NASA
GODDARD SPACE FLIGHT CENTER

STATEMENT OF WORK

FOR

OMNIBUS MULTIDISCIPLINE ENGINEERING SERVICES (OMES) III

FOR THE
ENGINEERING AND
TECHNOLOGY DIRECTORATE
(ETD)

INTRODUCTION

National Aeronautics and Space Administration (NASA) is responsible for directing aeronautical and space activities sponsored by the United States. The aeronautical and space activities conducted by NASA contribute materially to one or more of the core objectives under the National Aeronautics and Space Act of 1958 for the benefit of all mankind. The most notable objectives include (1) the expansion of human knowledge of the Earth and of phenomena in the atmosphere and space; (2) the development and operation of vehicles capable of carrying instruments, equipment, supplies, and living organisms through space; (3) the preservation of the role of the United States as a leader in aeronautical and space science and technology and in the application thereof to the conduct of peaceful activities within and outside the atmosphere; and (4) the most effective utilization of the scientific and engineering resources of the United States.

The Goddard Space Flight Center (GSFC), located in Greenbelt, Maryland, is home to the nation's largest organization of combined scientists, engineers, and technologists and chartered to expand the knowledge of the Earth and its environment, the solar system, and the universe through observations from space. To this end, GSFC's primary emphasis is in scientific investigation, in the development and operation of space systems, and in the advancement of essential technologies. In accomplishing this responsibility, the GSFC has undertaken a broad program of scientific research, both theoretical and experimental, in the study of space phenomena and Earth sciences. The program ranges from basic research to flight experiment development and from mission operations to data analysis.

The Engineering Technology Directorate (ETD) is GSFC's largest organization responsible for providing multidiscipline engineering expertise to all projects within GSFC. ETD comprises five engineering divisions: the Mechanical Systems Division (MSD), the Instrument Systems and Technology Division (ISTD), the Electrical Engineering Division (EED), Software Engineering Division (SED), and the Mission Engineering and Systems Analysis Division (MESA). ETD is an end-to-end science mission operation that is instrumental in designing missions, building satellites and instruments, operating and controlling spacecraft, and acquiring and distributing data to the world-wide science community. ETD will be responsible for providing multidiscipline engineering expertise to both in-house and out-of-house instrument and spacecraft programs, including the Joint Polar Satellite System (JPSS) program and NASA's Exploration and In-space Services (NExIS) projects division. To fulfill these responsibilities and ultimately achieve missions, the ETD must acquire a wide range of engineering services in support of its divisions to implement the GSFC mission.

SCOPE OF WORK

The principal purpose of this contract is to provide multidiscipline engineering support services and related work to EED, ISTD, SED, MSD, MESA, JPSS, NExIS, and related organizations, as required, for the study, design, systems engineering, development, fabrication, integration, testing, verification, and operations of space flight, airborne, and ground system hardware and software, including development and validation of new technologies to enable future space and science missions.

To this end, the contractor shall provide on/off-site multidiscipline engineering services, pursuant to Task Orders issued by the Contracting Officer. These services shall include the personnel, facilities, and materials (unless otherwise provided by the Government) to accomplish the tasks. Travel may be required by the Contractor to support certain Task Orders, these travel requirements will be identified on a task by task basis.

Qualified personnel with security clearances up to the top-secret level (as defined in the Task Order) shall be required by the Contractor to support certain Task Orders. In addition, some Task Orders require the involved staff to hold Sensitive Compartmented Information (SCI) clearances based on current single-scope background investigations. Some special task requirements must be accomplished in a Sensitive Compartmented Information (SCI) facility and the ability to access to an SCI facility and material is required. All contractor staff providing support to these special task requirements must obtain and maintain SCI clearances. The contractor must also comply with applicable NASA, DoD, National Industrial Security Program Operating Manual (NISPOM) and Director of Central Intelligence Directives (DCIDs) security regulations.

Task Orders will be issued to perform services in the following areas for components, subsystems, systems, science instruments, and spacecraft, suborbital craft (e.g., aircraft, sounding rockets, UAVs, balloons), including free-flying spacecraft, suborbital craft payloads, and Space Station payloads as well as ground support equipment, simulators, non-flight models, and prototypes; candidate, feasibility, and systems definition studies; project management; systems engineering; analysis; preliminary design; detailed design; fabrication; assembly; integration; test and verification; test instrumentation; data systems management; launch and post-launch operations; research and technology unique to system development; parts and materials; documentation; maintenance; sustaining engineering; configuration management; performance assurance; systems safety; and contamination control.

GENERAL RESPONSIBLITIES

The Contractor's responsibilities shall include the management of personnel, timely and effective implementation of Task Orders, control and monitoring of contract and subcontract performance, management of scheduled deliveries, and timely and effective reporting to the Government. These responsibilities shall also include efficient cost management methods as well as procedures to ensure that the Government is aware of task order status and progress achieved.

The Contractor shall be responsible for ensuring that all contractor and subcontractor personnel engaged in performance of this Statement of Work have appropriate qualifications, knowledge, and certification to perform work in accordance with the Task Orders.

PERFORMANCE MEASUREMENT

Performance-based statements of work/specifications will be used for establishing contract requirements. Therefore, each task order issued by the Contracting Officer will include, as a minimum, the following:

1. Statement of Work, including the requirements to be met, the standard(s) of performance/quality of work, and required deliverables (or other output)

2. Performance Specification (if applicable)

3. Applicable Documents (if required)

4. Period of Performance

5. Surveillance Plan

The Contractor shall be required to adhere to the performance measurements detailed in each task order.

TASKS

Services shall be required in one or more of the areas described in the scope above for any given task order. Services within the scope of this Statement of Work and specified in Task Orders shall include, but not be limited to, the specific services delineated in the following sections.

FUNCTION 1 – TECHNOLOGY DEVELOPMENT SERVICES

The contractor shall provide advanced research and technology support to EED, ISTD, SED, MSD, MESA, JPSS, NExIS and related organizations. These services may include development, test and analysis work in support of the Research and Technology activities.

A. SOLID STATE DEVICE RESEARCH AND DEVELOPMENT

The Contractor shall provide research, design, development, and analysis of electronic devices for application to science missions.

1. <u>Electronic Device Development Specific Tasks</u> – The Contractor shall provide electronic device development services, including:

   a. Activities that support the research, development, evaluation, design, manufacture, and test of semiconductor devices in current use or in development as future technology for use in aerospace applications
   b. Research and development of new, state-of-the-art electronic packaging techniques
   c. Research and implementation to flight standards of surface mount and multi-chip modules technology

B. INSTRUMENT SYSTEMS TECHNOLOGY SERVICES

The Contractor shall provide research, design, development, and testing, and analysis services for instrument systems, including:

1. <u>Instrument Systems Specific Tasks</u> – The Contractor shall provide services for the research and development of advanced analytical, engineering, integration, testing, and software engineering techniques including:

   a. Software engineering
   b. Software test techniques
   c. System functional test techniques and methods
   d. Data analysis algorithms and methods
   e. System performance testing techniques
   f. Real-time computer system conceptual design
   g. Statistics, statistical inference, neural net applications
   h. Finite element analysis
   i. Controls and structural interaction analysis
   j. Laser communications analysis
   k. Robotic simulations
   l. Reconfigurable computing system conceptual design
   m. Instrument Systems Performance modeling

n. X-Ray, Ultraviolet, Optical, and Infrared Instrument systems performance testing and analysis
o. Particle and field Instrument design development and analysis
p. Instrument Systems signal to noise analysis
q. Advanced hyperspectral imaging concepts
r. Microwave and sub millimeter wave radiometer advanced concepts and performance modeling
s. Lossless and lossy compression algorithms
t. Science data archival formats and data distribution methods
u. Instrument applications of computational optics
v. Synthetic Aperture Radar advanced concepts
w. Computational Image enhancement
x. Autonomous Instrument systems

C. PHOTONICS TECHNOLOGY SERVICES

The Contractor shall provide research, design, development, test, and analysis services for electro-optical subsystems for scientific systems, including:

1. Optoelectronics Specific Tasks – The Contractor shall provide services for optoelectronics technology tasks as follows:

   a. Read/write magnetoptical disk storage
   b. Optical engineering
   c. Opto-mechanical engineering
   d. Fiber optic systems
   e. Calibration and test sets
   f. Alignment

2. Opto-Mechanical Specific Tasks – The Contractor shall provide services for opto-mechanical technology tasks as follows:

   a. Develop advanced opto-mechanical technology for components and subsystems
   b. GSE optical instrumentation
   c. Develop novel materials for lightweight optical components, mounts, and support structures
   d. Develop novel thin film design, fabrication, and characterization processes
   e. State-of-the art diffractive optics and characterization
   f. New optical design concepts and analysis techniques
   g. State-of-the-art optical fabrication and test methods

D. MICROWAVE AND MILLIMETER WAVE TECHNOLOGY SERVICES

The Contractor shall provide research, design, development, test, and analysis services for microwave and millimeter wave systems for ground and space flight applications, including:

1. Antenna and Tracking Systems Specific Tasks – The Contractor shall provide services for antenna and tracking system technology tasks, including:

   a. Instrument antenna systems
   b. Communication antenna systems
   c. Antenna deployable/retractable assemblies
   d. Antenna feed networks/components
   e. Servo controls
   f. Gimbals
   g. Phased array antenna technology

2. Microwave and Millimeter Wave Components Specific Tasks – The Contractor shall provide services for microwave and millimeter wave components technology tasks, including:

   a. Research and development of high-speed analog and digital electronics for RF, microwave, and millimeter wave communications systems.
   b. Research and development of components for space communication applications, including modulator/exciters, solid-state power amplifiers, low-noise amplifiers, low-noise mixers, and improved local oscillator technology.
   c. Systems engineering
   d. Transponder technology

3. Microwave Instruments Specific Tasks – The Contractor shall provide services for microwave instruments technology tasks, including:

   a. Instrument antenna systems
   b. Low noise receivers, including improved local oscillator technology
   c. Instrument antenna coverage
   d. Microwave sources
   e. Studies and models
   f. Interferometric systems
   g. Polarimetric systems
   h. Instrument system calibration
   i. Instrument maintenance, upgrades, and field campaign support

