STATEMENT OF WORK

FOR THE GLOBAL PRECIPITATION MISSION MICROWAVE IMAGER (GMI)

PHASE B/C/D PROCUREMENT

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1. INTRODUCTION

1.1 General

This Statement of Work (SOW) defines the minimum effort required by the contractor for the design, analysis, development, fabrication, integration, test, evaluation and support for the Global Precipitation Mission (GPM) Microwave Imager, hereafter referred to as GMI. One copy of the GMI will be integrated with the GPM Core spacecraft, and a second copy of the GMI will integrated with a GPM Constellation spacecraft. In addition the Government may exercise a contractual option to purchase a third copy of the GMI for integration on a future constellation spacecraft.

GPM is a joint mission sponsored by the National Aeronautics and Space Administration (NASA) of the United States and the National Space Development Agency (NASDA) of Japan. Integration of GMI with the Core spacecraft will be performed by NASA at the Goddard Space Flight Center (GSFC), with the launch of the Core spacecraft by NASDA scheduled to take place from Tanegashima, Japan in November 2007. Integration and launch of the Constellation spacecraft is TBD.

1.2 Scope

In accordance with the requirements of the GMI Requirements Document 422-30-00-001, and the GPM GMI Mission Assurance Requirements (GMI MAR) GMP-INS-REQX-0220A (Attachments **XX** and **XX**) to this contract, the contractor shall provide the personnel, materials, equipment, and facilities necessary for the design, analysis, development, fabrication, assembly, test, engineering data analyses, calibration, qualification, storage, storage testing and delivery for each instrument. Following instrument delivery the contractor shall support post-delivery testing, spacecraft (S/C) integration, spacecraft test, and preparation of the integrated spacecraft for shipment to the launch facility. At the launch facility the contractor shall provide pre-launch support. Post-launch support shall be provided by the contractor for instrument check-out and verification of on-orbit performance. In support of the above activities, the contractor shall provide the required reports, reviews and documentation identified in the contract.

2.0 REQUIREMENTS

The requirements to which GMI shall be designed are contained in the GMI Requirements Document 422-30-00-001, the GMI Mission Assurance Requirements GMP-INS-REQX-0220A, this Statement of Work (SOW), and referenced and applicable documents. The order of precedence is this SOW, the GMI Requirements Document 422-30-00-001, GMI Mission Assurance Requirements GMP-INS-REQX-0220A, then referenced and applicable documents.

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2.1 Project Management

The contractor shall maintain a project office that shall manage the technical activities and resources of the GMI project. The contractor shall appoint a dedicated Project Manager to direct and manage this office. The contractor's Project Manager shall have responsibility for the overall technical performance and resource management of the contractual effort and all subcontracts. The contractor's Project Management Office shall provide administrative and technical direction, schedule control and reporting, financial control and reporting, subcontract management, software management, configuration management and documentation, progress reports and reviews, preparation and support of all reviews, documentation, and generation as required of minutes of meetings/reviews. The contractor's Project Management Office shall be responsible for compliance with the reportable items set forth in the Contract Data Requirements List (CDRL), Attachment XXXX of this contract.

The contractor shall establish and maintain a configuration management system. This system may be in accordance with the contractor's standard plans and policies, provided the configuration management requirements identified in the GMI Mission Assurance Requirements document are included.

The contractor shall provide to NASA for review purposes electronic access to all completed reports, analyses, internal technical memoranda and other documents relating to the development and management of GMI contained in electronic data bases customarily used by the contractor for projects such as GMI. Within the data bases the contractor shall maintain an index of the material and update this index at least monthly. The material contained in these electronic data bases may be in contractor format.

The contractor shall implement an Earned Value System (EVS). The EVS may be implemented in accordance with the contractor's standard plans and policies, provided it conforms to the minimum requirements established by NASA. The EVS shall provide financial management, control, and reporting of all resources allocated to this project. Project status shall be reported to NASA in accordance with the contractor's standard policies and procedures. In addition financial reporting shall be provided by the contractor in accordance with the standard requirements of NASA Form 533, in accordance with DID 09 of this contract.

The contractor shall provide, in contractor format, a Software Management and Development Plan for review and approval in accordance with DID 12. Among the topics to be addressed in this plan shall be the requirements development and software development methodology, testing, key metrics, support of independent verification and validation (IV&V) analyses, and schedule. The contractor shall present the major software reviews in conjunction with the corresponding instrument review. (For example, the Software Critical Design Review shall be presented as an element of the Instrument Critical Design Review.)

