3 **CONTENTS (CONTINUED)**:

8. Inspection and Test (describe who performs what inspections where) – include: how the quality of purchased items is validated at receiving inspection or at sub-tier suppliers' facilities, specific in-process (manufacturing) inspections performed, details of final inspection, functional and environmental test monitoring details, and pre-ship inspections. When applicable, provisions will be included for development of site quality plans for major end item test and flight test.
9. Nonconforming Product (Material Review Board (MRB) Process) – describe the process of convening a nonconforming product material review board to disposition nonconforming product using a defined board of qualified personnel including Subcontractor quality assurance personnel and customer representatives. MRB limitations within the Statement of Work (SOW) and membership qualification shall be defined. An MRB membership listing shall be submitted within the quality plan or by contract letter.
10. Flight Operations, Refurbishment, and Reuse – when applicable, describe how the Subcontractor's quality assurance system will be implemented for flight operations, refurbishment, and reuse.
11. Record retention – for those records not delivered to the Contracting Authority, specify which records are required to be kept, who keeps them, for how long, and how they are to be dispositioned at the end of the retention period.
12. Sampling and Process procedures.

d. The plan shall include a discussion of which, if any, terrestrial quality assurance requirements would be beneficial to space reactor development.

15.4 **FORMAT**: Subcontractor format is acceptable.

15.5 **MAINTENANCE**: Changes shall be incorporated by change page or complete reissue.

# DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1SA-001**
3. **DATA TYPE**: 2/2a
4. **DATE REVISED**:
5. **PAGE**: 1/3

6. **TITLE**: System Safety Plan (SSP)

7. **DESCRIPTION/USE**: The System Safety Plan (SSP) defines the objectives, responsibilities, and methods to be used for overall system safety program conduct and control. It describes the integration of system safety provisions into the total program based on early implementation, planned safety certification review/process, and total program life cycle support.

8. **OPR**: N/A 9. **DM**: N/A

10. **DISTRIBUTION**: Per Contracting Officer's letter

11. **INITIAL SUBMISSION**: Preliminary at System Requirements Review (SRR)

12. **SUBMISSION FREQUENCY**: Update as required. The System Safety Plan shall be updated to be kept current with program status.

13. **REMARKS**: This plan may be incorporated in more comprehensive safety and mission assurance plans or other general program plans provided the system safety data elements remain identifiable and completely reflect the requirements of this DRD. *NOTE*: A Department of Energy (DoE)-equivalent plan may be substituted but shall include rationale and justification for the plan substitution.

14. **INTERRELATIONSHIP**: DRD SNP1QE-002, *Quality Assurance Plan.* SOW Attachment A, Table A.1-1; and SOW section 3.1.1.2

15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The System Safety Plan (SSP) will be consistent with the status of the program's technical development providing a description of the system safety program necessary to support the total program life cycle. The plan will include detailed task requirements for the system safety task as tailored for this program. It will address requirements for safety organization participation in design, safety, and readiness reviews.

15.2 **REFERENCE DOCUMENTS**:

| | |
|---|---|
| NPD 8700.1A | *NASA Policy for Safety and Mission Success* |
| NPR 8715.3 | *NASA Safety Manual* |

15.3 **CONTENTS**: The System Safety Plan shall meet the intent of the reference documents in 15.2. The level of detail in the plan directly correlates with the nature and complexity of the system safety effort required to meet program requirements and objectives. It shall provide a general description of the appropriate safety tasks that shall become the foundation for safety efforts during the system definition, design, manufacture, test, and operations. The SSP shall be the vehicle for safety task planning. The elements of the SSP shall identify the interfaces with other program activities including design, development, test, operation, continuous risk management, and program control (waivers, deviations, corrective actions). While individual program characteristics may vary the emphasis for a particular effort, the plan shall focus on the basic elements:

a. Planning.
    1. Identify special safety studies that may be required during system definition or design.
    2. Personnel requirements both in terms of skills and level of effort required for the safety program during the complete system life cycle.
    3. Establish safety goals and objectives to determine the type of safety input for the overall program. The goals and objectives shall be identified in the initial submittal and evaluated at the major milestone reviews.
        (a) Goals shall be measurable and state what would be accomplished by performing the various safety tasks.
        (b) Goals shall be structured so that safety tasks can be selected to accomplish them.
        (c) Task results shall clearly demonstrate that the goals have been met.