E. INSTRUMENT ELECTRONICS SYSTEMS TECHNOLOGY SERVICES

The Contractor shall provide services for research, design, development, test, and analysis of advanced signal processing electronics for space flight systems, including support for language-based microelectronics development (VHDL, Verilog):

1. Sensor Signal Processing Specific Tasks – The Contractor shall provide services for sensor signal processing technology tasks, including:

   a. Systems engineering
   b. Digital signal processing electronics development
   c. Analog signal processing electronics development
   d. Advanced flight hardware
   e. Applications unique electronic test equipment
   f. Low-level analog signal electronics development
   g. Software engineering
   h. Flight robotics
   i. Analog/Mixed-signal ASIC development

2. Digital Signal Processing Specific Tasks – The Contractor shall provide services for digital signal processing technology tasks, including:

   a. Microprocessor development
   b. Command and data handling functions (e.g, processor, command ingest, telemetry outputting, timekeeping, fault detection/correction, analog collection, custom I/O interfaces, standardized data buses, data storage)
   c. Digital logic design through schematic capture and/or HDL coding
   d. Reconfigurable computing system design and implementation

3. Advanced Applications Specific Tasks – The Contractor shall provide services for advanced applications technology tasks, including:

   a. Data and image compression
   b. Data coding
   c. High-speed electronics development
   d. Packet telemetry development
   e. RISC development
   f. Proof-of-concept studies
   g. Electronic engineering design

4. Power Systems Specific Tasks – The Contractor shall provide services for power systems technology tasks, including:

   a. Instrument power system design and analysis
   b. Instrument power distribution electronics

F. THERMAL CONTROL SYSTEMS TECHNOLOGY SERVICES

The Contractor shall provide technology services for the research and development of advanced, two-phase thermal control systems, and cryogenic systems for instruments, systems, and spacecraft, including:

1. <u>Thermal Control Systems Specific Tasks</u> – The Contractor shall provide thermal design, fabrication, test, and analysis technology services for thermal control systems, including:

   a. Engineering design, analysis, fabrication, testing, and analysis for fixed and variable conductance heat pipes, diode heat pipes, and phase change materials.
   b. Design, analysis, fabrication, and test of mechanically and capillary pumped thermal control systems.
   c. Systems engineering to define and recommend appropriate enhancements to existing thermal control technology.
   d. Testing facilities and services for testing two-phase heat transfer systems containing ammonia and other working fluids.
   e. Thermal/mechanical capabilities to perform Phase A and Phase B studies for proposed flight experiments to demonstrate two phase heat transfer technology.
   f. Thermal/mechanical/electrical/system engineering capabilities to perform testing on mechanical cryocoolers. This includes the design, fabrication, and testing of cryocooler drive electronics and analysis of thermal performance test results.
   g. Mechanical/electrical/thermal support for on-going flight projects using mechanical cryocoolers.
   h. Variable emittance thermal control surfaces, alternative materials.
   i. Supporting the development of thermal flight experiments.

G. POWER SYSTEMS TECHNOLOGY SERVICES

The Contractor shall provide research, design, development, evaluation, and qualification of power system designs and components for space flight applications, including:

1. <u>Power System Architecture Specific Tasks</u> – The Contractor shall provide services for power system architecture technology, including:

   a. Direct energy transfer
   b. Peak power tracker

2. <u>Energy Conversion Devices Specific Tasks</u> – The Contractor shall provide services for energy conversion device technology, including:

   a. Multi-junction solar cells
   b. Thin film solar cells
   c. Concentrators

3. <u>Energy Storage Devices Specific Tasks</u> – The Contractor shall provide services for energy storage device technology, including:

   a. Li Ion
   b. Flywheel technology

      c.   Fuel cells
      d.   Li Polymer

4.   <u>Power Electronics Specific Tasks</u> – The Contractor shall provide services for power electronics technology, including:

      a.   Low and High voltage dc-dc converters
      b.   Microprocessor controlled spacecraft power management and distribution

H. GUIDANCE, NAVIGATION AND CONTROL (GN&C) TECHNOLOGY SERVICES

The Contractor shall provide services for the research and development of advanced GN&C technology for systems, subsystems, components, devices, and elements for spacecraft, balloons, UAV's, sounding rockets, instruments, systems, and other platforms.

1. <u>Advanced GN&C Sensor/Actuator Design</u> – The Contractor shall provide hardware systems engineering to design, develop and test sensor/actuator hardware and software.

I. CRYOGENIC AND FLUIDS SYSTEMS TECHNOLOGY SERVICES

The Contractor shall provide technology services for developing advanced cryogenic and fluid systems to support new NASA missions and applications:

1. <u>Cryogenic and Fluids Systems Specific Tasks</u> – The Contractor shall provide services, including:

      a.   Structural and thermal interfaces to mechanical refrigerators
      b.   Components for an advanced adiabatic demagnetization refrigerator
      c.   Cryogenic actuators
      d.   Design & develop monopropellant, bi-propellant and cryogenic fluid transfer systems for in-space refueling

J. ADVANCED COATING AND FILM TECHNOLOGY SERVICES

The Contractor shall provide technology services for developing advanced coating and film technologies to support new NASA missions and applications:

1. <u>Advanced Coating and Film Technology Specific Tasks</u> – The Contractor shall provide services, including:

      a.   Developing, procuring, calibrating, testing, and maintaining new or existing coatings and films.
      b.   Writing and presenting papers documenting the development and application of this new technology.

K. SCIENCE DATA PROCESSING APPLICATIONS & PROCESSING TECHNOLOGY SERVICES

The Contractor shall provide technology services formulating and developing advanced technology concepts and the advancement of their associated technology readiness level (TRL).

1. Science Data Processing Technology Specific Tasks – The Contractor shall provide services, including:

   a. Plan and accomplish the infusion of the resulting technology into mission or project systems for data processing or the implementation of data processing prototypes.
   b. Design and develop advanced concepts for all aspects of mission including hardware, complex electronics, reconfigurable computing, and software solutions to meet highly complex mission data processing objectives.

L. ROBOTIC TECHNOLOGY SERVICES

The Contractor shall provide technology services for developing advanced robotic systems to support new NASA missions and applications:

1. Robotic Technology Specific Tasks – The Contractor shall provide services, including:

   a. Design and develop advanced robotic arm end-effectors and satellite capture devices for cooperative and non-cooperative targets
   b. Design and develop new robotic tools for in-space servicing
   c. Develop robot algorithms and write robot ground and flight software
   d. Integrate end-effectors, tools, robot arms and avionics with spacecraft bus
   e. Design & develop new robot control avionics
   f. Design and develop vision systems to monitor and illuminate robotic worksites
   g. Design and develop contact dynamics systems and ground simulations systems for in-space robotic operations

M. AUTONOMOUS RENDEZVOUS AND CAPTURE (AR&C) SERVICES

The Contractor shall provide technology services for developing in-space AR&C systems to support new NASA missions and applications:

1. AR&C Specific Tasks – The Contractor shall provide services, including:

   a. Design and develop AR&C systems for in-space servicing
   b. Integrate AR&C systems
   c. Integrate AR&C systems into spacecraft operations
   d. Design and develop advanced ground simulations to support flight operations

The Contractor may be required to work with other NASA Centers and Government agencies to accommodate hardware interface and other in-space servicing requirements.

FUNCTION 2 – PRE-FORMULATION AND FORMULATION SERVICES: CANDIDATE, PRELIMINARY ANALYSIS, AND SYSTEMS DEFINITION STUDIES

The Contractor shall provide engineering services for mission concept development that integrate the aspects of flight systems, ground systems, instrument systems, and launch systems.

The Contractor shall produce pre-formulation and formulation phase study inputs for spacecraft, suborbitalcraft, instruments, and ground systems. The contractor shall perform hardware and software design and trade-off analyses, as well as develop preliminary, relative cost and schedule estimates based on design alternatives, and identify and assess high-risk elements in designs.

In general, the Contractor shall:

- Produce pre-formulation and formulation phase study inputs for spacecraft, suborbital craft, and instruments.

- Develop mission needs (mission objectives, measurement concept, and instrument concept) and mission design (mission requirements, architectural design, and operations concept).

- Develop preliminary, relative cost and schedule estimates based on design alternatives, and identify and assess high-risk elements in designs

- Document the history of design, qualification, flight experience, and modifications where existing components or subsystems are to be utilized

- Identify interface requirements for pre-launch, launch, on-orbit servicing, or retrieval of flight hardware

- Define interface engineering and management requirements

- Prepare mission systems and operations documentation

- Prepare requirements and specification packages that conform to applicable standards defined within Task Order statement

- Identify interfaces and prepare interface control documents

- Provide technical inputs for problem-solving and/or design inputs in selected spacecraft, instruments, suborbital craft, ground system, and data disciplines

- Analyze various reports (i.e., progress reports) delivered by the GSFC mission contractor(s) and provide recommendations to the project

- Provide liaison and coordination services for project activities

- Provide design services that include performance of preliminary design (leading to a Preliminary Design Review) of the subsystems, components, and assemblies that comprise the instrument/spacecraft/platform/launch system.

