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Global Precipitation Measurement Project

Navigator GPS Front-End Electronics

Statement of Work

Goddard Space Flight Center
Greenbelt, Maryland

National Aeronautics and
Space Administration

CM FOREWORD

This document is Global Precipitation Measurement (GPM) Configuration Management (CM)-controlled document. Changes to this document require prior approval of the applicable Configuration Control Board (CCB) Chairperson or designee. Proposed changes shall be submitted to the GPM CM Office (CMO), along with supportive material justifying the proposed change. Changes to this document will be made by complete revision.

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CHANGE HISTORY LOG Sheet: 1 of 1

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Rev-	Baseline Release per GPM-CCR- 444	C. Carlisle	4/2/2010

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1.0 GENERAL INFORMATION

The National Aeronautics and Space Administration (NASA), the Office of Space Science (OSS) and the Goddard Space Flight Center (GSFC) have the stated mission to design, develop, integrate, launch, and operate the Global Precipitation Measurement (GPM) Mission.

The GPM mission is one of the next generation satellite-based Earth science constellation missions that will study global precipitation (rain, snow and ice). The GPM Core Observatory will be carrying both a dual frequency radar instrument and a passive microwave radiometer. The Core Observatory will serve as a calibration standard for the other members of the GPM constellation.

This document defines the work to be performed for Contractor design, development, fabrication, and delivery of the GPM GPS Front–End Electronics, also referred to as the FEE.

1.1 GENERAL REQUIREMENTS

The Contractor shall provide the facilities, personnel, services, tools, equipment, and materials necessary to deliver:

- Five Flight Unit Front-End Electronics

The Contractor shall generate a matrix that lists each section in this statement of work and indicates either compliance or non-compliance. Areas of non-compliance need to be addressed by the Contractor showing how they plan to meet the requirement(s) or why it will remain non-compliant.

1.2 APPLICABLE DOCUMENTS

All applicable and reference documentation identified in this document shall apply in the situations where they are specifically referenced. In the event of a conflict between the SOW and the specification, the SOW shall take precedence. See Appendix C for referenced documents.

2.0 MANAGEMENT, REPORTING, DOCUMENTATION AND REVIEWS

2.1 MANAGEMENT AND REPORTING

The Contractor shall designate and identify by name a single individual who will be given full responsibility and authority to manage and administer all phases of the work specified by the contract, and ensure that all objectives are accomplished within schedule and cost constraints.

The Contractor shall designate and identify by name a single individual who shall serve as a point of contact with the GSFC Contracting Officer Technical Representative (COTR) for all technical aspects of the GPM Front End Electronics contract.

The Contractor shall provide for managing all resources, controlling schedules, managing all engineering, manufacturing and procurement activities, configuration management, Quality Assurance, documentation control, and distribution.

The Contractor shall prepare and present to the NASA/GSFC COTR monthly status via teleconference and a written report. The report shall be a summary presentation of the period's progress, problem areas, on-going activities, and planned activities. The Contractor shall generate a list of significant milestones that will enable the NASA/GSFC COTR to ascertain program progress.

2.2 DOCUMENTATION

The Contractor shall ensure the generation and delivery of all documentation as called for in the Contract.

In addition to that documentation specifically called for in the Contract, upon request by the NASA/GSFC COTR, the Contractor shall make available a copy of any document or data generated during this contract performance for review by the GSFC at either the Contractor's facility or via the internet. This includes, but is not limited to, technical reports and memorandums, drawings, schematics, studies, analyses, parts and materials data, test data, alerts, etc.

2.3 REVIEWS AND MEETINGS

2.3.1 Design Conformance Review (DCR):

The Contractor shall organize and present a Design Conformance Review to a GSFC Review Team at the Contractor’s facility on a date defined in the contract. This review shall demonstrate overall conformance of the requirements specified in the Global Precipitation Measurement GPS Front-+2End Electronics Performance Specification GPM-GN&C-SPEC-0103 and this Statement of Work. This 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 Design Conformance Review Presentation Package and all other required deliverables as specified in this SOW and the accompanying DILS. Refer to section 3.2.3 for the list of required deliverable data.

Review minutes shall be prepared by the Contractor and, as a minimum, shall include attendance, action items, action item accomplishment responsibility and agreements. All items shall be in sufficient detail to be self-explanatory. A Design Conformance Review Report shall be prepared by the Contractor following the review and, as a minimum, contain meeting notice, agenda, review meeting minutes described above and responses to all recommendations and action items.

2.3.2 Pre-Environmental Review (PER)

The Contractor shall organize and conduct a Pre-Environmental Review (PER) at the Contractor's facility before the environment test program begins. This review shall demonstrate overall conformance of the requirements specified in the Global Precipitation Measurement GPS Front - End Electronics Performance Specification GPM-GN&C-SPEC-0103 and this Statement of Work for this phase of the procurement. This review shall cover programmatic, technical, test and verification, and quality assurance topics. This review shall also provide an opportunity to review test plans and procedures and all analyses required to approve the testing of the hardware.

2.3.3 Pre-Ship Review (PSR)

The Contractor shall hold a Pre-Ship Review at the Contractor's plant at the completion of verification tests and prior to shipment of the hardware to GSFC. A PSR shall be held prior to the delivery of each hardware item. A Data Delivery Package (reference 3.2.4) shall be presented for review at each PSR.

2.3.4 Technical Interchange Meetings (TIM)

The Contractor shall plan for up to three (3) informal, face-to-face technical interchange meetings to be held at the Contractor facilities. These TIMs shall support review and coordination of technical issues including, but not limited to, parts, test plans, test procedures, software changes, design modifications, and design analyses. The TIM meeting notice shall be seven (7) calendar days in advance of each meeting.

2.4 NOTIFICATION TO NASA/GSFC CONTRACTING OFFICER (CO) AND CONTRACTING OFFICER TECHNICAL REPRESENTATIVE (COTR)

The Contractor shall notify the NASA/GSFC Contracting Officer Technical Representative at least seven (7) calendar days in advance of all mandatory hardware inspections, test activities, and deliveries at either the Contractor's or a sub-Contractor's facility to allow timely participation by the NASA/GSFC Quality Assurance activates.

3.0 ENGINEERING

3.1 GENERAL REQUIREMENTS

The Contractor shall perform analyses of the technical and environmental requirements specified in the Global Precipitation Measurement GPS Front-End Electronics Performance Specification GPM-GN&C-SPEC-0103 to ensure compliance of the hardware fabrication and to assemble the documentation necessary to ensure its usability by NASA/GSFC users.

3.2 ENGINEERING DOCUMENTATION

The system engineering analyses of the detailed design and subsequent fabrication and assembly, test, and inspection of the FEE shall result, as a minimum, in the following technical documentation, as required in the Contract. Contractor format is acceptable for this documentation.