b. Organization. The program organization and system safety relationships and responsibilities shall be described along with reporting channels for this task. The description will include any provisions for independent reporting of issues in addition to the program processes.

c. Contracting. The identification of the relationships to other program elements, team members, and supplier system safety efforts will be done.

d. Interface/Coordination. Relationships to other program planning documentation shall be identified to assure proper coordination of activities.

e. Requirements. Applicable requirements and their sources (programmatic, agency or other) shall be listed.

f. Analysis. The plan shall stipulate hazard analysis methodologies and their intended application. The related DRDs for Hazard Reports (HRs) shall be identified along with the approval process for the reports. System Safety analysis strategies shall define that support:
    1. Concept trade studies (Initial hazard identification and recommended design alternatives).
    2. Utilization of HR results in the design development and the process to assure the analysis maintains currency with the evolving system and program requirements.
    3. Inputs to test and system verification activities.
    4. Definition of operational system safety requirements.
        (a) Redundancy.
        (b) Probabilistic Risk Level for loss of vehicle and/or loss of crew.
        (c) Technical and engineering.
    5. Evaluation of end of life and/or disposal safety issues.
        (a) Orbital Debris Generation Issues.
        (b) Flight Termination System Implementation.
        (c) Environmental hazards.

15.3 **CONTENTS (CONTINUED)**:

g. Safety review and certification process. The plan shall address safety review and certification processes that apply to the program.

h. Risk assessment. The description of the role of system safety in the program risk management process shall address:
   1. The review of pertinent historical safety data from similar systems.
   2. The utilization of Hazard Analysis and related safety assessments. This shall include the process for recommending corrective action or alternatives to the appropriate management level for a decision to either eliminate the hazard or accept the risk.
   3. The program definition for acceptable or residual risk. If the risk management process allows for risk acceptance at varied levels, the plan shall address the role of system safety at each level and in the notification of risk acceptance to the program manager.

i. Reporting. The implementation of the requirements for reporting System Safety activities and products shall be provided at program milestone review.

j. Mishap investigation. The role of System Safety in the investigation, development of corrective actions and the application of lessons learned. Provisions for supporting related Contracting Authority activities in the investigation process.

k. Data retention. Planning for the maintenance of the system safety documentation shall be identified. Data documentation shall include safety risk acceptance rationale and the associated supporting information.

15.4 **FORMAT**: Subcontractor format is acceptable unless another format is specified in the general contract provisions. The plan shall be provided in both hard copy and in an electronic format as specified by the program.

15.5 **MAINTENANCE**: Changes shall be incorporated by change page or complete reissue.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: XXXX **ISSUE**: RFP
2. **DRD NO.**: **XXXXSE-001**
3. **DATA TYPE**: 2
4. **DATE REVISED**:
5. **PAGE**: 1/1

6. **TITLE**: Systems Engineering Management Plan

7. **DESCRIPTION/USE**: To describe the overall systems engineering approach for the project.

8. **OPR**: TBD

9. **DM**: TBD

10. **DISTRIBUTION**: Per Contracting Officer's letter

11. **INITIAL SUBMISSION**: As part of System Requirements Review (SRR) data package

12. **SUBMISSION FREQUENCY**: Update as required

13. **REMARKS**:

14. **INTERRELATIONSHIP**: SOW section 3.1.1.1

15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Systems Engineering Management Plan defines the Systems Engineering and Integration (SE&I) process and products throughout the project life cycle and its' interface(s) with other engineering disciplines across the project.

15.2 **REFERENCE DOCUMENTS**: None

15.3 **CONTENTS**: The Systems Engineering Management Plan shall provide a description of the planned systems engineering and integration (SE&I) activities including, but not limited to, requirements development, system analyses, interface control, verification, and associated technical performance measurements. The plan shall include key milestones, a schedule of SE&I tasks and products, an overview of planned technical reviews, the methods, tools, and techniques for performing and controlling the systems engineering and integration functions, and the organizational structure utilized to accomplish these activities.