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The contractor shall prepare monthly status reports which will address, as a minimum, technical status, schedule status, financial status, EVS metrics, status of project risks, problems encountered during the reporting period and their proposed corrective actions, significant plans and activities for the following month, and identification per the approved Configuration Management Plan of any Class I or Class II changes (Refer to DID 7, Monthly Reports).

The contractor's Project Manager shall be the principal interface between the contractor and the NASA/GSFC GPM Project; the GPM Project's principal point of contact will be the GMI Instrument Manager who will be designated as the Contracting Officer's Technical Representative (COTR) for this procurement. The contractor's designated Project Manager shall report to a level of company management appropriate to insure prompt resolution of all problems.

2.2 System Engineering

The contractor shall provide the personnel, equipment and facilities necessary for all required system engineering activities, including all aspects of instrument performance, testing and evaluation. These activities include definition and allocation of system and subsystem requirements, test and calibration, and preparation of analyses, plans, reviews and procedures. The system engineering effort shall address all considerations necessary for the development of an instrument that complies with the GMI Requirements Document 422-30-00-001, including electrical, structural, mechanical, thermal, calibration, and data subsystems, as well as interfaces within the instrument and between the instrument and the spacecraft. The systems engineering effort includes understanding the customer's requirements, performing analyses and maintaining mass, power, and data budgets and margins. It includes supporting NASA GSFC and TBD Constellation spacecraft contractor in the generation of the initial drafts of the GMI Interface Control Documents (ICD) for the Core spacecraft and the Constellation spacecraft, respectively, and the review and refinement of the ICDs at appropriate times during the instrument and spacecraft development projects. It includes the development of component, subsystem, system, and end-to-end system test requirements and test plans, integration and test support, test data analyses, generation of reports and specifications, control of internal instrument interfaces, and control of the instrument side of interfaces to the spacecraft. It includes generation of technical reports, response to action items from design reviews, issue and reissue of reports, preparation and management of contractor internal technical memoranda, and support of storage testing. It includes reporting the status and progress of the system engineering work. And it includes providing the personnel and facilities to develop the required test documentation and execute the required performance, calibration and final acceptance tests necessary to demonstrate compliance with the GMI Requirements Document 422-30-00-001 and GMI Mission Assurance Requirements GMP-INS-REQX-0220A.

Analyses and algorithms necessary to support all instrument testing, calibration, and performance evaluation shall be developed by the contractor. The calibration error

analyses and algorithms shall be delivered to NASA (refer to DID 16) and are required to cover the entire operating temperature range of the GMI while in orbit.

Analyses performed by the contractor demonstrating that the instrument meets GMI Requirements Document 422-30-00-001 shall be delivered to NASA.

2.3 Instrument Design and Development

The contractor shall provide the personnel, equipment and facilities necessary for the design and development effort. This effort shall include the electrical, structural, mechanical, thermal, data, and safety and reliability design of the instrument, the instrument to spacecraft interface design, the instrument calibration, and ground support equipment. The contractor shall strive to minimize the use of titanium and the types of stainless steel which may survive re-entry; when the use of these materials is proposed, the contractor shall consult with NASA concerning their application and provide the quantities of material used. The contractor shall consider incorporation of features and design approaches into the instrument's design which will make it conducive to servicing and adjustment during integration and testing. The contractor shall provide the personnel and facilities necessary for material and processing engineering, sustaining engineering for system fabrication, integration and test, production engineering, instrument radiometry and calibration analysis, software/firmware development, maintenance, and any other required support activities.

The contractor shall prepare in addition to the requirements of this contract, additional engineering studies, technical analyses and design modifications in response to studies and tasks authorized by the COTR. In advance of initiation of any work associated with these activities, the contractor shall propose to the COTR the specific task elements which will be performed, and the labor and materials costs associated with the effort (refer to DID 10). The cumulative cost of tasks authorized by this effort will not exceed over the life of the contract the amount specified in Section B1 of the Contract. For planning purposes, the contractor should anticipate that most of the studies and tasks will be performed prior to CDR.

The contractor shall provide all the instrument software and firmware, and associated documentation, necessary to operate, calibrate and test the instrument. The contractor shall provide an instrument command list and description, as well as general instrument operating procedures as part of the GMI Users Manual (DID 17).