A. CANDIDATE STUDY SERVICES

The Contractor shall provide study services for the conceptual design and development of subsystems and systems, thereby participating in the identification of scientific objectives, mission requirements and technical concepts. Study products produced during this phase shall include, but not limited to:

- Strategic technology planning
- Integration of joint missions, partnerships, and other collaborative efforts
- Research/science/technology/cost trade studies
- Candidate operations concepts
- Candidate system architectures
- Cost, schedule, and risk estimates
- Research and technology unique to system development
- Customer development support and outreach

B. PRELIMINARY ANALYSIS STUDY SERVICES

The Contractor shall provide preliminary analysis study services focusing on analyzing mission requirements and establishing mission architectures in order to demonstrate that a credible, feasible design(s) exist(s). The Contractor shall develop top-level requirements and evaluation criteria, identify alternative operations/logistics concepts, and identify project constraints and system boundaries. Study products produced during this phase shall include, but not limited to:

1. <u>Analysis Services Specific Task Orders</u> – The Contractor shall perform analysis services Task Orders, including but not limited to:

   a. Preliminary system design of a feasible, but not necessarily optimum configuration.
   b. Assessment of technical risks, including identification of technical problems and the criticality of their solution to follow-on efforts. Identification of those problems currently being addressed, and a judgment of effort and time likely to be necessary to find a practical solution.
   c. Identification of all recommended systems characteristics, including launch and control capability, tracking and data acquisition, facility considerations, and institutional base activities.
   d. Implementation plans, which include the identification of all major systems and subsystems.
   e. Preparation of the system design that forms the basis for implementing system development (hardware or software).

f. Provide alternative design concepts including feasibility and risk studies, cost and schedule estimates, and advanced technology requirements.

g. Prepare for and support the appropriate Phase A project and technical reviews and prepare Phase A project documentation as appropriate (see the NASA Systems Engineering Handbook, SP-6105, December 2007).

2. <u>Documentation Specific Task Orders</u> – The Contractor shall document all results from the study in a Feasibility Study Report.

C. SYSTEM DEFINITION STUDY SERVICES

The Contractor shall provide system definition and preliminary design study services to establish (and evolve) the project baseline(s). These shall include:

1. <u>Analysis Services Specific Task Orders</u> – The Contractor shall perform system definition analysis services specific Task Orders, including:

a. Defining system requirements, system budgets (e.g., mass, power, memory), error budgets, system/subsystem requirements, software requirements, ground support equipment requirements, and integration and test requirements.

b. Identifying all recommended system characteristics, defining the subsystem components and assemblies, identifying the required complement of flight and ground support equipment, specifying internal and external interfaces, and verifying that the recommended design approach's critical subsystems and components are within the state-of-the-art.

c. Providing a formal flow down of project-level performance requirements to a complete set of system and subsystem design specifications for both flight and ground elements. Phase B baseline information shall be developed including system requirements and verification requirements matrices, system architecture and work breakdown structures, operations concepts, "design-to" specifications at all levels, and project plans including schedule, resources, and acquisition strategies.

d. Performing risk assessments of all critical elements, describing the risks and control methods. The knowledge and use of Probability Risk Assessment (PRA), Failure Modes and Effects Analysis (FMEA) and Fault Tree Analysis (FTA) is required.

e. Preparing the system design that shall form the basis for implementing/developing the system (hardware or software); defining the tasks and sequence of tasks that shall be performed to provide orderly technical development, design, review, interface, test, and integration of the system; and providing the required plans (modeling, analysis, and simulation; configuration; logistics; information; software; verification; integration and test, etc.) for the effort.

f. Describing and documenting integrated mission architecture.

g. Preparing for and supporting the appropriate Phase B project and technical reviews and prepare Phase B project documentation as appropriate (see the NASA Systems Engineering Handbook, SP-6105, December 2007).

2. Documentation Specific Task Orders – The Contractor shall document all results from the study effort in a Definition Study Report.

FUNCTION 3 – IMPLEMENTATION PHASE SERVICES

The Contractor shall provide services to design, develop, fabricate/code, assemble, unit test, system integrate, verify, integrate, deploy, and operate hardware and software on spacecraft, platform, and/or payload as defined by this Statement of Work. The implementation phase services shall include:

A. PROJECT MANAGEMENT

The Contractor shall provide management services, including establishment of a management organization that ensures that all the assigned task objectives are accomplished within specified schedule and cost constraints. Management shall provide frequent and timely status to the Government via cost, schedule, progress and other reports during all phases of work.

B. MISSION SYSTEMS ENGINEERING

The Contractor shall provide systems engineering support for project development, reporting progress and conformance to appropriate practices and specifications (see the GPR 7123.1 Systems Engineering). The Contractor shall perform key mission and spacecraft-level systems engineering functions that include, but are not limited to:

1. Operations Concept Development & Support:

    a. Developing the operations concept
    b. Preparing/reviewing mission operations concepts in regards to the intended functionality and interfaces among the flight subsystems and the ground
    c. Generating Mission Operations Concept Documents (ConOps)
    d. Participating in user interface meetings and joint integrated mission simulation training aimed at developing viable user operations
    e. Supporting satellite operations
    f. Analyzing flight anomalies and recommending implementing appropriate actions
    g. Working with principal investigator and science working group in planning operations
    h. Supporting "lessons learned" presentations
    i. Preparing plans for and supporting mission disposal operations

2. Architecture & Design Development:

    a. Defining systems and conducting trade-off studies/design studies for spacecraft, suborbital craft, instruments, space segments and ground segments
    b. Reviewing software development and software system test activities

    c. Generating and maintaining and/or reviewing system block diagrams

3. <u>Requirements Analysis, Identification and Management:</u>

    a. Generating and managing and/or reviewing Level 1 and 2 requirements
    b. Conducting requirements traceability
    c. Documenting specified and lower level derived requirements to demonstrate that performance requirements are met
    d. Reviewing/performing independent design and development requirements analyses, and submitting comments and recommendations
    e. Reviewing technical specifications, and submitting comments and recommendations
    f. Providing specification of Requirements for Design, non-flight fabrication, and checkout of ground support equipment
    g. Reviewing contamination control requirements
    h. Reviewing operating plans and procedures for cryogenics, fuels, and other hazardous materials

4. <u>Verification and Validation:</u>

    a. Generating and/or reviewing Verification Plans
    b. Performing design, drawing, and specification reviews
    c. Providing comments and/or recommendations to ensure: 1) that designs meet specification and interface requirements, 2) that appropriate parts standards are compatible with specified mission requirements and risk levels, 3) that detailed specifications are compatible with mission requirements, including margin and error budgets, 4) and that proper consideration is given to cost, reliability, safety, non-flight fabrication requirements, contamination control, magnetic materials/interference, launch requirements, and space environmental requirements.
    d. Documentation and/or review of system qualification requirements
    e. Preparing and/or reviewing hardware and software integration plans and procedures, and witnessing execution
    f. Preparing and/or reviewing detailed functional and environmental test plans and procedures, and witnessing test execution
    g. Ensuring that the technical aspects of shipping requirements and equipment are met
    h. Preparing and/or reviewing plans for launch site checkout, integration and testing of flight systems, including adequacy of the launch site facility
    i. Analyzing data from spacecraft telemetry data sources to ensure total system compatibility
    j. Analyzing Flight performance from flight data

5. <u>Interfaces and Interface Control Documents (ICDs):</u>

    a. Reviewing and analyzing design interfaces

    b. Identifying interface control requirements for engineering and design of components for launch, on orbit servicing, or retrieval of flight hardware
    c. Preparing, reviewing, and analyzing interface documentation for mission systems
    d. Preparing interface control documents and verifying proper implementation for flight and ground subsystems and systems
    e. Controlling external interface documentation and requirements

6. Mission Environments:

    a. Defining and/or reviewing subsystem and hardware specifications to ensure that they meet the specific mission or spacecraft environment

7. Technical Resource Budget Tracking:

    a. Documenting and controlling and/or Review of budget plans, including power, thermal, data storage, computer processing and communication through-put , attitude control, timing, mass properties, command and telemetry signal margin and bit error rates etc., both at the flight system level and allocated to lower levels of assembly
    b. Error margins

8. Risk Analysis, Reduction, and Management:

    a. Identifying high risk elements and developing/executing contingency plans for controlling the high risk elements
    b. Reviewing contractor risk management plans and commenting on alternate approaches

9. System Milestone Review Candidates:

    a. Conducting and documenting internal design reviews
    b. Supporting standards definition and review
    c. Attending and conducting technical meetings/design reviews, and submitting comments and recommendations
    d. Preparing and presenting of technical information for technical conferences/reviews/briefings

10. Configuration Management and Documentation:

    a. Analyzing configuration, design, anomaly resolutions, and procedural changes submitted to change control boards

11. Systems Engineering Management Plan:

    a. Generating System Engineering Management Plans (SEMP).

b. Documenting/reviewing system, subsystem and organizational processes in terms of ISO compliance, NASA Standards as well as GSFC GOLD Rules.
c. Developing or reviewing existing systems engineering tools for applicability as required.
d. Review of Fabrication Plans.

C. INSTRUMENT SYSTEMS ENGINEERING

The Contractor shall provide instrument systems engineering support for project development reporting progress and conformance to appropriate practices and specifications (see the GPR 7123.1 Systems Engineering).

The Contractor shall perform key Instrument systems engineering functions that include, but not limited to the following:

1. Instrument Data Processing Development & Support:

   a. Developing the instrument data processing concept
   b. Developing hardware and software designs for the Instrument Data Processing Center.
   c. Performing Systems analysis of Instrument Data Processing Center to verify performance.
   d. Developing Instrument operations concept.
   e. Supporting instrument operations.
   f. Analyzing flight anomalies and recommending implementing appropriate actions.
   g. Working with principal investigator and science working group in planning operations.
   h. Supporting "lessons learned" presentations post-launch.

2. Instrument Architecture & Design Development:

   a. Defining systems and conducting trade-off studies/design studies for instruments, space segments and ground segments.
   b. Developing Instrument Architecture.
   c. Reviewing subsystem development and test activities.
   d. Generating and maintaining and/or reviewing system block diagrams.
   e. Characterization of the technology readiness level for all candidate technologies.

3. Requirements Analysis, Identification and Management:

   a. Generating and managing and/or reviewing Level 1 and 2 requirements.
   b. Conducting requirements traceability.
   c. Documenting specified and lower level derived requirements to demonstrate that performance requirements are met.
   d. Reviewing/performing independent design and development requirements analyses, and submitting comments and recommendations.

e. Reviewing technical specifications, and submitting comments and recommendations.
f. Providing specification of Requirements for Design, non-flight fabrication, and checkout of ground support equipment.
g. Reviewing contamination control requirements.
h. Reviewing operating plans and procedures for cryogenics, and other hazardous materials.

