

**Global Precipitation Measurement Project**  
**(GPM)**  
**Core Spacecraft**  
**Propellant Tank**  
**Deliverable Items List and Schedule**  
**(DIL)**



National Aeronautics and  
Space Administration

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Goddard Space Flight Center  
Greenbelt Maryland

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Questions or comments concerning this document should be addressed to:

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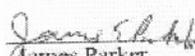
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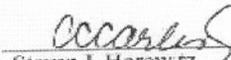
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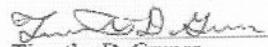
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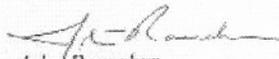
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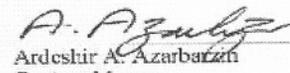
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# **1 Introduction**

## **1.1 General Information**

This document lists the deliverable items required from the Contractor for the development of the GPM Core Spacecraft Propellant Tanks, from here on referred to as the propellant tank(s) or tank(s). Minimum content requirements for the deliverable documentation are also included.

## **1.2 Reference**

The deliverable items detailed in this document are referenced from the Statement of Work (SOW) For Global Precipitation Measurement (GPM) Project Core Spacecraft Propellant Tank, GPM 422-06-01-11-003.

# **2 Definition of Terms**

This section defines the terms used in the hardware and data deliverable schedules.

## **2.1 Category**

A = Approval – Documents in this category require approval from the NASA GSFC CO. In general, documents shall be provided in contractor format as long as required content, as specified in the SOW, is addressed.

R= Review – Documents in this category do not require formal NASA GSFC CO approval. They must be received within a specified time period and are subject to evaluation. The NASA GSFC CO reserves the time-limited right of disapproval for each submission. The time-limited period is two weeks from receipt of documents.

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

## **2.2 Quantity**

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



### 2.3 Delivery Date

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

## 3 Deliverable Schedules

### 3.1 Hardware

**Table 1: Hardware Deliverable Schedule**

Item #	Description	Reference	Quantity	Delivery Date
1	Development Tank	SOW Section 5.2	1	2 weeks after efforts involving the development tank are completed
2	Qualification Tank	SOW Section 5.3	1	2 weeks after completion of all qualification efforts
3	Flight Tank	SOW Section 5.4	1	28 months after Contract Award
4	Tank Covers	SOW Section 5.5	3	With delivery of the flight tank
5	Tank Lifting GSE	SOW Section 5.10	1	With delivery of the flight tank

### 3.2 Meetings/Reviews

**Table 2: Meetings/Reviews Deliverable Schedule**

Item #	Description	Reference	Category	Quantity	Delivery Date
1	Technical Interchange Meetings (TIM)	SOW Section 2.2.1	I	As required	Average every two months (except when major reviews scheduled)/Seven (7) calendar days advance notice
2	Contract Initiation Meeting (CIM)	SOW Section 2.2.2	I	5	4 weeks after Award of Contract/TBD



Item #	Description	Reference	Category	Quantity	Delivery Date
3	Preliminary Design Review (PDR)	SOW Section 2.2.3	R	5	6 months after Award of Contract
4	Critical Design Review (CDR)	SOW Section 2.2.4	R	5	12 months after PDR (prior to flight hardware manufacture initiation)
5	Pre-Environmental Review (PER)	SOW Section 2.2.5	R	5	1 week prior to beginning environmental test program
6	Pre-Ship Review (PSR)	SOW Section 2.2.6	R	5	1 week prior to the delivery of each hardware item

### 3.3 Documentation

**Table 3: Data Deliverable Schedule**

Item #	Description	Reference	Category	Quantity	Delivery Date
1	Monthly Status Report	SOW Section 2.1.2.2	I	5	Monthly, Electronic version by COB on the 5 <sup>th</sup> day of the following month
2	Action Items List	SOW Section 2.3.1	R	5	Monthly, same schedule as monthly report
3	Program Schedule	SOW Section 2.3.2	I	5	Monthly, same schedule as monthly report
4	Near Term Schedule	SOW Section 2.3.2	I	5	Monthly, same schedule as monthly report