3.2.1 Interface Control Document (ICD)

The Contractor shall provide a document or documents that define, in detail, all performance, functional, environmental specifications, and all command, telemetry, data, electrical, and mechanical interfaces.

3.2.2 Drawing Package

The Contractor shall provide a drawing package that includes, but is not limited to;

ELECTRICAL: assembly and interface drawings (board level schematics available on request)

MECHANICAL: assembly and interface drawings

3.2.3 Design Conformance Review Presentation Package

The Contractor shall provide a Design Conformance Review Presentation Package prior to the manufacturing program. The Design Conformance Review data package shall address all program management, design, analysis, manufacturing, test, and quality assurance activities outlined in this SOW and the Global Precipitation Measurement GPS Front - End Electronics Performance Specification GPM-GN&C-SPEC-0103 in sufficient detail to ensure that the proposed design conforms to all requirements and is ready for fabrication to begin. At a minimum, the design package should cover the following areas:

- Program Management
- Quality Assurance
- Reliability Data (including assessment and predictions)
- Electrical, Mechanical, and Environmental specifications

- Parts, including stress analysis and radiation hardness assessment
- Detailed architectural block diagrams for the different deliverable units
- Manufacturing flow with inspection points
- Facilities
- Verification test plan (Including Performance Test Description)
- Materials and Processes
- Thermal analyses
- Mechanical/Structural analyses
- Electrical Worst-Case analyses
- Failure Modes Effects Analysis
- Flight Heritage
- Verification Matrix
- Contamination Control Plan

3.2.4 Data Delivery Package

The Data Delivery Package shall be made available for review during mandatory inspections and pre-ship reviews for each of the different hardware deliverables. This package shall also be delivered with each end item with the level of detail required of that item. The package should be comprised of, but not limited to, the following data:

All Items:

- As-Built vs. As Designed Parts List, (includes serialization/revisions)
- Final Drawing Package (including rework instructions, if any)
- Critical Parameters Trend Data,
- Problem/anomaly reporting (complete copies of report)
- Deviations/Waivers/open items/non-conformances and their dispositions,
- Class I MRBs (complete copies of reports)
- List of Materials and Processes used,
- Log of total operating time,
- List and status of all identified Life-Limited Items,
- Verification matrix, test data and reports,
- Flight connector mate/demate log (Flight Unit only)
- Photograph Documentation (Pre-Closure and Closed)
- Certificate of Conformance
- Open Items with proposed closure dates

3.2.5 Verification Test Plan

A Verification Test Plan shall be generated by the Contractor to perform verification tests identified in the requirements GPM-GN&C-SPEC-0103. Verification tests must demonstrate acceptable performance over the specified range of performance requirements, measure performance parameters and designed to reveal inadequacies in manufacturing and assembly such as workmanship or material problems.

The plan should 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 should include a test matrix summarizing all tests that will be performed on the FEE.

This plan shall be a Contractor controlled document and shall indicate all changes made after the initial approval by the GSFC. After verification test plan approval, no changes shall be made without written NASA GSFC COTR approval.

3.2.6 Verification Test Procedures

The Contractor shall generate Verification Test Procedures. The verification procedures shall be step-by-step instructions for performing tests outlined by the Verification Test Plan. The procedures should 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 limits. 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.

Verification test procedures shall be Contractor controlled documents and shall indicate all changes made after the initial release for review to NASA.

3.3 THERMAL ANALYSIS

The vendor thermal analysis must show that the device and/or the electronic part junction temperatures are within the EEE parts de-rating guidelines for operation in a vacuum environment. Analysis shall combine maximum power dissipation with maximum interface temperature. In addition, hot and cold survival temperatures at the interface, must be specified and tested by the vendor.

The results of these analyses shall be summarized in a Contractor format for the Thermal Analyses Report, which shall be provided for review as per the contract schedule.

The Contractor shall provide a reduced thermal model with approximately 10-20 nodes. This model shall identify the nodalization, the thermal couplings, and masses, etc. such that the GSFC can recreate the model in the SINDA thermal analyzer and achieve temperature predictions

within 3C of measured values. It is preferred, but not required, that the model be in Thermal Desktop/SINDA FLUINT format.

3.4 STRUCTURAL ANALYSIS

A Structural Analysis shall be performed on the Flight Unit structure to ensure the capability to withstand and survive launch and ascent loads. The effects of any thermal inputs shall be reflected in the analyses as appropriate. The results of these analyses shall be summarized in a Contractor format Mechanical Analyses Report that will be provided to the NASA GSFC COTR for review.

3.5 RESERVED

4.0 HARDWARE MANUFACTURE

4.1 FRONT-END ELECTRONICS

The Contractor shall manufacture and test hardware to meet the requirements of the Global Precipitation Measurement GPS Front-End Electronics Performance Specification GPM-GN&C-SPEC-0103

4.2 RESERVED

4.3 CONNECTOR SAVERS

Flight units shall be tested with connector savers to minimize mates and de-mates. Connector savers shall be delivered with each Flight unit.

4.4 SUPPORTING HARDWARE

The Contractor shall provide the following supporting hardware:

- One set of the mating half of the external connectors for each delivered flight unit, plus two additional sets per contract delivery schedule
- ESD flight protective caps, as applicable
- Closeout caps for test connectors

5.0 QUALITY ASSURANCE

5.1 GENERAL REQUIREMENTS

5.1.1 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 (1994 or 2000 version) or equivalent. GSFC shall be notified of any changes to the QA program.

5.1.2 Surveillance of the Contractor

The work activities and operations of the Contractor, subcontractors, and suppliers are subject to evaluation, review, survey, and inspection by GSFC representative.

The Contractor shall provide the GSFC representative with documents, records, equipment, and workings areas within their facilities that are required by the representative to perform their overview activities.

5.1.2.1 Government Source Inspection

The Government may elect to perform inspections at a supplier's plant. The following statement shall be included on all procurement documents: “All work on this order is subject to inspection and test by the Government at any time and place”.

The Government quality representative who has been delegated NASA quality assurance functions on this procurement shall be notified immediately upon Contractor receipt of any supplier/subcontractor orders. The Government representative shall also be notified 48 hours in advance of the time that articles or materials are ready for inspection or test.

5.1.2.2 Contractor Source Inspection

The Contractor shall ensure that its procurement documents impose the applicable requirements on subcontractors and other suppliers. The subcontractor and other suppliers shall in turn impose the requirements on their procurement sources.

The Contractor shall perform source inspection at the subcontractor’s or supplier's facilities in accordance with the procurement documentation or when one or more of the following conditions exist:

In process, end item controls, or tests that are destructive in nature prevent the developer from verifying quality after delivery to the developer's facility.