4. Verification and Validation:

   a. Generating and/or reviewing Verification Plans.
   b. Performing design, drawing, and specification reviews.
   c. Providing comments and/or recommendations to ensure: 1) that designs meet specification and interface requirements, 2) that appropriate parts standards are compatible with specified mission requirements and risk levels, 3) that detailed specifications are compatible with mission requirements, including margin and error budgets, 4) and that proper consideration is given to cost, reliability, safety, non-flight fabrication requirements, contamination control, magnetic materials/interference, launch requirements, and space environmental requirements.
   d. Documentation and/or review of system qualification requirements.
   e. Preparing and/or reviewing hardware and software integration plans and procedures, and witnessing execution.
   f. Preparing and/or reviewing detailed functional and environmental test plans and procedures, and witnessing test execution.
   g. Ensuring that the technical aspects of shipping requirements and equipment are met.
   h. Preparing and/or reviewing plans for launch site checkout, integration and testing of flight systems, including adequacy of the launch site facility.
   i. Analyzing data from spacecraft telemetry data sources to ensure total system compatibility.
   j. Analyzing Flight performance from flight data.

5. Interfaces and ICDs:

   a. Reviewing and analyzing design interfaces.
   b. Identifying interface control requirements for engineering and design of hardware for launch, on-orbit servicing, or retrieval of flight hardware.
   c. Preparing, reviewing, and analyzing interface documentation for Instrument systems.
   d. Preparing interface control documents and verifying proper implementation for flight and ground Instrument subsystems and systems.
   e. Controlling external interface documentation and requirements

6. Instrument Environments:

a. Defining and/or reviewing subsystem and hardware specifications to ensure specific instrument environment is met. Instrument environment includes (but not limited to) the discipline areas such as Mechanical, Electrical, EMI/EMC, Grounding, Thermal, Radiation, Parts engineering, Contamination, Reliability, Charging, Timing, time distribution, Data rates and Safety.

7. <u>Technical Resource Budget Tracking:</u>

   a. Documenting and controlling and/or Review of budget plans, including power, thermal, data storage, computer processing and communication through-put , timing, mass properties, command and telemetry, signal margin plan, including bit error rates etc., both at the flight system level and allocated to lower levels of assembly.

8. <u>Risk Analysis, Reduction, and Management:</u>

   a. Identifying high risk elements and developing/executing contingency plans for controlling the high risk elements
   b. Reviewing contractor risk management plans and commenting on alternate approaches

9. <u>Instrument System Milestone Review Candidates:</u>

   a. Conducting and documenting internal design reviews
   b. Supporting standards definition and review
   c. Attending and conducting technical meetings/design reviews, and submitting comments and recommendations
   d. Preparing and presenting of technical information for technical conferences/reviews/briefing

10. <u>Configuration Management and Documentation:</u>

   a. Analyzing configuration, design, and procedural changes submitted to change control boards

11. <u>Instrument Systems Engineering Management Plan:</u>

   a. Generating Instrument System Engineering Management Plans (SEMP).
   b. Documenting/reviewing system, subsystem and organizational processes in terms of ISO compliance, NASA Standards as well as GSFC GOLD Rules.
   c. Developing or reviewing existing systems engineering tools for applicability as required.

D. SOFTWARE SYSTEMS ENGINEERING, STUDIES, ANALYSIS AND SUPPORT

The Contractor shall perform Software Systems engineering, studies and analysis for requirements definition, operations concept definition, systems engineering, trade studies, and system definition in support of efforts in the formulation, implementation, and/or operations phases for Flight, Ground, and Science Data Systems. The contractor's duties may include end-to-end systems engineering activities that relate to requirements and architecture development, design, verification and validation approaches, risk analysis, safety assessments, integration, and test support. The activities span the entire mission development life cycle from advanced concepts through launch and mission operations.

1. Requirements Generation:

   a. Perform software systems engineering, studies and analysis for requirements definition, operations concept definition, systems engineering, trade studies, and system definition in support of efforts in the formulation, implementation, and/or operations phases for Flight, Ground, and Science Data Systems with applicable documentation.

2. Documentation, Traceability, & Compliance:

   a. Produce specific documentation and evidence in accordance with the requirements defined within the NASA software requirement NPR-7150.2, "NASA Software Engineering Requirements".
   b. Perform an analysis of the project's software with respect to compliance to the NASA Software Safety Standard, NASA-STD-8719.13.
   c. Identify safety critical software components, evaluation of requirements compliance for safety critical software and verification and validation approaches for safety critical items.
   d. Coordinate with personnel in other GSFC organizations responsible for safety oversight of flight and ground software systems.

3. Software Review Process:
   a. Participate in various reviews including system and subsystem documentation reviews and provide comments/inputs of the documents that are reviewed.
   b. Support government staff on various review panels responsible for review and submittal of comments to the chair of the panels, and if requested code analysis.

4. Support Services:

   The contractor may perform engineering services to provide a diverse variety of services and tools to maintain and manage the secure Information Technology (IT) environment supporting research, engineering, and administrative information requirements. The contractor may develop and maintain testbed and operational labs in support of flight, ground, and science software based activities.

   The contractor may also be required to support the design, development, test and deployment of web-based collaborative and knowledge management systems,

Capability Maturity Model Integration (CMMI) compliance and improvement support, and network design and performance studies. The contractor may also support the prototyping, design, and implementation of collaborative computing environments.

The contractor may also provide configuration management support for all software systems and system administration activities. The contractor may support configuration management of:

- Flight Software
- Ground Software
- Simulation Software
- Testbed hardware and software
- Ground and Flight databases

The contractor may provide systems administration including backups, new product installation, platform maintenance, etc. for the following:

- Flight software development and maintenance facilities
- Ground software development and maintenance facilities
- Simulation software development and maintenance facilities
- Testbed hardware and software development and maintenance facilities

a. Software Process Improvement Support

The contractor may provide support in developing and maintaining the CMMI Process Assets and Tool Library for GSFC and NASA, deploying process assets and tools through mentoring and software training programs, and implementing the Division measurement program.

b. Network Engineering Support

The contractor may provide network engineering support. The contractor may research, design, develop, test, evaluate, integrate, validate, and demonstrate information assurance solutions for end-to-end mission/project networks. Areas of investigation include network security, scheduling, cryptographic modernization and key management, and cross domain solutions to meet the demands of network centricity and to resolve issues regarding current technology and capability shortfalls.

c. Software Engineering Support for Application Development

The Contractor may provide engineering studies and analysis for requirements definition, operations concept definition, systems engineering, trade studies, and system definition in support of efforts focused on developing web services for mission systems traditionally not web based. The Contractor may provide support

to develop prototypes and demonstrate solutions to meet capability needs, ensuring the necessary IT security and usability constraints and requirements are met.

5. System Deployment:

The contractor may deploy systems for missions. This work may include closely coordinating with the flight projects or other government organizations to identify requirements, perform trade studies, configure/enhance existing systems, delivery, integration, testing, documentation and training.

E. MULTIDISCIPLINARY ANALYSES SERVICES

The Contractor shall provide analytical and detailed design support that includes multi-disciplinary system analyses and trade studies involving, but not limited to, mechanical, thermal, optics (including radiometrics and stray light), contamination, control, guidance, navigation, detector, electrical, electronic, and software aspects of flight and ground systems, including associated ground support equipment. Services shall include the definition, development and use of models and simulations to study and quantify system performance and to conduct system trade studies. This includes, but is not limited to, such specific efforts as electromagnetic interference/electromagnetic compatibility (EMI/EMC) analysis, environmental testing, magnetics testing, thermal vacuum testing, systems performance error budgets, power and weight budgeting and tracking, microphonics analyses, fracture control analyses, microwave communication system analyses (including link margin availability), controls-structures analyses, control-structural-thermal-optical analyses, instrument system analyses (including system sensitivities), computer performance analyses (including CPU, memory, simulations, etc), and systems reviews of selected critical subsystems. Services shall also include the development of measurement tools and models, analysis of measurement data, defect tracking, process improvement, cost estimation of hardware and software systems, modeling of organizational processes, electrical parts analyses, printed wiring board layouts, thermal analysis, printed-wiring board fabrication, mechanical enclosure design, and technical writing documentation.

F. DETAILED DESIGN SERVICES

The Contractor shall provide design services that include performance of detailed (leading to a Critical Design Review) design of the subsystems, components and assemblies that comprise the instrument/spacecraft/platform. This effort includes hardware and software (flight and ground) as well as ground support equipment (electrical, thermal, contamination, mechanical, and cryogenic). Documentation, including technical reports, drawings, schematics, design database files, analyses, block diagrams, layouts, parts and materials list, and equipment lists, shall be provided. The Contractor shall document all results from the modeling, simulations, analyses, and design effort and shall provide supporting materials and documentation. Specific tasks shall include:

1. Optical Specific Tasks – The Contractor shall provide optical design services, including the design, development and analysis of the following:

    a. Geometric optical design
    b. Diffraction analysis
    c. Tolerancing of components
    d. Gaussian beam analysis
    e. Interferometry
    f. Radiometry
    g. Stray light/energy analysis
    h. Alignment and calibration
    i. Optical communications systems design

2. Mechanical Specific Tasks – The Contractor shall provide mechanical design services, including the design, development and analysis of the following:

    a. Assembly and subassembly hardware to house flight components
    b. Mechanisms and electromechanical assemblies
    c. Component mount design
    d. Structure
    e. Ground support and bench test equipment
    f. Analytical studies, including structural analyses (stress, dynamics, thermal, deformation, jitter, etc.); mechanical alignment; interfaces; fracture control; controls analysis; mechanism dynamics; composite material/structure dimensional stability; load analyses, including Expendable Launch Vehicle (ELV) and Space Transportation System (STS) launch, on-orbit, and landing
    g. Associated instrumentation and control systems
    h. Mechanical analysis of large instrument antenna structures including interferometric systems
    i. Finite element model analysis
    j. Flight loads analysis
    k. On-orbit loads analysis
    l. Stress analysis
    m. Dynamic analysis
    n. Fracture control
    o. Mechanical design and drawing production/verification