15.4 **FORMAT**: Subcontractor format is acceptable.

15.5 **MAINTENANCE**: Changes shall be incorporated by change page or complete reissue.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1SE-004**
3. **DATA TYPE**: 2/2a
4. **DATE REVISED:**
5. **PAGE**: 1/1

6. **TITLE**: Interface Definition Documentation (IDD)

7. **DESCRIPTION/USE**: To provide and control the functional interface definition for reactor-to-engine interfaces and reactor-to-test facility interfaces.

8. **OPR**: N/A

9. **DM**: N/A

10. **DISTRIBUTION**: Per Contracting Officer's letter

11. **INITIAL SUBMISSION**: Preliminary IDDs at System Requirements Review (SRR).

12. **SUBMISSION FREQUENCY**: Baseline at 30% Design Review (30%DR).

13. **REMARKS**: The following documents may be used as reference documents:

| | |
|---|---|
| ASME Y14.100 | *Engineering Drawing Practices including Appendices B through E* (must be used in conjunction with ASME Y14.24, ASME Y34M, and ASME Y14.35M) |
| ASME Y14.41-2003 | *Digital Product Definition Data Practices* |

14. **INTERRELATIONSHIP**: SOW section 3.1.5

15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The IDDs contains all information necessary to describe and control the interface between two end items or elements.

15.2 **REFERENCE DOCUMENTS**: None

15.3 **CONTENTS**: The IDDs shall contain all requirements (physical, functional, and performance) necessary to describe and control the interface between two end items or elements. IDD content shall be sufficient to assure hardware, software and associated data and functional compatibility of the interfacing end items.

15.4 **FORMAT**: Subcontractor format is acceptable for documentation. Format for any interface drawings shall be in accordance with ASME Y14.100 and provided in CGM (Computer Graphics Metafile) format. Model-based interface definition digital data sets shall be in accordance with ASME Y14.41 and provided in Low End Viewer, native CAD or neutral STEP (Standard for the Exchange of Product Model Data) format.

15.5 **MAINTENANCE**: Electronic submission is required.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1SE-005**
3. **DATA TYPE**: 3 (change to 2/2a after System CDR)
4. **DATE REVISED**:
5. **PAGE**: 1/1
6. **TITLE**: Instrumentation Program and Command List Specification
7. **DESCRIPTION/USE**: The Instrumentation Program and Command List Specification (IP&CL) is the single authoritative source of measurements, commands, and components implementation throughout the project lifecycle.
8. **OPR**: N/A
9. **DM**: N/A
10. **DISTRIBUTION**: Per Contracting Officer's letter
11. **INITIAL SUBMISSION**: Preliminary at System Requirements Review (SRR). First release at 30% Design Review (30%DR).
12. **SUBMISSION FREQUENCY**: As part of the 90% Design Review (90%DR) data package, baseline 90 days after 90%DR, update per Contracting Officer's direction
13. **REMARKS**: Reference is made to DRDs SNP1SE-002, *System Design Definition Document*
14. **INTERRELATIONSHIP**: SOW section 3.1.6
15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Instrumentation Program and Command List Specification identifies, defines, and controls measurements, commands, and their applications in the data handling system.

15.2 **REFERENCE DOCUMENTS**:

MSFC-STD-1924 *Standard for IP&CL* (Applies to class A and B payloads only)

15.3 **CONTENTS**: The IP&CL shall be prepared and maintained as specified in MSFC-STD-1924, Standard for IP&CL, Sections 1.0, 3.0, and 4.0.

15.4 **FORMAT**: The format of the data tables in this DRD is dictated by INL/NASA and is used for command and measurement resource analyses. These tables must be in the formats shown in MSFC-STD-1924, Sections 6.0 and 7.0.

Assignment of measurement and command numbers and format descriptions for their corresponding attributes are specified in MSFC-STD-1924, Sections 6.0 and 7.0. The IP&CL shall contain a separate section as specified by MSFC-STD-1924, Section 5.0.