Item #	Description	Reference	Category	Quantity	Delivery Date
5	Interface Control Document (ICD)	SOW Section 2.3.3.1	R	5	Draft with the Proposal  Preliminary Two (2) weeks prior to PDR  Final 1 (one) month prior to CDR
5.5	Inputs to drawing GSFC GD 2085095	SOW 2.3.3.1	A	1	Preliminary – 4 months after contract award  Final – 10 months after contract award
6	Drawing Package	SOW Section 2.3.3.2	R	5	Preliminary Two (2) weeks prior to PDR  Final 1 (one) month prior to CDR
7	Preliminary Design Review Presentation Package	SOW Section 2.3.3.3	R	5	Two (2) weeks before PDR
8	Critical Design Review Presentation Package	SOW Section 2.2.4 (all.)	R	5	Two (2) weeks before CDR
9	Development Report	SOW Section 2.3.3.4	R	5	Preliminary Two (2) weeks prior to PDR  Final 1 (one) month prior to CDR



Item #	Description	Reference	Category	Quantity	Delivery Date
10	Verification (Compliance) Matrix	SOW Section 2.3.4	R	5	Draft with the Proposal  Preliminary Two (2) weeks prior to PDR  Final one (1) month prior to CDR
11	Verification Test Plan	SOW Section 2.3.5	A	5	Draft with the Proposal  Preliminary Two (2) weeks prior to PDR  Final one (1) month prior to CDR
12	Verification Test Procedures	SOW Section 2.3.6	R	5	Two (2) weeks prior to Testing
13	Contamination Control Plan	SOW Section 2.3.7	A	5	Preliminary Two (2) weeks prior to PDR  Final one (1) month prior to CDR
14	Fracture Control Plan	SOW Section 2.3.8	R	5	Preliminary Two (2) weeks prior to PDR  Final one (1) month prior to CDR



Item #	Description	Reference	Category	Quantity	Delivery Date
15	Range Safety Compliance Document	SOW Section 2.3.9	A	5	Preliminary Matrix Two (2) weeks prior to PDR  Final With Data Delivery Package and Range approval
16	Qualification Test Report	SOW Section 2.3.10	R	5	2 weeks after QTP completion
17	Tank Operational Constraints Document	SOW Section 2.3.11	R	5	Preliminary Two (2) weeks prior to PDR  Final With Data Delivery Package
18	Damage Control Plan	SOW Section 2.3.12	R	5	Preliminary Two (2) weeks prior to PDR  Final one (1) month prior to CDR
19	Data Delivery Package	SOW Section 2.3.13	A	5	Prior to the delivery of each hardware item (with each PSR)
20	PMD Analysis Report	SOW Section 3.2	R	5	Preliminary Two (2) weeks prior to PDR  Final one (1) month prior to CDR



Item #	Description	Reference	Category	Quantity	Delivery Date
21	Mechanical Analysis Report	SOW Section 3.4	R	5	Preliminary Two (2) weeks prior to PDR  Final one (1) month prior to CDR
22	Finite Element Model	SOW Section 3.4.2	R	1	Preliminary Two (2) weeks prior to PDR  Final one (1) month prior to CDR
23	Quality Assurance Plan	SOW Section 6.1.1	A	1	Draft with Proposal  Final at PDR
24	Class I CM Changes	SOW Section 6.1.3	A	1	10 Days after CM meeting
25	Class II CM Changes	SOW Section 6.1.3	R	1	10 Days after CM meeting
26	Anomaly Reports	SOW Section 6.1.4	A	1	With monthly status report as needed
27	Hazard Analysis	SOW Section 6.2	R	1	Preliminary Two (2) weeks prior to PDR  Final one (1) month prior to CDR



Item #	Description	Reference	Category	Quantity	Delivery Date
28	Failure Mode and Effects Analysis (FMEA)	SOW Section 6.3.1	R	1	Draft with the Proposal  Preliminary Two (2) weeks prior to PDR  Final one (1) month prior to CDR
29	Limited-Life Items List	SOW Section 6.3.1.1	A	1	Preliminary Two (2) weeks prior to PDR  Final With Data Delivery Package
30	Test and Trend Analysis Reports	SOW Section 6.5.2 (all.)	R	1	With Data Delivery Package
31	Trended Parameter List	SOW Section 6.5.2	R	1	Preliminary list of parameters to be monitored (1) month prior to CDR  Final With Data Delivery Package
32	Alert/Advisory Documentation	SOW Section 6.6.6	I	1	Monthly/TBD
33	Materials Identification List	SOW Section 6.7.1.2	R	1	Preliminary Two (2) weeks prior to PDR  Final With Data Delivery Package