3. Electromechanical Specific Tasks – The Contractor shall provide electromechanical design services, including the design, development and analysis of the following:

    a. Concept trades, concept design, and detailed design of electromechanical systems and their components.
    b. Fabrication, assembly, and testing services, including life testing.
    c. Magnetic bearings, active/smart structures, vibration isolation, and large aperture, lightweight systems.

d. Analyses using CAD and simulation tools utilizing hardware and software compatible with those used by the MSD.
e. Set-up and operate electronic design and test equipment compatible with equipment used by the MSD
f. Design, analysis, selection, implementation, and testing of bearings, flex-pivots, and flexures.
g. Robotics
h. Micro electromechanical systems (MEMS)
i. Micro-miniaturization of mechanisms, or sub-assemblies of conventional mechanisms.
j. Small scale structures, materials, fabrication techniques, packaging, photolithography, lithography electroforming and molding (LIGA in German), interfacing with macro-components, micro-actuators, focused ion-beam milling and welding, and coatings and tribology issues.
k. SISO and MIMO controllers

4. Thermal Specific Tasks – The Contractor shall provide thermal design services, including the design, development and analysis of the following:

a. Thermal system design, active and passive
b. Component/subassembly/assembly cooling, including electronics and detectors.
c. Cryogenic design, including detectors, optics, and mechanisms
d. Advanced thermal control systems
e. Associated instrumentation and control systems
f. Thermal analyses compatible with Systems Improved Numerical Differencing Analyzer (SINDA), Thermal Radiation Analyzer System (TRASYS), Thermal Synthesizer Systems (TSS), Finite Element Modeling and Post-processing (FEMAP/TCON), Simplified Space Payload Thermal Analyzer (SSPTA), Thermal Desktop, or Thermal Model Generator (TMG) software packages.
g. Cryogenic GSE thermal analysis and design, including dewar system
h. Thermal laboratory support
i. Thermal vacuum test support

5. Detector Specific Tasks – The Contractor shall provide engineering services for state-of-the-art detection systems requiring low noise levels and calibrations traceable to physical standards including the design, development, test, and analysis of the following systems:

a. RF
b. Submillimeter wave
c. Microwave
d. Millimeter wave
e. Infrared
f. Visible
g. X-ray
h. Gamma-ray
i. Neutral and charged particle detection

    j. MEMS
    k. Nanotechnology

6. <u>Electrical/Electronics Specific Tasks</u> – The Contractor shall provide electrical/electronic design services, including the design, development, documentation, analysis, review, verification, integration and test of the following:

    a. Flight electronic subsystems
    b. Command and data handling systems
    c. Flight and ground data systems
    d. Low noise electronics
    e. Digital and microprocessor based designs
    f. Analog control circuits
    g. Control systems
    h. Low voltage systems
    i. High voltage systems
    j. Power supplies with programmable voltage and current outputs
    k. Electromagnetic field analysis
    l. Electromagnetic compatibility and interference (EMC/EMI)
    m. Test circuitry and equipment, including interface to computer-based systems
    n. Bench test equipment
    o. Electrical ground support equipment
    p. High speed electronics
    q. Communication electronics
    r. Microcontroller based systems and embedded systems
    s. Flight and test harnesses (conventional wire and fiber optic)
    t. Breakout boxes
    u. Pyrotechnics
    v. Simulators
    w. FPGA-based reconfigurable computing systems
    x. Analog and mixed-signal ASIC devices
    y. Programmable logic devices (FPGA and ASIC devices)

In addition, analyses includes, but is not limited to, Worst-case analysis, Parts Stress analysis, reliability analysis, thermal analysis, structural analysis, signal integrity analysis and performance/throughput analysis. Peer design reviews shall be an integral part of the overall development cycle. Test support includes shift support for environmental tests (thermal-vacuum, EMI, vibration, etc)

7. <u>Flight Software (FSW) Systems:</u>

The Contractor shall support the planning, formulating, designing, developing, testing, and sustaining engineering of flight software systems for instruments and spacecraft associated with in-house GSFC projects and other multi-center commitments in accordance with established organizational compliance of procedures and policies such as NPR 7150.2. The Contractor shall manage, refine, and extend the flight software infrastructure,

products, plans, and processes related to new flight software developments, flight software reuse libraries, flight software configuration management systems, flight software test, verification and validation systems, and flight software lessons learned databases. The contractor may develop simulation capabilities for all aspects of the flight software including, dynamic simulation, command and data handling simulation and science data simulation.

a.   Flight Software Engineering
b.   Flight Software Development
c.   Flight Software Verification and Validation
d.   Flight Software Maintenance and On-orbit Sustaining Engineering
e.   Flight Software High Fidelity Testbeds and Simulations'
f.   Flight Software Infrastructure/Support
g.   Flight Software Technology Development

8. Ground Software and Systems:

The Contractor shall perform new or ongoing development and sustaining engineering of ground software and data systems. Contractor activities may include participation as a part of a mission's or project's ground system development team. Ground systems development includes software design, development, test, and deployment, and associated hardware integration, test, and delivery. The software may include commercial off-the-shelf (COTS), government off-the-shelf (GOTS), new development, or some combination of the aforementioned. The Contractor may perform hardware systems and associated material procurement/inventory management. The procured hardware systems shall comply with established NASA safety protocols including at least Hazardous Material Management and Electrostatic Discharge (ESD).

a. Ground Software Architectures
b. Ground Software Development
c. Ground Software Sustaining Engineering

9. Flight Software System Verification, and Validation:

The Contractor shall support flight mission operations including build verification testing, system validation testing, and flight software and flight operations test tools development for the mission.

Validation and Verification Functional Areas:
a. Utilize flight software test-beds and simulators required for verification and validation of flight and ground software related products.
b. Support mission readiness testing to include communication and functional test of the mission ground system, ground station interfaces, and end-to-end testing of the communication path from the spacecraft to the ground and/or science operations systems.
c. Generate and/or review Verification Plans

d. Support the design, drawing, and specification reviews
e. Prepare documentation and/or review of system qualification requirements
f. Prepare and/or review hardware and software integration plans and procedures, and witnessing execution.
g. Prepare and/or review detailed functional and environmental test plans and procedures, and witness test execution.
h. Prepare and/or review plans for launch site checkout, integration and testing of flight systems, including adequacy of the launch site facility.
i. Analyze data from spacecraft telemetry data sources to ensure total system compatibility.
j. Analyze flight performance from flight data.

10. <u>Software Science System Development:</u>

The contractor shall provide science data system engineering, software system engineering and software engineering services to design, develop and deploy science systems and applications for science operations, data processing, data management, and data analysis and visualization. Data system engineering may include problem definition, solution analysis, process planning and control, system documentation development and maintenance, system integration, and product evaluation. Software system engineering may include requirements definition and analysis, software design, process planning and control, software documentation development and maintenance, verification, validation and test, and software integration. Software engineering may include detailed software design, implementation, and unit testing. The science system software may include COTS, GOTS, new development, legacy code, or some combination of the aforementioned. Science systems development may include hardware definition, integration, test and deployment. The contractor may provide science operations support for ongoing missions.

a. Science Data Systems Engineering
b. Science Operations Systems
c. Science Data Processing Systems
d. Science Data Management Systems
e. Science Data Analysis and Visualization Applications

11. <u>Power Specific Tasks</u> – The Contractor shall provide power design services, including the design, development, and analysis:

a. Power system design and analysis tools for energy balance and regulation
b. Spacecraft power management and distribution electronics
c. Photovoltaic energy conversion cells, arrays, and associated ground testing
d. Electrochemical energy storage cells, batteries, and associated destructive physical analysis and ground testing
e. Payload and instrument low and high voltage power conditioning electronics (converters, filters, regulators)

12. <u>Radiation Effects and Analysis (REA) Specific Tasks</u> – The Contractor shall provide radiation services for the design, development, testing, and analysis of EEE components, including:

   a. Space radiation environmental analysis and specification including nuclear interaction simulations
   b. Design and development of test plans and test suite hardware and software to support research and flight project efforts
   c. Documentation of radiation test techniques and research results
   d. Determination of mission-specific system level impact of radiation test results and evaluate mission radiation risk assessment
   e. Screening of parts list for radiation vulnerable devices
   f. Dissemination of radiation effects research results via paper and presentations
   g. Curator capabilities for maintenance and upgrade of the Radiation and Analysis (REA) WEB site
   h. Database development and management of the REA radiation effects test data
   i. General REA services in the area of graphics, schedules, and reporting requirements
   j. Development of user interface software for REA-developed environment models
   k. Instrument calibration
   l. Operation and maintenance of GSFC's radiation facility
   m. Design and fabrication of radiation flight experiments and providing services to support data analysis
   n. Analysis of in-flight data on experimental and operational systems to determine system performance in radiation environment
   o. Analysis of instrument data to support space environment modeling
   p. Analysis Performance of tests at established radiation test facilities (requires travel)

13. <u>Component Technologies Specific Tasks</u> – The Contractor shall provide component technology specific services for design, development, and analysis, including:

   a. Non-destructive Evaluation (NDE) of complex integrated circuits employing Finite Element Analysis, Scanning Acoustic Microscope, X-Ray, and thermal analyses
   b. Analysis of novel microelectronic materials
   c. Environmental analysis of active and passive fiber optic components
   d. Microelectronic assembly, including ASICs and custom hybrids
   e. Lightweight, low-power transmitters and receivers for active and passive microwave instrument system

14. <u>Environmental Testing Specific Tasks</u> – The Contractor shall provide environmental test services for design, development, and analysis, including:

   a. Vibration
   b. Acoustic
   c. E-M
   d. EMI

e. EMC
f. Thermal
g. Vacuum

15. <u>RF Specific Tasks</u> – The Contractor shall provide RF design services, including the design, development and analysis of the following:

a. RF Component design
b. Communications systems design
c. Communications systems component design
d. RF Modulator design (BPSK, QPSK, 64QAM, CDMA, 8PSK etc.)
e. Antenna Design L - Ka bands
f. Phased Array antenna design
g. Solid State Power Amplifier Design S to Ka bands
h. Transponder design S to Ka bands
i. Millimeter wave systems instrument and components design (50 –300 GHz)