15.5 **MAINTENANCE**: Changes shall be incorporated by change page or complete reissue.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1SE-006**
3. **DATA TYPE**: 2/2a
4. **DATE REVISED**:
5. **PAGE**: 1/3

6. **TITLE**: Mass Properties Control Plan

7. **DESCRIPTION/USE**: To ensure that the Subcontractor's management and control of mass properties is acceptable for the accomplishment of program objectives.

8. **OPR**: N/A

9. **DM**: N/A

10. **DISTRIBUTION**: Per Contracting Officer's letter

11. **INITIAL SUBMISSION**: As part of the Systems Requirements Review (SRR) data package

12. **SUBMISSION FREQUENCY**: Update as required

13. **REMARKS**: Reference is made to AIAA/ANSI R-020A-1999, *Recommended Practice for Mass Properties Control for Satellites, Missiles and Launch Vehicles.*

14. **INTERRELATIONSHIP**: SOW section 3.1.4

15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Mass Properties Control Plan defines the management program and the procedures to be used for mass properties analysis and control during all phases of the program. The objective of the Plan is to provide an organized process that can be effectively implemented early in the development phase and carried through to hardware operation. Addressing the total program span assures the hardware mass properties are properly defined, controlled, and verified. An overview of the verification process shall be addressed in the Control Plan, while the details shall be addressed in a separate Verification Plan.

15.2 **REFERENCE DOCUMENTS**: None

15.3 **CONTENTS**: The Mass Properties Control Plan shall include the following:

a. Discussion of the gross, inert, dry, and sequential mass properties control process including the following:
   1. Organizational structure including responsibility and authority.
   2. Data preparation and flow from discipline organizations through management.
   3. Change procedures.
   4. Activities including the data acquisition and reduction methodology and process for the entire engineering cycle and data accuracy anticipated at project milestones.

b. Mass growth allocations and accommodations for growth depletion as basic mass matures and over the operational life. A mass growth plan based on the Subcontractor's experience shall be utilized. INL/NASA shall provide a generic mass growth application and depletion plan upon request.

c. Subcontractor mass reserve and target masses.

d. Subcontractor's process in establishing mass allocations, reporting requirements, and verification requirements to vendors or team members.

15.4 **FORMAT**: Subcontractor format is acceptable.

15.5 **MAINTENANCE**: Changes shall be incorporated by change page or complete reissue.

15.6 **DEFINITIONS**: The definitions below are in general agreement with the Society of Allied Weight Engineers (SAWE) recommended practice, modified to NASA practice. Any Subcontractor changes and/or deviations to these definitions are negotiable and are to be documented in the Mass Properties Control Plan.

a. **Basic mass** – (identified mass) raw mass data from measurement(s), calculation(s), and/or estimate(s).
b. **Growth allowance** – an allowance added to a basic mass to account for deficiencies in detail of the current design. Growth is "depleted" as the design matures. Allocated growth is applied to each component per a weight growth and depletion schedule. Unallocated growth is applied at the vehicle level and depleted as a function of weight maturity.
c. **Predicted mass** – current prediction of the final mass based on current analytical and/or measured data plus a growth allowance to account for lack of existing design detail (basic + growth).
d. **Contractor limit** – mass limit which includes a margin above the predicted mass to allow for uncertainties during the design cycle. The Contractor Limit is the Mission Limit minus the Contracting Authority reserve.
e. **Contract End Item (CEI) Specification mass** – contractual mass of an end item. Note: The term "control mass" is sometimes utilized as a limit in lieu of CEI mass when a CEI mass does not exist. The term "ICD mass" (Interface Control Document mass) is another appropriate alternative.
f. **Contractor margin** – difference between the contractor limit and predicted mass.
g. **Mission Limit** – the maximum possible mass allowable to achieve the mission, or an agreed to maximum. Also known as the specified mass or booster performance limit.
h. **Contracting Authority reserve [or Contracting Authority margin]** – **Contracting Authority** mandated mass reserve required to manage out-of-scope changes. This is the difference between the mission limit and contractor limit.
i. **Target (bogie) mass** – the mass established by the Subcontractor (at the subsystem level or below) to control mass.
j. **Mass properties** – mass, center of gravity, moments and products of inertia, and coordinate system descriptions on which they are based.
k. **Mass maturity** – an indication of the level of confidence in a mass value expressed as the percentage of the current mass that is based on estimations, calculations, and actual masses. When maturity is presented at the estimated-calculated-actual level, "calculated" means calculated from released drawings.
l. **Pending changes** – changes affecting mass properties that occurred after report cutoff date.
m. **Potential changes** – changes affecting mass properties which are under study and have a high probability of incorporation or are otherwise significant enough to merit presentation or discussion.