Item #	Description	Reference	Category	Quantity	Delivery Date
34	As-Built Materials List	SOW Section 6.7.1.2	R	1	Preliminary Two (2) weeks prior to PDR  Final With Data Delivery Package
35	Materials Usage Agreement	SOW Section 6.7.2, 6.7.3, App. B	A	1	Draft at PDR  Final at CDR
36	Tripped Sensor Documentation	SOW Section 8.0	I	1	With Delivery Package
37	Pre-Environmental Review (PER) Presentation Package	SOW Section 2.2.5	A	5	Two week prior to PER
38	Pre-Ship Review (PSR) Presentation Package	SOW Section 2.2.6	A	5	Two weeks prior to PSR
39	Contractor Initiation Meeting (CIM)	SOW 2.2.2	A	5	Two weeks prior to CIM

## 4 Content Summaries

The Content Summaries section contains detailed descriptions of each deliverable item. The last decimal numeral corresponds to the item number in the relevant table.

### 4.1 Hardware – Table 1

The hardware delivery schedule is captured in Table 1. Extensive description of the deliverable hardware can be found in the specification and SOW.

### 4.2 Meetings/Reviews – Table 2

#### 4.2.1 Technical Interchange Meeting (TIM)

The technical interchange meetings (TIMs) shall review technical issues including, but not limited to, parts, test plans, test procedures, software changes, design modifications, and design analyses.



#### **4.2.2 Contractor Initiation Meeting (CIM)**

The Contractor Initiation Meeting (CIM) presentation package shall contain all information provided in the Contractor's proposal, including any new items for the purposes of clarifying or expanding said proposal. Proposed near term and long term schedules shall be prepared for discussion. Near term technical efforts of the Contractor and sub-Contractor(s) and any near term risks shall be summarized and presented for discussion. All other required deliverable data whose scheduled delivery is linked to CIM one week prior to the review shall be included in the CIM presentation package.

#### **4.2.3 Preliminary Design Review (PDR)**

The preliminary design review shall cover programmatic, technical, test and verification, and quality assurance topics. The Contractor shall provide an opportunity for GSFC to review drawings and analyses available at the time of the review. The Contractor shall provide to GSFC a Preliminary Design Review Presentation Package, detailed in Section 4.3.7, and all other required deliverable data whose scheduled delivery is linked to PDR two weeks prior to the review.

#### **4.2.4 Critical Design Review (CDR)**

The critical design review shall cover programmatic, technical, test and verification, and quality assurance topics. This review shall also provide an opportunity to review drawings and all analyses required to be approved before the start of fabrication. The Contractor shall provide to GSFC a Critical Design Review Presentation Package, detailed in Section 4.3.8, and all other required deliverable data whose scheduled delivery is linked to CDR two weeks prior to the review.

#### **4.2.5 Pre-Environmental Review (PER)**

The pre-environmental review shall cover programmatic, technical, test and verification, and quality assurance topics. This review shall also include a review of all test plans and procedures and all analyses required to approve the testing of the hardware.



#### **4.2.6 Pre-Ship Review (PSR)**

A Data Delivery Package, detailed in Section 4.3.19, shall be presented for review at each PSR. The Contractor shall provide to GSFC a PSR Presentation Package and all other required deliverable data whose scheduled delivery is linked to PSR two weeks prior to the review.

### **4.3 Documentation – Table 3**

#### **4.3.1 Monthly Status Report**

The report shall be a summary presentation of the period's progress, problem areas, and activities on-going and planned. The Contractor shall generate a list of significant milestones that will enable the NASA/GSFC COTR to ascertain program progress. The report shall include highlights from weekly meetings. A list of all open anomaly reports and a separate list of the anomaly reports closed during the month shall be included.