In addition, the Contractor shall provide independent systems engineering analysis and evaluation in support of customer mission-related activities as well as analysis and support of new capabilities considered for inclusion into the NASA Space Network (SN) and Ground Network (GN) as well as Global Positioning Satellite (GPS) Navigation. This also includes RF communications systems engineering support to independently evaluate and assess current space and ground network capabilities, system improvements, and new services to meet future mission needs. Additionally, this effort may include performing SN analyses for current space elements (TDRS Flight-1 through Flight-10 and TDRS K, L, M & N) including the ability for modeling of multiple access interference signals and the corresponding current ground elements at the White Sands Complex (WSC), Guam Remote Ground Terminal, and Space Network Expansion (SNE) Terminals. This effort may encompass analysis related to the Ground Network assets that are used for mission support to include analysis for other networks and commercial ground stations. Maintenance & development of analytical tools to perform the required analysis and associated data bases to support the analysis are included in this effort. This effort supports standards and protocol activities. Maintenance & extension of Space and Ground Network Users Guides are also encompassed in this effort. This effort includes the development and review of RF Interface Control Documents as well as technical reports on special studies. Analysis of new modulation schemes and transmission techniques including lasers are additionally covered under this effort activity including the ability to perform analysis of atmospheric effects of higher communication frequency bands (e.g. 37 GHz). Ability to perform dynamic analyses for S/C & launch vehicles which requires expert knowledge of trajectories, orbital mechanics & the 3-dimension modeling S/C to enable S/C & ELV antenna design to be compatible with the SN & GN.

16. <u>GN&C Component & Hardware Specific Tasks</u> – The Contractor shall perform specific GN&C component and hardware systems engineering tasks, including:

a. GN&C Systems Engineering Specific Task Orders – The Contractor shall perform specific GN&C systems engineering tasks that include:

1. Flight Project GN&C Subsystem Engineering, including requirements development; analysis; trade studies; ICD development; verification and validation; risk management; general coordination of all GN&C elements; maintenance of mass, power, and pointing budgets; operations planning
2. GN&C Conceptual Design, Modeling and Simulation
3. GN&C Science and Instrument Interface Engineering
4. Spacecraft Reentry Systems Engineering
5. Re-entry Debris Analysis, Modeling and Simulation
6. GN&C Engineering Support to Integrated Mission Design Center (IMDC)
7. Advanced GN&C Systems Technology Development, including the design, analysis, non-flight fabrication, assembly, and test of hardware and/or software
8. Advanced GN&C Testbeds, Tools and Methods Development
9. Balloon, UAV and Sounding Rocket GN&C Engineering
10. Formation Flying Test Bed (FFTB) Design and Development
11. Rendezvous Proximity Operations, Docking, Undocking (RPODU) Systems
12. Autonomous Rendezvous & Capture (AR&C) Systems
13. Pose Estimation Systems
14. Technical Consultation and Support (Proposals, Peer, Design, and Anomaly Reviews)

b. GN&C Analysis & Simulation Specific Task Orders – The Contractor may be called upon to perform specific GN&C analysis and simulation engineering tasks that include:
1. Attitude Design, Analysis and Simulation
2. Attitude Control Design, Analysis and Simulation
3. Space and Launch Vehicle Dynamics Analysis and Simulation
4. Control/Structure Interaction Analysis and Simulation
5. Attitude Estimation Design, Analysis and Simulation
6. Aerodynamics Design, Analysis and Simulation
7. Formation Flying/Constellation Design, Analysis and Simulation

c. Component and Hardware Systems Engineering Specific Task Orders – The Contractor shall perform specific GN&C component and hardware systems engineering tasks that include:

1. Advanced GN&C Sensor/Actuator Design, Development, and Test (hardware and/or software)

d. Test Bed & Simulator Design/ Development Services

The Contractor shall provide engineering services for the design, development, validation, implementation, certification and maintenance of ground or on-board

computer system simulators/emulators, including validation of flight system software for ascent, transfer, or on-orbit phases and near real-time reprogramming and validation of modifications for recovery from anomalous situations.

e. Propulsion Engineering Specific Task Orders

The Contractor shall perform specific spacecraft propulsion systems engineering tasks that include:
1. Spacecraft Propulsion Subsystem Engineering
2. Advanced Propulsion Technology Development, including advanced chemical propulsion, electrical propulsion (EP), Micro-Electrical-Mechanical Systems (MEMS), micro-propulsion components; test equipment and instrumentation to support development & testing of sub-microN thrusters
3. Fluid Systems Engineering including transient flow, vapor diffusion, fluid slosh and plume impingement analyses
4. Power & Electric Propulsion System Engineering, including low thrust trajectory design; EP system design & trades; EMI testing, analysis and mitigation
5. Nanocalorimetry
6. Propulsion Chemical Analyses
7. Propulsion GSE Design and Development
8. Propulsion System Engineering Support to IMDC and advanced mission studies
9. Propulsion System Engineering Support to Flight Project, including technical consultations and engineering support for design reviews, analyses, proposal development, and anomaly resolution. Data Acquisition Engineer, including software and hardware design, development and test.
10. Mechanical and Thermal Engineering Support specific to propulsion system design and analysis.

f. Propulsion System Technician Specific Task Orders - The Contractor shall perform specific spacecraft propulsion system technician tasks that include:

1. Mechanical Technician tasks for the fabrication, assembly, integration and test of propulsion subsystems, including subsystem manifold fabrication, precision cleaning, certified welding, integration of propulsion subsystem components, and clean room operation.
2. Electrical Technician tasks for the fabrication, assembly, integration and test of propulsion subsystems, including certified soldering, crimping, staking, harness fabrication, electrical component test and integration.
3. Advanced Propulsion Technology Development Technician tasks, including conducting micro-Newton thrust stand tests; vacuum system assembly, maintenance and operation; chemical handling; fluid system assembly and operation.

G. FABRICATION, ASSEMBLY AND TESTING SERVICES

The Contractor shall provide flight (including protoflight), and non-flight (including prototype) hardware fabrication and assembly support for spacecraft primary structure, secondary structure, instrument structures, mechanical subassemblies, components, mechanisms, electronics assemblies, electromechanical devices, thermal control devices and subsystems, and thermal flight experiments. All fabrication and assembly support shall be in accordance with the workmanship requirements of NASA-STD-8739.4 and 8739.5 and IPC 6011, 6012, 6013, 6015, 6016, and 6018, as well as all subsequent updates to these documents. All fasteners used in assembling or installation shall conform to GPG 541-PG-8072.1.2, GSFC fastener integrity plan. Also provide support to fabricate mechanical ground support equipment, special test and evaluation equipment (including electronic equipment) necessary to support the operation of all mechanical hardware. In situations where hardware fabrication is required in a quick reaction mode and the contractor decides to perform the task under subcontract, the contractor shall minimize both the subcontract implementation and fabrication phases of the task. Subcontractors used for fabrication and/or assembly shall be ISO 9001 compliant.

The Contractor shall provide fabrication, assembly and testing services, including breadboards, engineering models, protoflight models, and flight models at all levels of assembly specified by this Statement of Work, including:

1. <u>Planning Specific Tasks</u> – The Contractor shall provide planning services, including:

    a. Implementation and maintenance of overall production and quality engineering plans.
    b. Manufacturing, integration and test plans, describing sequences, qualification and acceptance test levels, and facilities needed to accomplish assembly, integration, alignment, testing, quality control, and checkout

2. <u>Fabrication Specific Tasks</u> – The Contractor shall provide fabrication services, including:

    a. Optical, mechanical, detector, electrical/electronics, and microwave, including antennas.
    b. Ground support equipment, including mechanical and electrical, and optical
    c. Laboratory control systems
    d. Wiring harnesses
    e. Special parts
    f. Surface mount printed circuit boards, including leadless chip carriers, chip-on-board techniques, and column grid array technology
    g. Composites

3. <u>Assembly Specific Tasks</u> – The Contractor shall provide assembly services, including:

    a. Optical, mechanical, detector, electrical/electronics, and microwave, including antennas
    b. Ground support equipment including mechanical, electrical, and optical
    c. Test equipment and fixtures
    d. Wiring harnesses

  e. Active thermal control devices (heaters, thermostats, thermocouples, thermistors, heat pipes, CPLs, etc.)

  f. Hardware protective coatings

  g. Operation of Government-Owned, Contractor-Operated Board Layout and Assembly Facility

4. <u>Logistics Specific Tasks</u> – The Contractor shall provide logistics services, including:

  a. Identification of critical spares and material

  b. Storage and control of critical spares and material

  c. Shipment of materials, supplies, subsystems, ground support equipment, systems, and flight systems to and from integration, test and launch facilities

5. <u>Testing Specific Tasks</u> – The Contractor shall test and/or participate in the GSFC's testing and qualification of hardware and software, including retesting/requalification of spare units and breadboards previously developed for flight projects. These tests shall be conducted in accordance with Government-approved procedures and shall include both functional and environmental tests. Functional tests shall be designed and performed to demonstrate compliance with the operating requirements of the system. Environmental tests shall be designed and performed using environmental conditions that meet the launch, safety, and operations requirements of the assigned task. The Contractor shall perform the following:

a. In-process testing during the fabrication process to demonstrate that the design meets the requirements specified. In-process testing shall include:

  1. Component value measurements and verification of polarity prior to installation and after installation, where feasible.