It is not feasible or economical for the Contractor to determine the quality of procured articles solely by inspections or tests performed at the Contractor’s facility.

Qualification tests are to be performed by the subcontractor or supplier.

Products are shipped directly from the source to NASA, by-passing the Contractor's inspection facilities.

5.1.2.3 Government Mandatory Inspection Points (MIPs)

The government or its representative will perform the following MIPs listed below. The government may request additional MIPs if a specific process prohibits inspection at a later time.

- Inspect 100% solder
- Inspect 100% crimps
- Inspect 100% conformal coating, staking, and potting
- Rework Inspection
- Pre-closure Inspection
- Pre-Ship Inspection / Data Review

5.1.3 Configuration Management

The Contractor's Configuration Management (CM) system (available for review on request) shall control the design and hardware/software by means of drawings, specifications, and other documents and shall ensure all applicable changes are reviewed in a systematic manner to determine the validity and impact on performance, schedule, and cost. The Contractor's Configuration Management system shall have a change classification and impact assessment process that ensures Class I changes are forwarded to the CO for approval prior to release/incorporation. Class I changes are defined as changes that affect form, fit, function, external interfaces, or requirements as stated within this document and GPM-GN&C-SPEC-0103.

All other changes are considered to be Class II changes and shall be controlled and dispositioned by the Contractor. All Class II changes shall be provided monthly to the COTR for review purposes. NASA/GSFC reserves the right to review all Class II changes for technical content to ensure the proper classification has been assigned. Any flight item that is found to be non-compliant with the quality, workmanship and performance requirements of the contract shall be dispositioned via a waiver or MRB, unless the affected item is reworked to restore compliance (CSO approval shall precede any such rework operation) or is replaced with a fully compliant item. The Contractor shall submit Waivers and MRB's to the COTR for final approval.

A Contractor QA representative shall be a member of the Configuration Control Board. The QA activities shall be defined in the Configuration Management Plan and described in detail in the QA Plan. Related portions of the plans shall be cross-referenced.

5.1.4 Anomaly Reporting

Reporting of hardware anomalies to the NASA/GSFC COTR shall begin no later than the first power application or the first cycle/actuation for mechanical items at the start of acceptance testing. The NASA GSFC COTR shall be notified within 24 hours of each anomaly.

The Contractor's processes for review, disposition and approval of anomaly reports shall be described in their quality plan/manual or provided as a supplement document. In addition, the Contractor's anomaly reporting document shall describe the members of the Material Review Board (MRB) and Failure Review Board (FRB). The MRB and FRB shall include GPM GSFC participation. These processes shall ensure that positive corrective action has been taken to preclude recurrence and that appropriate audits and tests are performed to verify the implementation of the corrective action.

The Contractor shall routinely inform the GPM Project of MRB and FRB meeting schedules and agendas with sufficient notice to permit GPM Project participation if desired by GPM.

At the Contractor's facility, NASA/Government representatives may participate in MRB/FRB activities as deemed appropriate by Government management or contract.

The NASA GSFC COTR reserves disapproval rights on MRB and FRB decisions. To assure process consistency, the Contractor shall provide the GPM Project on-line access to their GPM anomaly-reporting database.

The Contractor shall provide, as part of the monthly report, a list of all open anomaly reports and a separate list of the anomaly reports closed during the month. For each reported anomaly or nonconformance, there shall be a report that documents the investigation and engineering analysis needed to determine the cause and corrective actions to disposition the nonconformance, and identify any closed problem reports that do not have a definitive cause or corrective action. Reports shall be submitted to the NASA GSFC COTR for review and approval of the disposition.

The supplier shall establish and maintain documented procedures to ensure product that does not conform to specific requirements is prevented from unintended use or installation. This control shall provide for identification, documentation, evaluation, segregation (when practical), disposition of nonconforming product, and for notification to the functions concerned.

5.2 SYSTEM SAFETY REQUIREMENTS

The Contractor shall supply 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. For all identified hazards, the Contractor shall also document hazard controls, verifications and tracking methods.

The Contractor shall provide technical support to the GPM Project for safety working group and technical meetings as necessary in conjunction with TIMs.

5.3 RELIABILITY REQUIREMENTS

The Contractor shall prepare and conduct the following set of reliability analyses.

5.3.1 Failure Modes and Effects Analysis

The Contractor shall perform a Failure Modes and Effects Analysis (FMEA) in accordance with MIL-STD-1629, "Procedures for Performing an FMEA". The FMEA shall identify failures at the functional level and address attendant consequences. This analysis shall be provided to the NASA COTR for review.

5.3.2 EEE Parts Stress Analyses

The Contractor shall perform parts stress analyses on Electrical, Electronic, and Electromechanical (EEE) parts and devices as employed in the circuit designs of the Flight Item to certify conformance with the de-rating requirements of EEE parts. The analyses shall be documented, and justification shall be included for all applications that do not meet the de-rating criteria. The Contractor shall use NASA document EEE-INST-002, Instructions for EEE Parts Selection, Screening, Qualification, and De-rating to establish criteria. Contractor de-rating guidelines may be considered in place of EEE-INST-002 guidelines but shall be submitted to the GPM CSO for approval. This analysis shall be provided to the GPM CSO for review.

5.3.3 Worst Case Analyses

The Contractor shall perform worst-case parameter analyses on performance critical or functional critical components for which excessive operating variations could compromise mission performance. The Contractor shall identify the worst case analyses planned to assure the design meets critical performance and life requirements. Adequate margins in electronic circuits, optics, electromechanical devices, or other mechanical items (mechanisms) can be verified by analysis, testing or both. When verification by analysis is used, the analyses shall consider all parameters at worst-case limits and worst-case environmental conditions for the parameter or operation being evaluated. Similarly, when verification by testing is used, the testing shall be conducted to provide as direct a measure as possible of the critical performance or function while the element is subjected to worst-case parameter variations. Elements that may warrant worst case analysis may include: control loops that require adequate phase and gain margin to operate properly, sensitive analog circuitry, power supply or switching circuitry, motor and actuator systems, electro-mechanical elements that require torque margin to operate over life and environmental variations.

5.3.4 Limited-Life Items

The Contractor shall identify and manage limited-life items. Limited-life items include all 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.

The GPM Project COTR shall approve the use of an item whose expected life is less than twice the mission design life.

5.4 GROUND SUPPORT EQUIPMENT (GSE)

Mechanical and electrical Ground Support Equipment (GSE) and associated software that directly interfaces with flight deliverable items shall be assembled and maintained to mitigate potential risk to flight hardware. Parts and materials selection and reporting requirements are exempted as long as deliverable flight item contamination requirements are not compromised. However, all GSE interfaces to flight hardware shall be flight quality (i.e. connectors, baseplates, etc.).