The contractor shall design the GMI to operate a minimum of 36 months on-orbit. GPM has a goal of having the spacecraft and all instruments operational for 60 months on-orbit; the contractor may recommend to NASA design approaches which will extend the projected on-orbit operational life of the GMI from 36 months up to 60 months.

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2.4 Manufacturing

The contractor shall provide the personnel, equipment, materials and facilities necessary for the fabrication, assembly, test and delivery of the GMI instruments, ground support equipment and other items required by this contract. NASA shall have the opportunity to review and observe all manufacturing activities. In the performance of these tasks the contractor shall perform the following activities:

(a) Procure or fabricate all required parts, components, subassemblies and assemblies.

(b) Successfully complete all required subsystem-level alignment, functional, performance, calibration, and qualification tests.

(c) Successfully complete subsystems assembly and integration into the instrument.

(d) Successfully complete instrument-level alignment, functional, performance, calibration, and qualification tests to demonstrate full compliance with the GMI Requirements Document 422-30-00-001. The contractor shall provide records of all recorded instrument calibration & test results per DID 16.

(e) Perform the required preliminary and final testing of the GMI instrument required for instrument acceptance.

(f) Prepare the required test documentation.

(g) Provide mounting hardware and drill templates to be used for the mounting of the instrument to the spacecraft.

(h) Provide storage and storage testing consisting of all facilities, equipment, materials, and activities necessary to maintain the GMI instrument in a condition to meet GMI Requirements Document 422-30-00-001 prior to shipment to the facility where spacecraft integration will occur, at the at the spacecraft integration facility, and at the launch site.

The contractor shall provide the personnel, materials and facilities necessary for the design, fabrication and testing of models, components and coupons which are used to verify that the design meets the GMI Requirements Document 422-30-00-001 and GMI MAR GPM-XXX-XXX.

The contractor shall provide the personnel, materials, and facilities necessary to define the detailed Ground Support Equipment (GSE) hardware and software requirements needed to support the development, fabrication, test, operation, transport and integration of the GMI instruments onto their respective spacecraft, and to permit post-integration instrument ground operation. The contractor shall design, provide, document, and maintain all GSE hardware, software, and firmware, including sustaining engineering for hardware, software, and firmware maintenance and evolution. The GSE includes the System Test Equipment (STE), all GSE software, calibration equipment, expendable materials, handling fixtures, protective covers, shipping containers, and other necessary supporting equipment and fixturing.

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The contractor shall identify and procure commercial off-the-shelf (COTS) equipment and fixturing for use as GSE when available commercially and when economically appropriate. Where suitable COTS equipment is not available, the contractor shall design and fabricate or procure special test equipment and fixturing. The contractor shall verify performance and maintain all GSE hardware and software. The calibration equipment and software shall be under configuration control.

The contractor shall provide the personnel and facilities necessary to prepare and pack the instrument and its GSE for shipment, and shall be responsible for the transportation and shipment of the material to the designated spacecraft integration facility for integration and test with the appropriate spacecraft.

The contractor shall take digital color photographs of circuit boards and other major components, subsystems, and the system during the build, integration, and test of each instrument. The photographs shall be of sufficiently high resolution, for example, to permit identification of components on circuit boards. Videos shall be taken, as appropriate, of moving assemblies. As a minimum videos shall be taken showing the operation of the scan drive assembly and deployment mechanisms. One set of photographs and videos shall be sent to the GPM Project Office during the course of the contract (i.e., within two weeks following the date when the photographs were taken), and one set of photographs and videos shall be delivered on CD ROM with the instrument.

2.5 Mission Assurance

The contractor shall maintain a Mission Assurance function. This function may be based upon either an existing contractor mission assurance function comparable to the requirements identified in the GPM Microwave Imager Mission Assurance Requirements (GMI MAR) GPM-XXX-XXX (GMI MAR) and whose use is approved by NASA, or the mission assurance function may be implemented using the GMI MAR. The mission assurance function shall have sufficient staff and facilities to provide the required quality and reliability engineering, parts engineering, quality assurance engineering, system safety, and materials control for the fabrication, integration, calibration, and verification testing (including project test plans and environmental test plans) of the GMI instrument. The contractor shall provide the Government and its support contractors access to the reports, analyses, notebooks and working papers of the contractor's staff performing the analyses and assessments required by the GMI MAR. The Mission Assurance function shall also support the necessary bonded storage activities.