  2. Resistance checks of point-to-point wiring and cross tie points, where applicable

  3. Hi-pot operations from component-to-component, component-to-frame, etc. in accordance with the applicable GSFC specification or procedure, as required by and specified in a task order

  4. Leak/pressure testing at the lowest level of assembly possible and throughout the assembly stages

  5. X-ray, dye penetrant, and eddy current inspections, as well as other forms of nondestructive analysis.

  6. Tests to develop/validate models for structural, mechanical, thermal, optical, and electronic components and assemblies

b. Functional testing, including:

  1. Verification of operational characteristics of components and equipment

  2. Testing at Government facilities

  3. Testing and documentation to verify accuracy, repeatability, and stability while operating under simulated flight conditions

c. Flight qualification testing on units that have successfully completed functional tests and have been prepared for space flight. These tests may be conducted at any of the levels of assembly specified in this Statement of Work, including on the spacecraft. The qualification tests shall be carried out in a test environment specified by the task order. The Government may provide test facilities and/or test equipment to the contractor, as specified in the task order. Flight qualification testing shall include:

1. Vibration/Shock
2. Magnetic
3. Thermal vacuum
4. Thermal balance
5. Static loads
6. Acoustics
7. Mass properties
8. Alignment
9. Electromagnetic interference (EMI)
10. Electromagnetic compatibility (EMC)
11. Gravity effects
12. Radiation effects
13. Modal survey
14. Optical performance and characterization
15. Deployments
16. Mechanism Performance

H. INTEGRATION, TEST, AND VERIFICATION SERVICES

The Contractor shall provide management, engineering and test-conductor services that include integrating and verifying the flight, ground systems, and science data system/applications in accordance with applicable documentation and specifications, preparing test procedures, documenting all nonconformances and dispositions, calibrating the system and its ground support equipment, and providing operating manuals, reference documents, training, and launch site support.

1. <u>Integration, Test and Verification Specific Tasks</u> – The Contractor shall provide integration, test, and verification services, including:

    a. Major program reviews
    b. Space flight subsystems
    c. Space flight instruments
    d. Space flight payloads
    e. Suborbitalcraft instruments
    f. Ground instrumentation
    g. Ground support systems
    h. Science data systems/applications
    i. Spacecraft and science operations control rooms

      j.   Suborbitalcraft subsystems

Integration and test services may need to be supported at various locations, including vendor sites, NASA Centers, and Military sites.

I. LABORATORY AND TEST INSTRUMENTATION SERVICES

The Contractor shall provide the services necessary for conceptualization, prototyping, system engineering, design, development, integration, test, sustaining engineering, maintenance and utilization of laboratory and test instrumentation.

1. <u>Laboratory and Test Instrumentation Specific Tasks</u> – The Contractor shall provide laboratory and test instrumentation services, including:

   a. Optics/Fiber optics
   b. Detector engineering
   c. Laser communication and ranging
   d. Electrical ground support equipment
   e. Subsystem bench test equipment
   f. Special instrumentation
   g. Thermal/Cryogenics
   h. Contamination
   i. Operating power test facilities at the GSFC
      1. Large Area Pulse Solar Simulator
      2. Battery handling & conditioning laboratory
      3. High voltage partial discharge laboratory
   j. Calibration
   k. Crosstalk
   l. Microphonics analyses
   m. Analysis of instrument and spacecraft subsystem interaction
   n. RF communications engineering and millimeter wave services
      1. Operating microwave test equipment, including cryogenic testbeds
      2. Operating RF equipment, including radiating sources
      3. Supporting antennae test facilities, including anechoic chamber

J. MISSION ASSURANCE AND SYSTEMS SAFETY SERVICES

For all levels of flight hardware and software provided by the Contractor and specified by this Statement of Work, the Contractor shall establish and maintain a mission assurance program commensurate with mission requirements as specified by the Task Order. The mission assurance program shall incorporate a system safety program which meets the requirements of National Space Transportation Systems (NSTS) 1700.7C, "Safety Policy and Requirements for Payloads Using the Space Transportation System". For ELV missions at ETR or WTR, the system safety program shall meet NASA-STD 8719.24 (with Annex)

NASA Expendable Launch Vehicle Payload Safety Requirements, KNPR 8715.3, "KSC Safety Practices Procedural Requirements" (applicable at KSC property, KSC-controlled property, and offsite facility areas where KSC has operational responsibility), and NPR 8715.7, "Expendable Launch Vehicle Payload Safety Program", Launch Site Facility-specific Safety Requirements, as applicable).

The contractor shall establish and maintain practices, procedures, and processes that are ISO Q9001-2000 compliant.

1. Performance Assurance Specific Tasks – The Contractor shall provide performance assurance services, including:

   a. Reviewing payload designs to assure their compliance with performance assurance, reliability, and safety specifications.
   b. Developing, analyzing, and monitoring performance assurance, reliability, system safety plans, and procedures, fabrication assembly, integration and test, verification, and launch support
   c. Analyzing basic plans for system safety, contamination control, integration, and testing of subsystems and systems

2. Safety Specific Tasks – The Contractor shall provide safety services which conform to the system safety/mission assurance program, including:

   a. Establishing and documenting a systems safety plan in concert with the appropriate launch vehicle and NASA safety policy,
   b. Conducting and assessing system safety analyses for flight designs and launch/retrieval operations to satisfy NASA safety and reliability requirements,
   c. Analyzing design changes related to minimizing hazard levels
   d. Participating in system safety reviews
   e. Reviewing the proposed systems design to ensure that proper considerations are given to safety-critical areas, and that safety problems exposed in prior analyses, testing, and operational use of instruments and subsystems are corrected
   f. Conducting Verification and Validation (V&V) programs for flight and critical ground systems software
   g. Preparing the Safety Data Package, including writing and editing
   h. Performing hazards analysis of flight system, space station interface equipment, and ground support equipment
   i. Participating in required inspection/testing to fulfill safety data requirements
   j. Coordinating with the GSFC safety officer and participating in formal safety reviews
   k. Preparing final safety data packages

K. CONFIGURATION MANAGEMENT SERVICES

The Contractor shall provide overall management and oversight of the Configuration Management (CM), Documentation Management (DM), and Quality Control Management

(QCM) disciplines throughout the life cycle of flight hardware and software provided within the scope of this Statement of Work. Each discipline shall require the development, establishment, and implementation of procedures and processes and establishment of mechanisms and tools for consistency.

The Contractor shall support the planning, identification of processes, and leading GSFC Project efforts in these disciplines. This support shall also include the necessary planning and associated process development for the GSFC Project in meeting conformance requirements to NASA procedures and guidelines as well as the ISO standards.

The main CM/DM/QCM functions shall include:

- Configuration identification, configuration control, configuration accounting and reporting
- configuration verification and configuration auditing
- implementation and maintenance of a DM system

The Contractor shall be responsible for providing the necessary tools and databases to accomplish the above functions; developing and establishing procedures and guidelines and training in the configuration management, documentation management, and ISO Q9001-2000 disciplines.

L. CONTAMINATION AND COATINGS ENGINEERING SERVICES

1. Contamination Control Management Specific Tasks – The Contractor shall provide contamination control management services, including:

   a. Developing contamination control plans for spacecraft and instruments
   b. Determining contamination control requirements and developing appropriate monitoring plans and procedures to assess contamination control requirement compliance.
   c. Monitoring, reviewing, analyzing, and reporting on overall contamination control management, implementation, and development.
   d. Support project meetings at the spacecraft and instrument level, support and present at project reviews, support technical interchange meetings, peer reviews, working group meetings, failure review boards, facility cleanliness surveys/evaluations, lessons learned, knowledge capture, and other project meetings at vendor sites (as required).
   e. Provide support for implementation of contamination control plans and requirements at vendor sites and at launch sites.

2. Contamination Control Analysis Specific Tasks – The Contractor shall provide contamination control analysis services, including:

a. Developing analytical transport models (molecular and/or particulate) for spacecraft and instrument systems and/or other space flight hardware and generating contamination hazards predictions.
b. Performing detailed environmental analyses of all phases of assembly, integration, test, transportation, pre-launch, launch, on-orbit, and descent and comparing against requirements.
c. Establishing surface contamination limits based on allowable performance degradation and conducting trade-off analyses, analyzing specifications, and reviewing requirements.
d. Establish particulate and gaseous contamination limits for ambient temperature and cryogenic fluid systems.
e. Develop new, or improve existing contamination engineering analysis software. Perform tape lift sampling and analysis according to GSFC 545-WI-8072.1.2 and provide report of all events in IEST-STD-CC1246D and percent area covered formats where requested.
f. Monitor and model outgassing tests of flight systems and their components at the systems and subsystem vacuum level tests.
g. Perform data reduction of all contamination monitoring devices and present results in report format.
h. Analyze trends, make relevant analysis and predictions on performance.

3. <u>Integration and Test Contamination Control Specific Tasks</u> – The Contractor shall provide integration and test contamination control services, including:

a. Providing direction during test planning and the test preparation phase.
b. Designing, developing, fabricating, and integrating contamination control monitoring devices.
c. Developing procedures for specific test and cleanliness requirements.
d. Providing contamination control monitoring during integration and providing support during testing and integration

4. <u>Contamination Laboratory Support Specific Tasks</u> – The Contractor shall provide contamination laboratory support services, including:

a. Perform and record outgassing measurements in the Molecular Kinetics (MOLEKIT) facility.
b. Provide contamination flight monitor support for fabrication, testing, integration, on-orbit data review, and data reduction.
c. Provide setup and operation of airborne particle counters and microscopes

5. <u>Development and Use of Contamination Standards Specific Tasks</u> – The Contractor shall provide contamination laboratory support services, including:

a. Provide analysis and support for the development of GSFC, NASA, national and international contamination control standards.

b. Develop, procure and calibrate, and test new equipment for the purpose of developing new standards or monitoring flight projects contamination control.

c. Write and present papers documenting the development of new techniques and standards in contamination control.

6. <u>Cleaning Support and Technology Specific Tasks</u> – The Contractor shall provide cleaning support services, including:

   a. Provide cleaning procedures, and precision cleaning, for GSE and flight hardware.

   b. Investigate, develop, procure and calibrate, and test new cleaning techniques and applications to enhance our ability to provide and validate cleanliness of flight hardware.