#### **4.3.2 Action Item List**

The Action Item List shall identify all actions assigned by the GSFC COTR as a result of TIM, PDR, CDR or other type review. Each action item shall have a unique number to identify the action, a description of the action required and the expected closure date. The Action Item List shall be included in the Monthly Report. Closure of action items shall require acceptance by the COTR. The Action item List and closed action items shall be maintained in an electronic database such as an Excel spreadsheet.

#### **4.3.3 Program Schedule**

The contractor shall prepare and maintain a Program Schedule showing activities from the beginning of the contract until completion. The Program Schedule shall show chronologically major milestones that are fundamental to the progress of the overall project. Updates to the Program Schedule shall be submitted as part of the Monthly Status Report, and as required following major revisions to the overall project plan. As a minimum the Program Schedule shall include:



- Activities detailed by task with expected start and completion dates and slack
- Activities associated with major items such as components, or definable subassembly, such as the liner.
- Fabrication schedules detailed to the mechanical subassembly, and showing substantive milestones.
- Testing schedule and quality inspections
- An electronic version using Microsoft Project

#### **4.3.4 Near Term Schedule**

The contractor shall prepare a Near Term Schedule showing specific dates for the next three month reporting period of expected progress from the Program Schedule. The Near Term Program Schedule shall contain milestones that detail design progress, procurement, manufacturing steps, and testing that shall occur in the next three months of the reporting period.

#### **4.3.5 Interface Control Document**

The interface control document shall define all performance, functional, environmental specifications, and all mechanical interfaces. An interface control drawing shall be part of this package, including all revisions called out in detail.

#### **4.3.6 Drawing Package**

The drawing package shall include, but is not limited, to all mechanical assembly and interface drawings.

#### **4.3.7 Preliminary Design Review Presentation Package**

The preliminary design review presentation package shall address all program management, design, analysis, manufacturing, test, and quality assurance activities.

Review minutes shall be prepared and, at a minimum, shall include an agenda, attendance, action items, action item accomplishment responsibility and agreements. At a minimum, the design



package shall cover the following areas for both the tank and the propellant management device (PMD):

- Program Management & key personnel
- Status (with deliverables)
- Schedule
- Quality Assurance
- Mechanical and Environmental specifications
- Parts, including drawings and stress analysis
- Detailed architectural block diagrams for the different deliverable units
- Manufacturing flow with inspection points
- Facilities & certifications
- Verification test plan (Including Performance Test Description)
- Development status, including subscale development testing and piece part testing
- Materials and Processes
- Thermal analyses
- Mechanical/Structural analyses, including approach
- Margin of Safety Table
- Failure Modes Effects Analysis
- Flight Heritage
- Verification Matrix
- Performance Analysis (preliminary)

#### **4.3.8 Critical Design Review Presentation Package**

The critical design review presentation package shall address all program management, design, analysis, manufacturing, test, and quality assurance activities.

Review minutes shall be prepared and, at a minimum, shall include an agenda, attendance, action items, action item accomplishment responsibility and agreements. At a minimum, the design package shall cover the following areas for both the tank and the propellant management device (PMD):



- Program Management & key personnel
- Status (with deliverables)
- Schedule
- Quality Assurance
- Changes since PDR
- Mechanical and Environmental specifications
- Parts, including drawings and stress analysis
- Detailed architectural block diagrams for the different deliverable units
- Manufacturing flow with inspection points
- Facilities & certifications
- Verification test plan (Including Performance Test Description)
- Development status, including subscale development testing and piece part testing
- Materials and Processes
- Thermal analyses
- Mechanical/Structural analyses, including approach
- Margin of Safety Table
- Failure Modes Effects Analysis
- Flight Heritage
- Verification Matrix
- Performance Analysis
- Tank Operational Constraints Document (preliminary)

#### **4.3.9 Development Report**

The development report shall include the results of trade studies and any development efforts. The Contractor shall include less detail and data than is typical for a test report or processing procedure but more than is typical for an executive summary.