n. **Critical mass properties** – mass properties that have maximum limits or those that are otherwise technically important.
o. **Dry mass properties** – mass properties of non-expendable system, segments, elements, subsystems, assemblies, subassemblies and/or parts.
p. **Inert mass properties** – the sum of the vehicle dry mass and reserve and residual fluids, personnel and personnel provisions, and cargo.
q. **Gross mass properties** – the sum of the vehicle inert mass and usable fluids and gases.
r. **Sequential mass properties** – gross mass properties that vary as a function of time during operational life.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP
2. **DRD NO.**: **SNP1SE-007**
3. **DATA TYPE**: 3
4. **DATE REVISED**:
5. **PAGE**: 1/1

6. **TITLE**: Mass Properties Report

7. **DESCRIPTION/USE**: To ensure that the Subcontractor's management and control of mass properties is acceptable and to provide mass properties required for other technical analyses and/or trade studies.

8. **OPR**: N/A

9. **DM**: N/A

10. **DISTRIBUTION**: Per Contracting Officer's letter

11. **INITIAL SUBMISSION**: As part of the System Requirements Review (SRR) data package

12. **SUBMISSION FREQUENCY**: Quarterly reports shall be submitted after SRR and with any major milestone review package.

13. **REMARKS**: Reference documents:

AIAA S-120-2006 *Mass Properties Control for Space Systems*

14. **INTERRELATIONSHIP**: SOW section 3.1.4

15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Mass Properties Report provides current weight and other mass properties status consistent with the design, a current mass properties control and margins status, and mass properties required for other technical analysis and/or trade studies.

15.2 **REFERENCE DOCUMENTS**: None

15.3 **CONTENTS**: The Mass Properties Report shall include the following:

a. Weight summary (last, current, contract end item (CEI), maturity level in percent).
b. Comprehensive reasons for changes since the previous status report.
c. List of pending and potential changes.
d. Mass properties summary (subsystem, element, sequential).
e. Weight history plot.
f. Mass properties coordinate system description.
g. References, if applicable.
h. Critical mass properties status.

15.4 **FORMAT**: Shall be negotiated with the customer.

15.5 **MAINTENANCE**: None required

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP 2. **DRD NO.**: **SNP1SE-009**
3. **DATA TYPE**: 3 4. **DATE REVISED**:
5. **PAGE**: 1/2

6. **TITLE**: System Connectivity Diagrams and End-to-End Functional Schematics

7. **DESCRIPTION/USE**: To provide connectivity and end-to-end functional definition of systems for analysis and troubleshooting during design and operation.

8. **OPR**: N/A 9. **DM**: N/A

10. **DISTRIBUTION**: Per Contracting Officer's letter

11. **INITIAL SUBMISSION**: System Connectivity Diagrams three weeks prior to 30% Design Review (30%DR).

12. **SUBMISSION FREQUENCY**: System Connectivity Diagrams submitted every 120 days after 30%DR until 90% Design Review (90%DR); End-to-End Functional Schematics submitted at 90%DR and updates thereafter in accordance with 15.5

13. **REMARKS**:

14. **INTERRELATIONSHIP**: DRD SNP1SE-005, *Instrumentation Program and Command List Specification.* SOW section 3.1.1.2

15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: These diagrams and schematics include end-to-end paths and signal identification for command and control, power distribution and monitoring, temperature control, environmental control, etc., in sufficient detail to define functions and architecture of the integrated system.