5.5 DESIGN VERIFICATION REQUIREMENTS

5.5.1 Verification Requirements

The Contractor shall implement a program to verify all requirements specified in the Global Precipitation Measurement GPS Front - End Electronics Performance Specification GPM-GN&C-SPEC-0103.

The Contractor shall provide a verification matrix defining the method of verification for each specific requirement of this contract. Verification methods shall include:

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

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

Test: Designated as (T) and 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.

In-process production evaluation tests and environmental stress screening tests shall also be considered to be verification tests.

5.5.2 Analysis / Trending / Reporting Of Test Data

The Contractor shall properly record, maintain and analyze test information during the normal test program to assess performance and flight worthiness and to aid in the identification and analysis of flight hardware failures and problems.

The Contractor shall also perform trend analyses to track measurable parameters that relate to performance stability and repeatability. Selected parameters shall be monitored for trends starting at component acceptance testing and continuing through the system integration and test phases. These parameters will be compiled in a Trended Parameters List (TPL).

The reports will be delivered as part of the Data Delivery Package and presented at formal technical reviews as appropriate.

5.5.3 Demonstration of Failure-free Operation

The Contractor shall have demonstrated a period of 40 hours of contiguous failure-free operation for each Flight Unit prior to delivery.

5.6 WORKMANSHIP STANDARDS AND PROCESSES

5.6.1 Workmanship: Use of Alternate Workmanship Standards

GSFC recognizes that the Contractor may have an established workmanship program equivalent to the specific standards cited herein. In these instances, the Contractor may use existing standards upon review and approval by the GPM Project CSO. It must be established that the developer's workmanship program fully encompasses the specific requirements of this chapter. It is the Contractor's responsibility to list all deviations from the NASA workmanship standards and to provide data supporting their position/rationale.

5.6.2 Training and Certification of Contractor Personnel

All personnel performing work on flight hardware requiring a prerequisite set of skills and competency shall be certified as having completed the required training, appropriate to their involvement as per the Standards in 5.6.5.2.

5.6.3 Hardware Handling, Cleaning and Packaging

The handling of flight hardware shall be performed by qualified personnel in accordance with approved procedures that address cleaning, handling, packaging, tent enclosures, shipping containers, bagging, and purging. Compatible packaging shall be selected so that hardware is not contaminated or otherwise degraded during shipping or storage. All personnel working on flight hardware shall be certified as having completed the required training and competency certifications prior to handling any flight hardware. This includes, but is not limited to, workmanship, clean room and ESD awareness courses.

5.6.4 Electrostatic Discharge Control Requirements

The Contractor shall document and implement an ESD Control Program suitable to protect the most ESD-sensitive instrument components at all levels of assembly and integration in accordance with the requirements of ANSI/ESD S20.20.

All personnel who manufacture, inspect, test or otherwise process electronic hardware or who require unescorted access into ESD protected areas shall be certified as having completed the required training, appropriate to their involvement prior to handling any electronic hardware.

5.6.5 Workmanship Requirements for Printed Circuited Boards, Soldered Assemblies, Harnessing, and Fiber Optics

The following workmanship standards shall apply to printed circuit boards, soldered assemblies, harnessing, and fiber optics.

5.6.5.1 Requirements for Printed Wiring Boards

a) Printed Wiring Board (PWB) Design:

Space Flight PWB designs shall not include features that prevent the finished board(s) from complying with the Class 3 Requirements of the appropriate manufacturing standard (e.g., specified plating thickness, internal annular ring dimensions, etc).

- IPC-2223, Sectional Design Standard for Flexible Printed Boards
- IPC-2221, Generic Standard on Printed Board Design
- IPC-2222, Sectional Design Standard for Rigid Organic Printed Boards
  b) Printed Wiring Board (PWB) Manufacture:

- IPC-A-600, Acceptability of Printed Boards
- IPC-6011, Class 3, Generic Performance Specification for Printed Boards
- IPC-6012B, Qualification and Performance Specification for Rigid Printed Boards, rigid flight PWBs shall be fabricated to Class 3/A requirements per 6012B Performance Specification Sheet for Space and Military Avionics
- IPC-6013, Class 3, Qualification and Performance Specification for Flexible Printed Boards

The Contractor shall provide PWB coupons to the GSFC Materials Engineering Branch (MEB), or to a GSFC-MEB approved laboratory for evaluation. PWB coupon approval shall be obtained from GSFC MEB or a GSFC approved laboratory prior to population of flight PWBs. GSFC will ensure that analysis is performed and a response is provided within 21 days of receipt of PWB coupons if coupons are submitted to MEB.

One coupon per manufacturing panel shall be submitted for multilayer PWBs. Coupons shall be fully traceable to the printed circuit board(s) they represent. Coupon identification shall include, as a minimum, part number, revision letter, serial number, vendor CAGE code, date code or lot information.

5.6.5.2 Workmanship Requirements

The following workmanship requirements shall apply:

- Conformal Coating and Staking: NASA-STD-8739.1, Workmanship Standard for Polymeric Application on Electronic Assemblies;
- Surface Mount Technology (SMT): NASA-8739.2, Workmanship Standard for Surface Mount Technology;
- Hand Soldering Assemblies: NASA-STD-8739.3, Soldered Electrical Connections
- Crimping, Wiring, and Harnessing: NASA-STD-8739.4, Crimping, Interconnecting Cables, Harnesses, and Wiring;
- Fiber Optics: NASA-STD-8739.5, Fiber Optic Terminations, Cable Assemblies, and Installation;

5.6.5.3 New or Advanced Packaging Technologies

Workmanship requirements or standards, including design, qualification, and acceptance requirements, specified by the Contractor for advanced packaging technologies, such as multi-chip modules (MCMs), stacked memories, chip on board, column-grid arrays (CGA) or ball grid arrays (BGA), shall be submitted to the NASA/GSFC COTR for review and approval prior to use.

Each Non-Standard Process document shall address process control, fabrication, inspection, training, and acceptance and rejection criteria. Test data and evaluation records shall be submitted as part of the process support for approval, as applicable.

5.7 EEE PARTS REQUIREMENTS

5.7.1 General

Flight Unit parts shall be selected and processed in accordance with the requirements of EEE-INST-002, "INSTRUCTIONS FOR EEE PARTS SELECTION, SCREENING, QUALIFICATION, AND DERATING" for level 2 parts. All application notes in EEE-INST-002 will apply.