The trade studies summary shall review mass, cost, technical risk and schedule risk for each study (vacuum loading and yielding/non-yielding liner). The development efforts shall cover, but are not limited to:

- Wettable aluminum processing
- Non-wetting aluminum processing
- Heater and thermal component bonding
- Weld process qualification
- Special processes and manufacturing techniques developed during the development of the GPM tank
- All tests performed during the development phase of the GPM tank, such as weld development, contact angle testing, safe life coupon testing, and bubble point testing.

#### **4.3.10 Verification (Compliance) Matrix**

The verification (compliance) matrix shall list each section in the GPM SOW reflecting either compliance or non-compliance. The Contractor shall address areas of non-compliance showing how they plan to meet the requirement(s) or why it will remain non-compliant.

#### **4.3.11 Verification Test Plan**

The Verification Test Plan shall describe the verification tests performed to fulfill the requirements in tank specification GPM 422-06-01-11-002. The plan shall state the purpose of each test, state acceptance criteria, describe in detail the test method and instrumentation, and give the sequence of the tests. The plan shall include a test matrix summarizing all tests that will be performed on the propellant tanks.

#### **4.3.12 Verification Test Procedures**

The verification test procedures shall include step-by-step instructions for performing tests outlined by the Verification Test Plan. The procedures shall define the environmental conditions for the tests, required equipment and facilities, test constraints, use of diagnostic or performance test software, operating conditions, tolerance on all input stimuli, data to be recorded and pass/fail criteria. Data tables needed for related calculations and data sheets for each test/inspection shall be included in the test procedures. Test procedures shall also include Safe-



to-Mate procedures to verify that GSE can safely be mated to interfaces and that interfaces are safe to accept mating with the GSE. Instructions for delivery preparation after testing shall be included.

#### **4.3.13 Contamination Control Plan**

The Contamination Control Plan shall include details from raw materials through delivery of the finished flight item to GSFC, provisions for controlling contamination of GSE and contamination of flight hardware by GSE, and recommendations to GSFC for contamination control of the flight tank after receipt by GSFC. Product cleanliness levels and the Contractor's contamination Control Program shall conform to IEST-STD- CC1246D.

The plan shall cover definitions of cleanliness, a list of materials and specifications, facility descriptions, and general contamination requirements such as:

- Bagging
- Storing/inventory area precautions
- Sub-assemblies (including PMD) cleanliness and contamination controls
- Example cleaning procedures
- Inspection, machine shop, and treatment sequences
- Gas & fluids (filtering)
- Final cleaning process
- Final propellant tank cleanliness levels

#### **4.3.14 Fracture Control Plan**

The fracture control plan shall include an overall approach for designing for fracture control. The plan shall cover review and approval procedures, fracture design and analysis procedures, a safe-life plan (test sequence), and material fracture mechanics data. The plan shall also include control processes for fabrication (heat treating, welding, incompatible materials), flaw screening and pressure cycle log requirements.



#### **4.3.15 Range Safety Compliance Document**

The Range Safety Compliance Document shall show the Contractor's compliance with AFSPCMAN 91-710v3, 45th Space Wing Policy Letter, 23 NOV 1993, JMR-002A, and JERG-0-001.

The document shall cover, at a minimum, compliance or reasons for non-compliance to:

- Design, Analysis, And Test requirements
- Factor of safety requirements
- Safe-life demonstration requirements
- Qualification test requirements
- Acceptance test requirements
- Recertification test requirements
- Any special provisions

The document shall also include a tank design verification approach flow diagram in accordance with the range safety requirements.

#### **4.3.16 Qualification Test Report**

The qualification test report shall demonstrate the design is qualified for ground operations and space flight. The report shall include a summary of all qualification tests, a narrative of test occurrences (completions and anomalies), and a final qualification decision including documentation of final tank condition. Data sheets, picture(s) of the test setup, and drawing(s) of instrumentation locations shall be included for each test.

#### **4.3.17 Tank Operational Constraints Document**

The tank operational constraints document shall include at least the following information to prevent unintentional damage to the flight hardware: maximum water and gas flow rates for testing, maximum and minimum storage temperature and humidity, maximum propellant loading and offloading flow rates, maximum test fluid pressure, compatible fluids, and allowable pressurization and depressurization rates.