15.2 **REFERENCE DOCUMENTS**:

MIL-STD-100 *Engineering Drawings Practices*

15.3 **CONTENTS**:

a. System Connectivity Diagrams – Diagrams shall be prepared to graphically depict the integrated connectivity of services such as electrical power, command and data flow, thermal and environmental, and fluids structured in a logical manner to show relationships of functional assemblies/enclosures/equipment.
b. End-to-End Functional Schematics – Schematics shall be prepared to depict integrated end-to-end functional configuration of all signals (control and monitor), and power and energy paths within a system. Schematics shall be structured in a logical manner that will show the complete functional performance and relationship of the system and subsystems and the primary element interfaces to the plug/pin or connector level. End-to-End Schematics shall reference internal component/box design drawing for distribution or configuration details and shall identify various power sources, switch elements, controls, indicators, valves, motors, relays, sensors, effectors, wires pipes, etc. by symbol and reference designator number. Sensor and effector input/output channels and components shall be identified by the name and identification number as defined in the Instrumentation Program and Command List Specification. Logic functions performed by data management system shall also be depicted.

15.4 **FORMAT**: Format of product drawings shall be in accordance with MIL-STD-100.

15.6 **MAINTENANCE**: All drawings produced under this DRD shall be maintained current. Changes to and/or updating of drawings shall be in accordance with the Subcontractor's approved drawing system. Any changes to engineering drawings under Government Class I change control shall be submitted by engineering change proposal (ECP) and must include the changes to the system functional schematics and interconnect diagrams, if applicable.

## DATA REQUIREMENTS DESCRIPTION (DRD)

1. **DPD NO.**: SNP1 **ISSUE**: RFP 2. **DRD NO.**: SNP1VR-001
3. **DATA TYPE**: 2/2a 4. **DATE REVISED**:
5. **PAGE**: 1/1

6. **TITLE**: Verification / Validation Planning

7. **DESCRIPTION/USE**: To identify the verification/validation approach, to provide a description of the verification/validation activities and methods and to identify the organization and tools required to accomplish and track the proposed verification program.

8. **OPR**: N/A 9. **DM**: N/A

10. **DISTRIBUTION**: Per Contracting Officer's letter

11. **INITIAL SUBMISSION**: As part of the System Requirements Review (SRR) data package

12. **SUBMISSION FREQUENCY**: Update as required for each major review

13. **REMARKS**: Reference is made to MSFC-HDBK-2221, *Verification Handbook, Volume I: Verification Process*, and *Volume II: Verification Documentation Examples*. Volume II provides examples of verification documentation as specified in Volume I that can be used as a guide in the development of or in the assessment of similar documentation. Verification/validation planning documents developed to address specific verification activities (e.g. Test Plans, Analysis Plans, Inspection Plans, etc.) shall be acceptable as long as the respective content of the data meets that identified in CONTENTS (Item 15.3) and the submission of the collective data meets that identified in INITIAL SUBMISSION/SUBMISSION FREQUENCY (Items 11 & 12).

14. **INTERRELATIONSHIP**: SOW section 3.1.1.1, Attachment A.2, and Table A.2-1

15. **DATA PREPARATION INFORMATION**:

15.1 **SCOPE**: The Verification Planning information provides a detail description of the projects verification/validation approach and structure for implementing the verification/validation program.

15.2 **REFERENCE DOCUMENTS**: None

15.3 **CONTENTS**: The verification/validation planning information shall include the following;

a. Overview of the project's verification/validation program (i.e. qualification/acceptance versus protoflight, verification, verification/validation of spares, refurbishment/reverification/revalidation plans.)
b. Description of the projects organizational structure for implementing the verification / validation program (i.e., organizations involved with in component versus systems tests, review and signoff authority for compliance data).

15.4 **FORMAT**: Subcontractor format is acceptable, however all charts, data plots, and graphics must be explained in narrative form. Charts without facing page text acceptable only with prior approval.

15.5 **MAINTENANCE**: Changes shall be incorporated by change page or complete reissue.

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# Organizational Conflict of Interest (OCI) Mitigation Disclosure for the Nuclear Thermal Propulsion (NTP) Reactor Interim Design


The INL is a U.S. Department of Energy National Laboratory operated by Battelle Energy Alliance.