The minimum acceptable EEE part grade available for Flight Unit use on GPM is Class 2 with 100% Particle Impact Noise Detection (PIND) screening for cavity bodied devices and a sample Destructive Physical Analysis (DPA). This assumes that the radiation hardness requirements and system reliability goals are also being met. This would include parts costs, test costs, risk of test failures and reliability differences between both classes. The Contractor shall maintain an EEE Parts Identification List and shall review proposed parts with the GPM COTR. The COTR will provide the list to the GPM project for review by the Parts Control Board, which is established by GSFC. The Contractor shall also provide an As-Built Parts List as part of the Data Delivery Package.

5.7.2 Custom Devices

In addition to the applicable requirements of EEE-INST-002, custom microcircuits, hybrid microcircuits, MCM, ASIC and other non-standard application unique devices planned for Flight Unit shall be subjected to a parts-level design review (with GSFC participation). The design review shall address, at a minimum, de-rating of elements, method used to certify acceptable reliability, assembly and materials processes, methods for assuring adequate thermal matching of materials, and screening and qualification requirements.

5.7.3 Plastic Encapsulated Microcircuits (PEMs)

The use of Plastic Encapsulated Microcircuits is discouraged in the Flight Unit. However, when use is necessary to achieve unique requirements that cannot be found in hermetic high reliability microcircuits, plastic encapsulated parts, must meet the requirements of NASA GSFC EEE-INST-002. All PEM(s) require NASA/GSFC COTR review and concurrence. PEM usage shall be presented at the Design Conformance Review and TIMs, as applicable.

5.7.4 Radiation Hardness

All Flight Unit parts shall be selected to meet their intended application in the on-orbit GPM radiation environment as defined in the Global Precipitation GPS Measurement Front - End Electronics Performance Specification GPM-GN&C-SPEC-0103. The radiation environment consists of two separate effects: total ionizing dose (TID) and single-event effects (SEE). The Contractor shall document the radiation hardness assessment for each part with respect to both effects and include this assessment as part of the Design Conformance Review Presentation Package. Test plans and reports for parts that require radiation testing shall be submitted to the NASA/GSFC COTR for review.

5.7.5 Parts Age Control

Parts more than 5 years old require GPM COTR concurrence. Contractors shall present justification with inspection and test requirements.

5.7.6 GIDEP Alerts and Problem Advisories

Contractors shall keep sufficient selection and usage records for all flight parts and materials adequate to determine applicability of any issued Government Industry Data Exchange Program (GIDEP) alerts relevant to items used on GPM. The Contractor shall review and disposition all GIDEP Alerts for relevancy and impact. In addition, the Contractor shall review and disposition any NASA Alerts and Advisories provided to the developer by the GPM Project. Alert applicability, impact, and corrective actions shall be documented and status provided to the NASA/GSFC COTR on a monthly basis.

5.7.7 Reuse of Parts and Materials

EEE parts and materials, which have been installed in an assembly, and removed for any reason, shall not be used again for flight.

5.7.8 Part Notification of Failure

The Contractor shall provide failure-reporting data to NASA/GSFC COTR within 72 hours of part failure determination.

5.8 MATERIALS, PROCESSES AND LUBRICATION REQUIREMENTS

5.8.1 Materials Selection Requirements

Materials, processes and lubrication approval by the GPM Materials Assurance Engineer (MAE) is required for each usage or application in spaceflight hardware. All materials and processes shall be defined by standards and specifications and shall be identified in the lists of materials and processes. The contractor shall create and maintain a Materials and Processes Identification and Usage List for MAE review. An as-built List shall be included as part of the end item data package. The lists hall include the applicable references for the outgassing data, e.g. MAPTIS, GSFC online database, etc. and the SCC data, e.g. MAPTIS, MSFC-STD-3029.

To qualify as a material and process compliant with intended spaceflight use, they must have a satisfactory flight heritage, be approved by the MAE, and meet the applicable selection criteria as defined in the subsequent sections, the Mission Assurance Requirements, and Front End Electronics Specifications. A material that has limited spaceflight heritage or does not meet the applicable selection requirements listed herein shall be considered non-compliant. A Materials Usage Agreement (MUA) and/or a Stress Corrosion Evaluation Form shall be submitted to the MAE for approval for use of the proposed non-compliant material. Both forms will be required for a material that does not meet the SCC requirements.

Pure Tin, Zinc, and Cadmium are not acceptable for flight use.

The selection and use of material with hazardous properties (such as flammability and toxicity) shall be highlighted in the material and processes lists and they shall meet the requirements specified in AFSPCM91-710, "Range Safety User Requirements Manual," Chapters 10 and 12.

Wire, cable, and exposed surfaces of connectors shall meet the requirements of this document and be reported on materials usage lists. All other standard Electrical, Electronic, and Electromechanical (EEE) parts shall be exempt from reporting on materials lists, however they must be included in the EEE Parts Identification List for review.

The use of silicone-containing materials shall be accompanied by drawings showing their location withing the assembled component or subsystem.

5.8.2 Vacuum Outgassing of Polymeric Materials

Only materials that have a total mass loss (TML) less than 1.00% and a collected volatile condensable mass (CVCM) less than 0.10% shall be approved for use in a vacuum environment. Material vacuum outgassing shall be determined in accordance with ASTM E-595. If a material exceeds these maximum limits, the Contractor shall be required to either replace with a compliant material or bring it into compliance via a vacuum bakeout, or to submit a Material Usage Agreement (MUA) for its usage. If outgassing tests are required due to a lack of existing relevant and current data, the developer shall provide the samples for testing.

5.8.3 Stress Corrosion Cracking of Inorganic Materials

Materials used in structural applications shall be highly resistant to stress corrosion cracking (SCC) as specified in **MSFC-STD-3029**. A Material Usage Agreement (MUA) and a SCC evaluation form shall be submitted, Contractor format acceptable, for each material usage that does not comply with the **MSFC-STD-3029** SCC requirements.

5.8.4 Lubrication Systems

The Contractor's material list shall include lubrication usage. Lubricants shall be selected for use with materials on the basis of flight heritage and valid test results that confirm the suitability of the composition and the performance characteristics for each specific application, including compatibility with the anticipated environment and contamination concerns.

All lubricated mechanisms shall be life tested unless it can be established and documented that a valid flight heritage exists to an identical mechanism used in an identical flight application/environment or to an identical mechanism that has been separately qualified by suitable life testing.

5.8.5 Process Selection Requirements

Materials and manufacturing process information shall be provided in the Materials and Processes Identification and Usage List. The level of detail shall be such that the compilation of repeatable/controlled processes produces a consistent and reliable product.

5.8.6 Fasteners

The Contractor shall comply with the procurement and test requirements for flight hardware and critical ground support equipment fasteners contained in 541-PG-8072.1.2, Goddard Space Flight Center Fastener Integrity Requirements, and supply a plan as to how the requirements will be met. Traceability shall be maintained for every fastener lot. Fasteners shall be included in M&P lists along with their complete identification numbers.