The document shall also include any additional constraints for transportation, installation, and handling.

#### **4.3.18 Damage Control Plan**

The damage control plan shall identify all mechanical damage threats starting from the point of manufacture until the end-of-service life and define approaches and procedures to mitigate such damage during operation, handling, or shipping. Inspection points to document any mechanical damage shall also be defined.

#### **4.3.19 Data Delivery Package**

The Data Delivery Package shall contain all data items attached to specific tank to be delivered. The package shall contain but not be limited to the following data:

- As-Built vs. As Designed Parts List, (includes serialization/revisions)
- Final Drawing Package (including rework instructions, if any)
- Critical Parameters Trend Data (Trend Parameter List & Test and Trend Analysis Report)
- Problem/anomaly reporting (complete copies of report)
- Deviations/Waivers/open items/nonconformances and their dispositions,
- Class I MRBs (complete copies of reports)
- Materials and Processes List
- Certifications (material processing requirements, heat treat, cleaning, welding, NDE testing)
- Log of total operating time,
- List and status of all identified Life-Limited Items,
- Verification matrix, test data and reports (including qualification test report)
- Photograph Documentation (Pre-Closure and Closed)
- Certificate of Conformance
- Inspection results & certifications
- Physical properties (tensile) reports
- In-process test data
- Subassembly test data



- Results of the Final Comprehensive Performance (Acceptance) Test.
- List of Open Items with reason for item(s) being open and proposed closure date
- Contamination Control Plan
- Fracture Control Plan
- Range Safety Compliance Document
- Performance Analysis (final)
- Tank Operational Constraints Document (final)
- Copy of shipping memo

#### **4.3.20 PMD Analysis Report**

The contractor shall perform and document a PMD analysis to show that the PMD provides gas free propellant delivery under all mission phases. The report shall include design requirements, any trades performed to determine the final configuration, a description of the design, and any PMD analysis and testing performed. The analyses covered in the report shall include, but are not limited to:

- Bubble point analysis
- Pressure drop analysis
- Performance margins for each mission phase (including ground & in 0g)
- Analysis of the test cases in the SOW, Table 1
- Gas-free liquid flow capacity for 0g and 1g
- EOL residuals analysis
- Periodic slosh analysis
- Transient slosh analysis
- Ground loading analysis

The tests covered in the report shall include, but are not limited to:

- Porous Element Bubble Point
- PMD Assembly bubble point
- Pressure drop test



In addition, analytical models shall be provided with the PMD analysis report. These shall include the spring/damper model used in periodic slosh analysis, with the ability to manipulate input parameters, and the full CFD model used for transient slosh analysis.

#### **4.3.21 Mechanical Analyses Report**

The mechanical analysis report shall detail the analyses performed to verify the tank and PMD design has positive margins of safety due to the load requirements detailed in the tank specification, GPM 422-06-01-11-002. The report shall include a stress analysis detailing the input parameters, data, assumptions, rationales, methods, references and a summary of significant analysis results. The report shall also include a plot of stress versus position along the longitudinal axis of the tank for the launch conditions and MDP, a plot of stress versus position along the longitudinal axis of the tank for the tank pressurized to proof and burst pressures, and a summary table showing margins of safety for all stress analyses performed. The report shall also include a fracture mechanics analysis for those areas of the liner that remain elastic up to the proof pressure and detailed in a histogram to be provided by GSFC. Any documentation of major analysis milestones/meetings shall be included in the report.

#### **4.3.22 Finite Element Model**

The Contractor shall deliver an electronic copy of the MSC NASTRAN-compatible finite element model (FEM) to GSFC, including a description of the model (e.g., element and material properties, mass properties, constraints) and a summary of the model checks performed on the FEM.

#### **4.3.23 Quality Assurance Plan/Manual**

The Contractor shall implement a Quality Management System that meets the intent of the requirements of American National Standards Institute (ANSI)/ISO/ American Society for Quality (ASQ) Q9001 (2000) as modified by AS9100 (or equivalent). The contractor Quality Manual shall be made available for GSFC GPM Project review at the contractor facility. International Organization for Standardization (ISO) certification is not mandatory. GSFC shall be notified of any changes to the QA program.