The contractor shall define and implement the spares program necessary to minimize schedule impact for the project created by failures, contamination, or by other plausible events or conditions. In defining the spares program, the contractor shall consider the reliability, handling, and environment of subsystems, components, and parts, hence the

likelihood that these items would need to be replaced. The spares, in quantities to be defined by the contractor, shall be qualified, tested and calibrated as appropriate.

2.6 Integration and Test

The contactor shall provide personnel, special tools and equipment, and materials for instrument test, spacecraft integration and test support, pre-launch support, launch support, post-launch support, software support, and data analyses. This support includes operation of all GMI instrument GSE developed under this contract. This support shall be provided at the GSFC spacecraft integration facility and at the Tanegashima Space Center (TNSC), Japan for the Core spacecraft, and at TBD locations for the Constellation Spacecraft.

The contractor shall support hardware interface and functionality testing with the Core spacecraft. The initial testing shall be performed after hardware breadboarding to verify compatibility of electrical signaling and functionality of key instrument capabilities are included and at allow time for modifications of the design if necessary. Prior to CDR detailed functionality testing shall take place to confirm the compatibility of the spacecraft-instrument electrical design, and the compatibility and capability of the signaling to provide full functionality of the instrument.

For each instrument fabricated, the contractor shall support three interface tests with the spacecraft developer to ensure the design electrical and signal interfaces are compatible. Two interface tests shall be at the contractor's facility and one at the spacecraft developer's facility.

The contractor shall perform the initial test of the GMI instrument at the spacecraft integration facilities, and provide field support for the integration and test of GMI on each spacecraft. The field support dates shall correspond to the launch readiness dates.

The contractor shall perform analysis of initial orbital data for each instrument in order to determine instrument in-orbit performance.

Following completion of integration and launch activities, the contractor shall pack, arrange for shipment and ship at the contractor's expense all test and support equipment planned to be shipped to the contractor's facility.

3.0 MEETINGS AND REVIEWS

The Government and the contractor shall have, as a minimum, the following meetings and reviews.

3.1 Project Initiation Meeting

The contractor shall conduct a Project Initiation Meeting within 6 weeks of contract award to discuss the contractor's plans and schedule, the contractor's organizational structure and

Work Breakdown Structure, work packages/work plans, financial management, EVS, and cost reporting. This meeting shall include an overview of the contractor's instrument design, including design enhancements, any changes anticipated from the instrument's design presented in the proposal, and areas of concern or areas where problems or difficulties for satisfying requirements are anticipated. The meeting shall be held at the Contractor's Facility (CF).

3.2 Reviews of Contractor Plans

3.2.1 Earned Value System (EVS)

The contractor shall review with NASA its EVS, and allow the GSFC review team to evaluate the contractor's management system in operation for compliance with the criteria. The review will also demonstrate the use and understanding of the system by all levels of management. Follow-up reviews may be required to assess actions taken to correct deficiencies. The review shall be held at the contractor's facility.

3.2.2 Quality Program

The contractor shall implement a quality program substantially equivalent to the program identified in the GPM GMI Mission Assurance Requirements (GMI MAR) GMP-INS-REQX-0220A. If the contractor proposes to use its in-house Quality Program, the contractor shall review with NASA its Quality Manual and any pertinent aspects of the Quality Program not addressed in the Quality Manual. The Parts Control Plan and Materials and Process Control Plan shall be assessed as part of this review. Where deviations from the GMI MAR exist, the contractor shall either obtain a waiver from NASA, or amend their quality program to comply with the GMI MAR. The review of the contractor's Quality Manual and Quality Program shall be held at the contractor's facility.

3.3 Technical Interchange Meetings (TIMs)

The contractor shall conduct technical interchange meetings to discuss key technical issues relating to the design of the GMI. These meetings shall be held periodically during the instrument's design and development. These TIMs shall discuss requirements, analyses, tradeoffs, system margins, interfaces and performance for critical areas of the design. As a minimum, TIMs shall be held to discuss the antenna system, electromagnetic interference (EMI), calibration, sampling and data processing, and spacecraft interfaces. Additional TIMs may be held as other technical issues arise, or as requested by the Government. Approximately one-half of the TIMs will be held at the contractor's facility and one-half at GSFC.

3.4 Project Status Reviews

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The contractor shall conduct Project Status Reviews to serve as a means for NASA to maintain visibility into the project's status and track its progress. Each Project Status Review shall discuss technical status and significant technical issues, financial status, EVS and cost/schedule status verses plan, causes for cost and schedule variance, problems encountered during the reporting period and the proposed corrective actions, status of program risks, identification of Class I and Class II changes, and significant activities expected during the succeeding reporting period. Project Status Reviews shall be held every other month, or more frequently as necessary. These reviews shall be held alternately at GSFC and at the Contractor's Facility.