5.8.7 Materials Procurement Requirements

Raw materials purchased by the Contractor and its developers shall be accompanied by a Certificate of Compliance and, where applicable, the results of nondestructive, chemical and physical tests. When requested, this information shall be made available to the NASA GSFC COTR for review.

5.8.8 Corrosion

To avoid electrolytic corrosion, dissimilar metals should not be used in direct contact unless protection against corrosion has been provided in accordance with MIL-STD-889. Variances from this policy must be submitted to the government for approval. In addition, metals shall be chosen to be resistant to corrosion, i.e. rating A or B as in Materials and Processes Technical Information System (MAPTIS-II), and be protected from corrosion using an acceptable process.

5.8.9 Materials Used in "Off-the-Shelf Hardware"

"Off-the-shelf hardware" for which a detailed materials and processes list is not available and where the included materials cannot be easily identified and/or changed will be treated as non-compliant. The developer shall submit a MUA that defines the appropriate measures that will be used to ensure that all materials in the "off the shelf" hardware will be acceptable for use.

5.8.10 Shelf-Life Control Requirement

Polymeric materials and those that have a limited shelf-life (including lubricants, 'O' rings, and solder flux) shall be controlled by a process that identifies the start date (manufacturer's processing, shipment date, or date of receipt, etc.), the storage conditions associated with a specified shelf-life, and expiration date. The use of materials whose date code has expired requires that the developer demonstrate, by means of appropriate tests, that the properties of the

materials have not been compromised for their intended use. The data and rationale shall be documented in an MUA.

5.8.11 Sample Forms

Sample materials and processes related forms are shown in Appendix B.

6.0 CONTAMINATION CONTROL

The Contractor shall establish the specific cleanliness requirements to minimize performance degradation and delineate the approaches to meet the GPM Project requirements.

6.1 CONTAMINATION CONTROL PLAN

The Contractor shall prepare a Contamination Control Plan (CCP) that describes the procedures that will be followed to control contamination. The CCP shall establish the implementation and describe the methods and procedures that will be used to measure and maintain the levels of cleanliness required during each of the various phases of the item's lifetime. The contamination potential of material and equipment used in cleaning, handling, packaging, tent enclosures, shipping containers, bagging (e.g., anti-static film materials), and purging shall be described in detail at each phase of assembly, integration, test, and launch. Materials contacting flight hardware (including gloves, finger cots, wipes, and swabs) shall be screened to ensure they are in keeping with the CCP requirements for that component. The CCP shall define the use of protective covers and purges, vent locations and paths, and environmental constraints.

The Contractor shall submit their CCP to the NASA/GSFC COTR for review and approval.

6.2 MATERIAL OUTGASSING

All materials shall be screened in accordance with NASA Reference Publication 1124, Outgassing Data for Selecting Spacecraft Materials. Individual material outgassing data shall be established based on each component's operating conditions. Established material outgassing data shall be verified and shall be provided to the NASA/GSFC COTR for review and approval upon request.

6.3 THERMAL VACUUM BAKEOUTS

Thermal vacuum bakeout of the Front-End Electronics shall be performed before delivery. The parameters of the bakeout (e.g., temperature, duration, outgassing requirements, and pressure) are specified in the Global Precipitation Measurement GPS Front-End Electronics Performance Specification GPM-GN&C-SPEC-0103.

A quartz crystal microbalance (QCM) or temperature controlled quartz crystal microbalance (TQCM) and cold finger shall be incorporated during all thermal vacuum bakeouts. These devices shall provide additional information to enable a determination of the duration and effectiveness of the thermal vacuum bakeout as well as compliance with the CCP.

If a QCM or TQCM is unavailable then the vendor shall perform a final bakeout at +50C, under vacuum, for a minimum of 24 hours prior to delivery.

Thermal vacuum bakeout results shall be verified and shall be provided to the GPM Project for review. The following documents and data shall be collected and delivered to NASA GSFC COTR:

The following test data shall be collected and delivered to GSFC: Chamber Configuration and Test Report.

Chamber Configuration includes, but not limited to:

- Use of Shrouds
- Chamber Size
- General Test Setup
- Thermal layout
- Pressure Profile
- Temperature Profile
- TQCM Locations and how many (if available)
- Hardware placement plan (include drawings)
- TQCM Temperature (if available)
- Hardware Temperature
- Shroud Temperature
- Chamber dimensions
- Location of scavenger plates (if used)
- Location of cold finger (if used)
- Type of pump (ie: diffusion, cryopumped, etc.)

Test Report: (Provide 2 weeks after test is completed)

- Cold Finger Data
- Test Results Data
- TQCM Data (Take readings every 0.5 hours) (if available)
- Chamber Configuration Data

7.0 HANDLING, STORAGE, PACKAGING, PRESERVATION, AND DELIVERY

Products shall be stored, preserved, marked, labeled, packaged, and packed to prevent loss of marking, deterioration, contamination, excessive condensation and moisture, or damage during all phases of the program. Stored and stocked items shall be controlled in accordance with documented procedures and be subject to quality surveillance.

Contractor is responsible for providing an acceptable shipping container that protects the hardware appropriately.

While in a shipping container, the FEE shall be wrapped in a non-ESD-generating vapor barrier with redundant maximum humidity indicators.

The shipping container shall also include shock and humidity indicators and shall be capable of prolonged shipping conditions. 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.

By executing the act of product shipment, the supplier certifies that the product complies with all contract requirements. Prior to shipping, quality assurance personnel shall ensure that:

- Fabrication, inspection, and test operations have been completed and accepted.
- All products are identified and marked in accordance with requirements.
- The accompanying documentation (developer's shipping and property accountable form) has been reviewed for completeness, identification, and quality approvals.
- Evidence exists that preservation and packaging are in compliance with requirements.
- Packaging and marking of products, as a minimum comply with Interstate Commerce Commission rules and regulations and are adequate to ensure safe arrival and ready identification at their destinations.
- The loading and transporting methods are in compliance with those designated in the shipping documents.
- Integrity seals are on shipping containers and externally observable shock and humidity monitors do not show excessive environmental exposure.
- In the event of unscheduled removal of a product from its container, the extent of re-inspection and retest shall be as authorized by NASA or its representative.
- Special handling instructions for receiving activities, including observation and recording requirements for shipping-environment monitors are provided where appropriate.

The Contractor’s quality assurance organization shall verify prior to shipment that the above requirements have been met and shall sign off appropriate shipping documents to provide evidence of this verification. The Contractor shall ship Freight On Board (F.O.B.) Greenbelt, Maryland. The Contractor has the responsibility for any damaged incurred during shipment.