The quality assurance plan shall include:

- Descriptions of all quality assurance activities
- Policy, application, and responsibilities
- Documentation requirements
- Control of documents and records
- Configuration management
- Management responsibility (commitment, customer focus, quality policy, planning, communication, review)
- Resource management (provision of resources, human resources, infrastructure, work environment)
- Product realization (Planning, customer-related processes, design and development, purchasing, provisions, Control of Monitoring and Measurement Devices)
- Measurement, analysis, and improvement (internal audits of products and processes, control of nonconforming product, data analysis on quality control, corrective & preventative action)
- Document hierarchy

#### **4.3.24 Configuration Management Plan/CM Changes**

The Configuration management control plan shall include:

- Management organizational structure
- Configuration identification (parts and drawings)
- Configuration control (preparation and incorporation of changes, definition and review procedures of Class I & II changes, material traceability)
- Examples of document control forms
- Configuration status accounting (maintaining and verifying status)
- Subcontractor/vendor control
- Milestones
- Integration of CM and other management disciplines



- Definition of all quality assurance activities

#### **4.3.25 Anomaly Reports**

For each reported anomaly or nonconformance, there shall be a report that documents the investigation and engineering analyses needed to determine the cause and corrective actions to disposition the nonconformance, and to identify any closed problem reports that do not have a definitive cause or corrective action. The anomaly report shall include a description of the members of the Material Review Board (MRB) and Failure Review Board (FRB).

#### **4.3.26 Preliminary Hazard Analysis/Safety Assessment Report**

The Preliminary Hazard Analysis (PHA) report shall identify safety critical areas, provide an initial assessment of hazards, identify recommended hazard controls and identify recommended follow-on actions. The report shall include detailed descriptions of the design, test, operation and inspection requirements for all flight hardware and materials, ground support equipment, and their interfaces necessary for a valid identification, assessment, control and mitigation of documented hazards. This includes technical information concerning hazardous and safety critical equipment, systems, operations, handling and materials. The report shall also include a documentation of hazard controls, verifications and tracking methods for all identified hazards.

#### **4.3.27 Failure Modes and Effects Analysis (FMEA)**

The Failure Modes and Effects Analysis shall identify failures at the functional level and address attendant consequences. The document shall include a brief description of the design that may result in failures, such as performance characteristics, key components, and the manufacturing flow and inspection plan. The description of each failure mode shall include probable cause, its effect on the propulsion system, its effect on the mission (criticality), failure detection methods, and the compensating design features or control measures.

Each failure mode shall be assigned a severity category, determined in accordance with the table below, based on the most severe effect caused by that failure. All mission phases (i.e., ground handling, launch, and on-orbit operation) shall be addressed in the analysis. All failure modes that are assigned to Severity Categories 1, 1R, 1S, and 2, shall be itemized on a Critical Items



List (CIL) and maintained with the FMEA report. Rationale for retaining the items shall be included on the CIL.

Category	Severity	Description
1	Catastrophic	Failure modes that could result in serious injury, loss of life (flight or ground personnel), or loss of launch vehicle.
1R		Failure modes of identical or equivalent redundant hardware items that could result in category 1 effects if all failed.
1S		Failure in a safety or hazard monitoring system that could cause the system to fail to detect a hazardous condition or fail to operate during such condition and lead to Severity Category 1 consequences.
2	Critical	Failure modes that could result in loss of one or more mission performance requirements as defined by the GSFC project office.
2R		Failure modes of identical or equivalent redundant hardware items that could result in Category 2 effects if all failed.
3	Significant	Failure modes that could cause degradation to mission performance requirement.
4	Minor	Failure modes that could result in insignificant or no loss to mission performance requirements.

#### 4.3.28 Limited Life Items List

The limited life items list shall identify all limited life items, which include all material/hardware that is subject to degradation because of limited shelf life or expected operating times or cycles such that their expected useful life is less than twice the required life when fabrication, test, storage, and mission operation are combined. . An item's useful life period begins with fabrication and ends when the orbital mission is completed. The list shall include : the item, expected life, required life, duty cycle, rationale for selection and effect on mission parameters. Records shall be maintained that allow evaluation of the cumulative stress (time and/or cycles) for limited-life items, starting when useful life is initiated and indicating the activity that stresses



the items, a description the design life requirements and a list of all limited life items and their adherence.