## REVISION LOG

| Rev. | Date | Affected Pages | Revision Description |
|---|---|---|---|
| 0 | 11/03/2020 | All | New issue. |
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## CONTENTS

# 1. INTRODUCTION

The Nuclear Thermal Propulsion (NTP) Reactor Design Project team is a multi-organizational team, which includes participation by NASA and NASA's contractors. These organizations and team members are necessary to bring the best value to the government during the implementation of the project. However, inclusion of these organizations and employees could introduce potential organizational conflicts of interest (OCI). NASA and Battelle Energy Alliance, LLC (BEA) require mitigation of these potential conflicts to ensure there is no unfair competitive advantage conferred on any offeror, particularly any contrary to 48 C.F.R. Subpart 9.5, to BEA's contract with the U.S. Department of Energy (DoE) for management and operation of the Idaho National Laboratory (INL), or which could compromise the integrity of the procurement process for the acquisition and evaluation work in Statement of Work No. 17948 (SOW-17948). NASA and BEA have considered approaches to mitigate the following that can create impermissible OCI: 1) Unfair competitive advantage by unequal access to information; 2) impaired objectivity; and 3) biased ground rules. Contractors for NASA, DoE and BEA are expected to properly avoid and mitigate such OCI pertaining to such acquisition and evaluation. The mitigation strategies to these potential conflicts NASA and BEA intend to use are summarized below.

# 2. AVOIDING, NEUTRALIZING, AND MITIGATING AN OCI

## 2.1 Unfair Competitive Advantage by Unequal Access to Information

NASA and BEA will avoid this type of OCI by providing equal opportunity to access information and data necessary to prevent unfair competitive advantage in this acquisition (i.e., the effort described in SOW-17948) to all offerors. Each offeror will also have equal opportunity to access necessary DoE and NASA experts and facilities as appropriately requested by the offeror. Post contract award, the Project's management will facilitate support from DoE and NASA as necessary and appropriate to such effort when requested by the subcontractors. There is a potential that each offeror may request the same type of information and capabilities. To mitigate risk of OCI from unequal access to information required to prevent unfair competitive advantage, each offeror will have opportunity to access common experts at DoE and NASA as necessary. BEA will request confirmation and acceptance of this mitigation approach from each offeror under the RFP.

## 2.2. Impaired Objectivity

To avoid impermissible OCI due to impaired objectivity during the acquisition evaluation and selection process for the effort described in SOW-17948, neither NASA nor BEA intend to utilize personnel of a contractor of either to evaluate or make selection determinations relative to such contractor, such contractor's affiliates or such contractor's competitors.

NASA and BEA intend to avoid evaluation of proposals without first vetting OCI issues pertaining thereto with their respective legal offices.

NASA and BEA anticipate making staff, including experts available to the offerors when necessary, but will also utilize qualified experts to support the project team during all phases of work noted in SOW 17948. Individuals making selection or evaluation decisions must be appropriately firewalled from staff at NASA and BEA who are providing requested task support to the offerors. Such staff providing such task support will not make any selection or evaluation decisions relative to the effort described in SOW-17948 but may otherwise support project activities and provide technical information to the Project Manager.

2.3. Biased Ground Rules

Only NASA and BEA procurement cleared personnel with no impermissible conflict of interest : 1) Have had a substantial role in developing SOW-7948; 2) set evaluation or selection criteria pertaining to the effort in such SOW; and 3) will set evaluation or selection criteria pertaining to future efforts anticipated by that SOW (including, without limitation, those noted in Option 1 and Option 2 thereof). NASA and BEA developed the final version of such SOW.

# 3. CONFIRMATION AND ACCEPTANCE OF OCI DISCLOSURE

BEA will require confirmation and acceptance from each offeror that this OCI Disclosure identifies and provides acceptable mitigation strategies. This confirmation and acceptance will be in the form of a submittal statement under the RFP. If a potential OCI has not been addressed, or has been insufficiently addressed under this OCI Disclosure, offerors must identify their concerns or objections in the submittal statement so as to allow NASA and BEA to consider any revisions to the OCI Disclosure.