APPENDIX A: Abbreviations and Acronyms

Abbreviation/ Acronym	DEFINITION
ANSI	American National Standards Institute
BBU	Breadboard Unit
BSP	Board Support Package
C&DH	Command and Data Handling
CCP	Configuration Control Plan
CDR	Critical Design Review
CM	Configuration Management
CO	Contracting Officer
COTR	Contracting Officer Technical Representative
CVCM	Collected Volatile Condensable Mass
DCR	Design Conformance Review
DPA	Destructive Physical Analysis
ESD	Electrostatic-Discharge
FEE	Front End Electronics
FMEA	Failure Modes and Effects Analysis
FRB	Failure Review Board
GPM	Global Precipitation Measurement
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
ICD	Interface Control Document
LEO	Low Earth Orbit
MIP	Mandatory Inspection Point
MRB	Material Review Board
MUA	Materials Usage Agreement
PEMs	Plastic Encapsulated Microcircuits
PER	Pre-Environmental Review
PIL	Parts Identification List
PIND	Particle Impact Noise Detection
PSR	Pre-Ship Review
PWB	Printed Wiring Board
QA	Quality Assurance
QCM	Quartz Crystal Microbalance

ROM	Read-Only Memory
SCC	Stress Corrosion Cracking
SCM	Software Configuration Management
S/C	Spacecraft
SEE	Single-Event Effects
SOW	Statement of Work
SUROM	Startup Read-Only Memory
TML	Total Mass Loss
TID	Total Ionizing Dose
TIM	Technical Interchange Meeting
TPL	Trended Parameters List
TQCM	Thermal Quartz Crystal Microbalance
WVR	Waiver

APPENDIX B: Materials and Processes Forms

<table>
<tr><td colspan="3">MATERIAL USAGE AGREEMENT (MUA)</td><td colspan="3">USAGE AGREEMENT NO.:</td><td>PAGE OF</td></tr>
<tr><td>PROJECT:</td><td>:</td><td colspan="3">ORIGINATOR:</td><td>ORGANIZATION:</td></tr>
<tr><td>DETAIL DRAWING</td><td colspan="2">NOMENCLATURE</td><td colspan="2">USING ASSEMBLY</td><td>NOMENCLATURE</td></tr>
<tr><td></td><td colspan="2"></td><td colspan="2"></td><td></td></tr>
<tr><td colspan="3">MATERIAL & SPECIFICATION</td><td colspan="3">MANUFACTURER & TRADE NAME</td></tr>
<tr><td colspan="3"></td><td colspan="3"></td></tr>
<tr><td>USAGE</td><td>THICKNESS</td><td>WEIGHT</td><td>EXPOSED AREA</td><td colspan="2">ENVIRONMENT</td><td></td></tr>
<tr><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td><td>PRESSURE</td><td>TEMPERATURE</td><td>MEDIA</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td colspan="7">APPLICATION:</td></tr>
<tr><td colspan="7">RATIONALE:</td></tr>
<tr><td colspan="2">ORIGINATOR:</td><td colspan="3">PROJECT MANAGER:</td><td>DATE:</td></tr>
</table>

STRESS CORROSION EVALUATION FORM

1. Part Number _____
2. Part Name _____
3. Next Assembly Number _____
4. Manufacturer _____
5. Material _____
6. Heat Treatment _____
7. Size and Form _____
8. Sustained Tensile Stresses-Magnitude and Direction _____
   a. Process Residual _____
   b. Assembly _____
   c. Design, Static _____
9. Special Processing _____
10. Weldments _____
    a. Alloy Form, Temper of Parent Metal _____
    b. Filler Alloy, if none, indicate _____
    c. Welding Process _____
    d. Weld Bead Removed - Yes ( ), No ( ) _____
    e. Post-Weld Thermal Treatment _____
    f. Post-Weld Stress Relief _____
11. Environment _____
12. Protective Finish _____
13. Function of Part _____
    _____
14. Effect of Failure _____
    _____
15. Evaluation of Stress Corrosion Susceptibility _____
    _____
16. Remarks: _____
    _____

POLYMERIC MATERIALS AND COMPOSITES USAGE LIST

SPACECRAFT _____ SYSTEM/EXPERIMENT _____ GSFC T/O _____

DEVELOPER/CONTRACTOR _____ ADDRESS _____

PREPARED BY _____ PHONE _____ DATE PREPARED _____

GSFC MATERIALS EVALUATOR _____ PHONE _____ DATE RECEIVED _____ DATE EVALUATED _____

Area, cm^2	Vol., cc	Wt., gm
1 0-1	A 0-1	a 0-1
2 2-100	B 2-50	b 2-50
3 101-1000	C 51-500	c 51-500
4 >1000	D >500	d >500

ITEM NO.	MATERIAL IDENTIFICATION(2)	MIX FORMULA(3)	CURE(4)	AMOUNT CODE	EXPECTED ENVIRONMENT(5)	REASON FOR SELECTION(6)	OUTGASSING VALUES	
							TML	CVCM

NOTES

1. List all polymeric materials and composites applications utilized in the system except lubricants which should be listed on polymeric and composite materials usage list.

2. Give the name of the material, identifying number and manufacturer. Example: Epoxy, Epon 828, E. V. Roberts and Associates

3. Provide proportions and name of resin, hardener (catalyst), filler, etc. Example: 828/V140/Silflake 135 as 5/5/38 by weight

4. Provide cure cycle details. Example: 8 hrs. at room temperature + 2 hrs. at 150C

5. Provide the details of the environment that the material will experience as a finished S/C component, both in ground test and in space. List all materials with the same environment in a group. Example: T/V : -20C/+60C, 2 weeks, 10E-5 torr, ultraviolet radiation (UV)
   Storage: up to 1 year at room temperature
   Space: -10C/+20C, 2 years, 150 mile altitude, UV, electron, proton, atomic oxygen

6. Provide any special reason why the materials was selected. If for a particular property, please give the property.
   Example: Cost, availability, room temperature curing or low thermal expansion.