#### **4.3.29 Verification Matrix**

The Contractor shall provide an additional Verification Matrix showing the flow-down of each performance requirement specified in the tank specification GPM 422-06-01-11-002 and defining the method of verification for each specific requirement of this contract. Verification methods shall include:

Similarity: Designated as (S). Represents near identical form, usage, and environment

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

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

Test: Designated as (T). Represents a detailed test of performance and/or functionality throughout a properly configured test setup where all critical data taken during the test period is captured for review. The test category shall be further differentiated as development, acceptance, or qualification. In-process production evaluation tests and environmental stress screening tests shall also be considered to be verification tests and shall be grouped in the acceptance test category for purposes of the verification matrix. In-process production evaluation tests and environmental stress screening tests shall be differentiated from formal acceptance tests by a footnote or asterisk.

The following details shall be included in the verification matrix for each requirement:

- Requirement reference
- Description
- Verification Method



- Verification document
- Comments/analysis

#### **4.3.30 Trend Analysis Report**

The trend analysis report shall include any analysis performed to track measurable parameters that relate to performance stability and repeatability. These parameters shall be compiled in a Trended Parameters List (TPL). The report shall explain the reasoning behind the chosen parameters, backed by the analysis, or why the analysis is inapplicable.

#### **4.3.31 Trended Parameters List (TPL)**

The trended parameters list shall list and describe the parameters selected to measure performance stability and repeatability from the trend analysis. The TPL shall be included as part of the Trend Analysis Report.

#### **4.3.32 Alert/Advisory Documentation**

Applicability, impact, and corrective actions for Government Industry Data Exchange Program (GIDEP) alerts or NASA Alerts and Advisories relevant to items used on GPM shall be documented and status provided to the GPM Project on a monthly basis.

#### **4.3.33 Materials and Processes Identification List (M&P)**

The Materials and Processes Identification List (M&P) shall list all materials and process used during the development of the GPM tank and PMD. The list shall note all materials in contact with hydrazine or hydrazine vapors and shall provide justification for the use of the materials in a long term (10 year) exposure environment. The list shall include, at a minimum, for each part the part number and name, the material used, specification, and application. The list shall include for each process (vendor, military and subcontractor) the referenced document number, revision, a description, and application.

#### **4.3.34 As-Built Materials List (ABML)**

An As-Built Materials List (ABML) shall be included as part of the end item data package. The list shall include the same information as the M&P described in Section 4.3.33.



#### **4.3.35 Material Usage Agreement**

A Material Usage Agreement (MUA) shall be submitted for any materials intended for use that do not meet requirements. The GPM Material Usage Agreement form can be found in Appendix B of the SOW, GPM 422-06-01-11-003. The form includes a description of the material, its application, and a rationale for using the material despite nonconformance.

#### **4.3.36 Tripped Sensor Documentation**

The Contractor shall document what action NASA GSFC is to take if the sensors are tripped when hardware arrives at the NASA GSFC receiving area. A copy of this document shall be included with shipping documentation.

#### **4.3.37 Pre-Environmental Review Presentation Package**

The Contractor shall provide to GSFC a PER Presentation Package, detailed in Section 2.2.5 of the SOW, and all other required deliverable data whose scheduled delivery is linked to PER two weeks prior to the review.

#### **4.3.38 Pre-Ship Review Presentation Package**

The Contractor shall provide to GSFC a PSR Presentation Package, detailed in Section 2.2.6 of the SOW, and all other required deliverable data whose scheduled delivery is linked to PSR two weeks prior to the review.

#### **4.3.39 Contractor Initiation Presentation Package**

The Contractor shall provide to GSFC a Contractor Initiation Meeting Presentation Package, detailed in Section 2.2.2 of the SOW, and all other required deliverable data whose scheduled delivery is linked to CIM two weeks prior to the review.