3.5 Preliminary Design Review (PDR)

The contractor shall conduct a Preliminary Design Review to review the preliminary design of the instrument. At PDR all functional design issues shall be resolved. The topics addressed at the PDR shall include a flow-down of requirements from the GMI Requirements Document 422-30-00-001 to key instrument design parameters. The PDR shall address, as a minimum, the instrument performance requirements and expected performance (including radiometric performance, system linearity, and bandpass characteristics); budgets for mass, power, and data rate; preliminary plans and design for spacecraft interfaces; preliminary designs/analyses for the antenna system, calibration system, mechanisms, mechanical, structural, electrical, and thermal subsystems; and plans for contamination, performance verification (including a verification matrix), reliability analyses status and results, safety and mission assurance. The Software Preliminary Design Review shall be addressed as an element of this PDR. Included in the material to be addressed shall be the 1553 data bus data structure which shall be defined by PDR. Refer to DID 48 for a more comprehensive list of topics which may need to be addressed.

Schedule constraints associated with the overall GPM Mission require that the GMI PDR shall be held no later than TBS. It is desired to hold the instrument PDR in advance of the Core spacecraft PDR currently scheduled for October 2003. If the contractor anticipates difficulties complying with this date for the GMI PDR, the contractor shall advise NASA of this difficulty, and make recommendations concerning how the instrument developer may best support the spacecraft PDR. At the Core spacecraft PDR requirements for the GMI instrument-to-spacecraft interface and GMI accommodation requirements (mass, power, data rate and uncompensated momentum) are the areas of primary interest. The PDR shall be held at the contractor's facility.

3.6 Critical Design Review (CDR)

The contractor shall conduct a Critical Design Review to address the instrument's final design, just prior to procurement of flight parts. The CDR shall address the performance requirements and expected performance, mass, power, data rate, spacecraft interface/accommodation, mechanical, structural, electrical, thermal, software, safety, reliability, mission assurance, and verification and environmental test flow. It shall review test results from breadboards, test

components, and available test models. The contractor shall perform an analysis of their design to confirm that it conforms to all requirements established in the GMI Requirements Document 422-30-00-001 and GMI Mission Assurance Requirements (GMI MAR) GMP-INS-REQX-0220A. The Software Critical Design Review shall be addressed as an element of this CDR. Refer to DID 49 for a more comprehensive list of topics which need to be addressed. The review shall be held at the contractor's facility.

3.7 Pre-Environmental Review (PER)

Prior to subjecting the GMI instrument to environmental testing, the contractor shall conduct a formal review to determine readiness of the instrument for the testing. The contractor shall present as an element of the PER a Software Readiness Review. Refer to DID 50 for a list of topics to be addressed. The contractor shall conduct a Pre-Environmental Review for the first instrument fabricated prior to initiation of testing. A Delta PER for the follow-on instrument(s) may be presented; the Delta PER need address only the changes made to the configuration previously reviewed at a PER. The PERs shall be held at the contractor's facility.

3.8 Pre-Shipment Review (PSR)

The contractor shall conduct a Pre-Shipment Review at the completion of acceptance tests. Items which shall be addressed at this review include the results of system testing and calibration, malfunction reports, completeness of drawing package, reliability analyses and predictions, compatibility of performance with requirements, problems and solutions, data package to be shipped with instrument, and waivers, if any. The contractor shall conduct a Software Acceptance Review as an element of the PSR. Refer to DID 51 for a list of topics to be addressed. The contractor shall conduct a Pre-Shipment Review for the first instrument fabricated prior to shipment to the integration facility. Prior to shipment of follow-on instrument(s), the contractor shall provide a PSR data package to NASA for review. After review of the data package, NASA will make a determination as to whether a PSR is required for the subsequent instrument(s). A Delta Pre-Shipment Review (Delta PSR) shall be held if an instrument is placed in storage for more than 90 days (TBR) following acceptance. The Delta PSR shall be held at the end of storage and storage testing of the GMI instrument, and prior to instrument shipment. The Delta PSR shall discuss as a minimum the results of any post-storage testing, inspections and life-limited parts and materials. The PSRs and Delta PSRs shall be held at the contractor's facility.

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