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INORGANIC MATERIALS AND COMPOSITES USAGE LIST

SPACECRAFT _____ SYSTEM/EXPERIMENT _____ GSFC T/O _____

DEVELOPER/CONTRACTOR _____ ADDRESS _____

PREPARED BY _____ PHONE _____ DATE PREPARED _____

GSFC MATERIALS EVALUATOR _____ PHONE _____ DATE RECEIVED _____ DATE EVALUATED _____

ITEM NO.	MATERIAL IDENTIFICATION(2)	CONDITION(3)	APPLICATION(4) OR OTHER SPEC. NO.	EXPECTED ENVIRONMENT(5)	S.C.C. TABLE NO.	MUA NO.	NDE METHOD

NOTES:

1. List all inorganic materials (metals, ceramics, glasses, liquids and metal/ceramic composites) except bearing and lubrication materials which should be listed on Form 18-59C.
2. Give materials name, identifying number manufacturer.
   Example: a. Aluminum 6061-T6
   b. Electroless nickel plate, Enplate Ni 410, Enthone, Inc
   c. Fused silica, Corning 7940, Corning Class Works
3. Give details of the finished condition of the material, heat treat designation (hardness or strength), surface finish and coating, cold worked state, welding, brazing, etc.
   Example: a. Heat treated to Rockwell C 60 hardness, gold electroplated, brazed.
   b. Surface coated with vapor deposited aluminum and magnesium fluoride
   c. Cold worked to full hare condition, TIG welded and electroless nickel plated.
4. Give details of where on the spacecraft the material will be used (component) and its function.
   Example: Electronics box structure in attitude control system, not hermetically sealed.
5. Give the details of the environment that the material will experience as a finished S/C component, both in ground test and in space. Exclude vibration environment. List all materials with the same environment in a group.
   Example: T/V: -20C/+60C, 2 weeks, 10E-5 torr, Ultraviolet radiation (UV)
   Storage: up to 1 year at room temperature
   Space: -10C/+20C, 2 years, 150 miles altitude, UV, electron, proton, Atomic Oxygen

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LUBRICATION USAGE LIST

SPACECRAFT _____ SYSTEM/EXPERIMENT _____ GSFC T/O _____

DEVELOPED/CONTRACTOR _____ ADDRESS _____

PREPARED BY _____ PHONE _____ DATE PREPARED _____

GSFC MATERIALS EVALUATOR _____ PHONE _____ DATE RECEIVED _____ DATE EVALUATED _____

ITEM NO.	COMPONENT TYPE, SIZE MATERIAL(1)	COMPONENT MANUFACTURER & MFR. IDENTIFICATION	PROPOSED LUBRICATION SYSTEM & AMT. OF LUBRICANT	TYPE & NO. OF WEAR CYCLES(2)	SPEED, TEMP., ATM. OF OPERATION(3)	TYPE OF LOADS & AMT.	OTHER DETAILS(5)

NOTES

(1) BB = ball bearing, SB = sleeve bearing, G = gear, SS = sliding surfaces, SEC = sliding electrical contacts. Give generic identification of materials used for the component, e.g., 440C steel, PTFE.

(2) CUR = continuous unidirectional rotation, CO = continuous oscillation, IR = intermittent rotation, IO = intermittent oscillation, SO = small oscillation, (<30°), LO = large oscillation (>30°), CS = continuous sliding, IS = intermittent sliding.
No. of wear cycles: A(1-10^2), B(10^2-10^4), C(10^4-10^6), D(>10^6)

(3) Speed: RPM = revs./min., OPM = oscillations/min., VS = variable speed
CPM = cm/min. (sliding applications)
Temp. of operation, max. & min., °C
Atmosphere: vacuum, air, gas, sealed or unsealed & pressure

(4) Type of loads: A = axial, R = radial, T = tangential (gear load). Give amount of load.

(5) If BB, give type and material of ball cage and number of shields and specified ball groove and ball finishes. If G, give surface treatment and hardness. If SB, give dia. of bore and width. If torque available is limited, give approx. value.

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MATERIALS PROCESS UTILIZATION LIST

SPACECRAFT _____ SYSTEM/EXPERIMENT _____ GSFC T/O _____

DEVELOPER/CONTRACTOR _____ ADDRESS _____

PREPARED BY _____ PHONE _____ DATE PREPARED _____

GSFC MATERIALS EVALUATOR _____ PHONE _____ DATE RECEIVED _____ DATE EVALUATED _____

ITEM NO.	PROCESS TYPE(1)	CONTRACTOR SPEC. NO.(2)	MIL., ASTM., FED. OR OTHER SPEC. NO.	DESCRIPTION OF MAT'L PROCESSED(3)	SPACECRAFT/EXP. APPLICATION(4)

NOTES

(1) Give generic name of process, e.g., anodizing (sulfuric acid).

(2) If process if proprietary, please state so.

(3) Identify the type and condition of the material subjected to the process.
E.g., 6061-T6

(4) Identify the component or structure of which the materials are being processed.
E.g., Antenna dish

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APPENDIX C: List of Referenced Documents

All referenced documentation identified in the SOW shall apply in the situations where they are specifically referenced.

DOCUMENT NUMBER	TITLE	Revision/Date
GPM-GN&C-SPEC-0103	GPM Front-End Electronics Performance Specification	
541-PG-8072.1.2A	GSFC Fastener Integrity Requirements	12/07/06
ANSI/ASQ9001-2000	Model for Quality Assurance Design, Development, Production, Installation, and Servicing	Aug 1991
ANSI/ESD S20.20	Electrostatic Discharge Control	12/15/97
NASA-STD-8739.3	Soldered Electrical Connections	12/15/97
NASA-STD-8739.4	Requirements for Crimping Inter-connecting Cables, Harnesses, and Wiring	02/09/98
NASA-STD-8739.2	Workmanship Standard for Surface Mount Technology	08/31/99
NASA-STD-8739.1	Workmanship Standard for Polymeric Application on Electronic Assemblies	03/04/08
EEE-INST-002	Instructions for EEE Parts Selection, Screening, Qualification, and Derating	05/01/03
IPC-2223	Sectional Design Standard for Flexible Printed Boards	11/01/98
IPC-2222	Sectional Design Standard for Rigid Organic Printed Boards	02/01/98

IPC-2221	Generic Standard on Printed Board Design	05/01/03 Revision A
IPC-A-600	Acceptability of Printed Boards	11/01/99 Revision F
IPC-6011	Generic Performance Specification for Printed Boards	07/01/96
IPC-6012B	Qualification and Performance Specification for Rigid Printed Boards	08/01/04
IPC-6013	Qualification and Performance Specification for Flexible Printed Boards	11/01/98
S-311-M-70	Destructive Physical Analysis. Equivalent	01/07/91
NASA-STD-6001	Flamability, odor, off-gassing and compatibility requirements & test procedures for materials in environments that support combustion	02/09/98
MIL-STD-1629	Procedures for Performing an FMEA	Revision A
MSFC-STD-3029	Multiprogram/project common-use document guidelines for the selection of metallic materials for stress corrosion cracking resistance in sodium chloride environments	05/22/00
ASTM E-595	Standard test method for total mass loss and collected volatile condensable materials from outgassing in a vacuum environment	10/01/03
NASA Reference Publication 1124	Outgassing Data for Selecting Spacecraft Materials	09/01/03
MIL-HDBK-217	Reliability Modeling and Prediction	Revision F
422-40-01-004	GPM Mission Assurance Requirements (MAR)	