7. <u>Space Environmental Coatings Testing and Management Specific Tasks</u> – The Contractor shall provide support services, including:

   a. Perform Flight qualification and space environment testing of coatings along with thermal radiative property measurements, thickness measurements, and coating adherence testing.

   b. Develop, operate, and maintain GSFC unique facilities to select, apply, and qualify coatings for use on spacecraft and instrument surfaces.

   c. Characterize thermal control surfaces and assess degradation from environmental effects due to UV radiation, thermal cycling, charged particles, electrostatic discharge, outgassing and humidity.

   d. Develop and maintain a database of thermal property test data and coordinates extended shelf life testing of paints.

8. <u>Space Environmental Coatings Testing, Applications and Management Specific Tasks</u> – The Contractor shall provide support services, including:

   a. Perform Flight qualification and space environment testing of coatings along with thermal radiative property measurements, thickness measurements, and coating adherence testing.

   b. Develop, operate, and maintain GSFC unique facilities to select, apply, and qualify coatings for use on spacecraft and instrument surfaces.

   c. Characterize thermal control surfaces and assess degradation from environmental effects due to UV radiation, thermal cycling, charged particles, electrostatic discharge, outgassing and humidity.

   d. Develop and maintain a database of thermal property test data and coordinates extended shelf life testing of paints.

9. <u>Thin Films Specific Tasks</u> – The Contractor shall provide support services, including:

a. Provide support in the area of vacuum vapor deposition and sputter deposited thin films.
b. Provide support to apply thin film coatings on space flight parts at either government facilities and/or the contractor facilities. Provide offsite support for the use of these techniques.

M. EEE PARTS PROGRAM SERVICES

The Contractor shall provide parts and materials services for hardware/software within the scope of this contract, including:

1. Materials and Processes Services:

a. <u>Materials and Processes Specific Tasks</u> – The Contractor shall provide materials and process services specific to parts engineering including:

   1. Contamination analysis and control
   2. Construction analysis
   3. Design compatibility
   4. Material evaluation

2. Protective Coating and Encapsulation Services:

a. <u>Protective Coating and Encapsulation Specific Tasks</u> – The Contractor shall provide protective coating and encapsulation services, including:

   1. Iridite, anodize, or use comparable coating processes to finish metal surfaces
   2. Conformal coat and/or encapsulate components, parts, and fixtures in accordance with Task Orders and applicable flight application documentation.
   3. Prime and paint surfaces, parts, and assemblies

3. Component and Parts Labeling Services:

a. <u>Component and Parts Labeling Specific Tasks</u> – The Contractor shall provide component and parts labeling, including:

   1. Label and identify parts with location as specified by the applicable document or drawing.
   2. Cover labels with GSFC approved protective finish where required

4. Space Electronics Packaging Services:

   The Contractor shall provide Space Electronics Packaging Services, including:

a. <u>Packaging Design</u>

1. Circuit board design and layout
2. Enclosure design and layout
3. Mechanical mounting including thermal and vibration isolation
4. Board-mounted mechanical parts
5. EMI/EMC isolation and protection
6. Ground support equipment including mechanical electrical and optical
7. Test Equipment
8. Mechanical analysis
9. Thermal analysis
10. Contamination analysis
11. Radiation mitigation analysis

b. Manufacturing and Assembly Services

1. Circuit board manufacturing and assembly.
2. Enclosure & circuit board mechanical parts manufacturing and assembly
3. Manufacturing and assembly of optical, mechanical, detector, electrical/electronics, RF and microwave boards & components
4. Ground support equipment manufacturing and assembly, including mechanical, electrical, and optical
5. Test equipment and test fixture manufacturing and assembly
6. Electrical test assembly support
7. Wiring harness manufacturing and assembly
8. Mechanical and electronics protective coatings

5. EEE Parts Services:

a. Project Parts Engineering and Program Management Specific Tasks – The Contractor shall provide parts engineering and program management services, including:

1. Commodity Expertise for all EEE part categories listed in EEE-INST-002, and Detectors, Microwave, and Fiber optics.
2. Develop, review and implement Parts Control Plans.
3. Interface with Designers, Radiation Engineers and Chief Safety and Mission Assurance Officer (CSO) in parts selection and approval process.
4. Develop, review and maintain parts lists
5. Conduct and participate in Parts Control Boards.
6. Review and disposition all GIDEP Alerts and NASA Advisories.
7. Specification preparation and interfacing with manufacturers for custom flight parts.
8. Investigations of reliability issues related to parts failures.
9. Evaluation of advanced technology parts.
10. Prepare and follow counterfeit parts avoidance and lead free control plan.

b. <u>Parts Testing and Analysis Laboratory Specific Tasks</u> – The Contractor shall provide parts testing and analysis laboratory services, including

1. Failure Analysis- Conduct analysis of failed parts, materials and components to determine and classify the physical mechanisms of failures
2. Destructive Physical Analysis (DPA)- Conduct DPA to determine if the part quality and workmanship meet the requirements of applicable NASA or Manufacturer specification. DPA shall include electrical, mechanical, environmental and analytical testing
3. Incoming Test and Inspection, Screening, Evaluation and qualification testing - Conduct these tests in accordance with appropriate part specification and test procedures. Analyze test results and provide summary reports and certification logs as require
4. Test Equipment specific tasks- Support the calibration, maintenance and upgrading of test equipment related activities and support property system requirements.
5. Ensure safe operating procedures, practices and availability of personal protection equipment in the Lab.

c. <u>Photonics Tasks</u> - The Contractor shall provide following test laboratory services:

1. Building fiber optic cables and arrays for spaceflight and ground test using a wide variety of fiber optic components. Conducting investigations into fiber optic and photonic reliability, radiation effects and other related engineering tasks, including design of optical fiber and optical free space components.
2. Operating a Technology Validation laboratory with a variety of environmental, optical microscopy and x-ray microscopy equipment for the purpose of investigating the reliability of Electrical, Electromechanical and Electronic, (EEE) parts and technologies.
3. Evaluating new photonics technologies for suitability for use in space flight application.

N. MATERIALS ENGINEERING

The contractor shall provide materials engineering support in the two major areas of Materials Assurance Engineering and Materials Laboratory Support.

1. <u>Materials Assurance Engineering Specific Tasks</u> – The Contractor shall provide materials engineering support for the development and implementation of materials assurance programs for GSFC managed flight projects, including:

   a. Selection and application of materials and processes
   b. Material usage lists
   c. Facility evaluations of GSFC and NASA contractor Materials Engineering, processing and quality facilities for required equipment, processes personnel, training and capability for producing flight quality hardware

     d. Hardware evaluation via audit of NASA and NASA contractor manufacturing of flight hardware, including in-process and end item inspections for compliance with agency and project requirements

2. <u>Laboratory Support Specific Tasks</u> – The contractor shall provide engineering support for laboratory operations associated with the testing and analysis of organic, ceramic, composite and metallic materials typically used in space flight projects, including:

     a. Organic materials - failure analysis, material investigations, process development, and analyses, etc.
     b. Ceramic and composite materials engineering
     c. Metallurgical engineering
     d. Materials Identification and Certification
     e. Life testing
     f. Cryo lab support
     g. Metallurgical engineering
     h. Electrical properties of materials testing

FUNCTION 4 – OPERATIONAL PHASE SERVICES

A. DATA SYSTEMS MANAGEMENT SERVICES

The Contractor shall provide data systems management services, including:

1. Design, development, reviewing, and analyzing software requirements and specifications.
2. Limited contributions to validation, implementation, certification, and maintenance of ground or on-board computer system simulators/emulators, as well as reach back for anomaly situations.
3. Analyzing the design and implementation of simulators/emulators for ground crew training, systems testing and procedure validation

B. LAUNCH AND POST-LAUNCH OPERATIONS SERVICES

The Contractor shall supply launch and post-launch services, including:

1. <u>Launch Site Preparation Specific Tasks</u> – The Contractor shall provide limited subsystem services at the launch site, including:

     a. Payload system and its support equipment
     b. Interfaces to the mission operations control centers
     c. Technical services to facilitate interfacing with the launch site organization

d.　Development of launch site support requirements
　　e.　Development of launch site plans and procedures
　　f.　Provide support for shipment of the flight hardware and associated support equipment to and from the launch site

　2.　<u>Launch Operations Specific Tasks</u> – The Contractor shall provide limited launch operations services, including:

　　a.　Assuring flight readiness of the delivered subsystem
　　b.　Pre-launch testing of the delivered subsystem
　　c.　Operation of associated ground support equipment
　　d.　Services to the launch vehicle team for payload integration to the vehicle at launch facility

FUNCTION 5 – INFRASTRUCTURE SERVICES

A.　COMPUTER SUPPORT TECHNOLOGY SERVICES

The Contractor shall provide computer technology services, including:

　1.　<u>Computer Support Specific Tasks</u> – The Contractor shall provide computer technology services, including:

　　a.　Engineering support to analyze data acquisition, processing, distribution, archival/storage, and measurement problems.
　　b.　Data reduction to include statistical and thematic trends analyses
　　c.　Diagnostics support for instrument checkout between test consoles and test components.

d. Program services to utilize test instruments in aerospace system test and analysis, including GPIB type operation and GUI based software system.
e. General in-house computer software maintenance to include, but not be limited to, updating and debugging programs
f. Design, coding, integration, test, documentation, and maintenance of special applications programs
g. Updating of existing technical in-house computer databases
h. Transfer of programs from one system to another and testing for functional operations and real time data transfer between dissimilar systems
i. Debugging of general utility programs, such as graphic packages
j. Provide support for analyzing and implementing solutions to computer hardware interface problems
k. Provide support for network and operating system configurations, troubleshooting, installation, and maintenance
l. Design and debug of test procedures

2. <u>IT Systems Security and System Administrator Function</u> – The contractor shall provide Windows, Macintosh, Linux, UNIX, Web, LAN systems administration services to desktops, workstations and servers, including:

a. Logging, reporting, diagnosing and correcting system faults
b. Configuring systems for performance, security and network compatibility
c. Performing updates of the operating system and associated software for desktops and workstations
d. Supporting in the preparation and updating of IT security and system administration documentation
e. Coordinating with the Office of the Chief Information Officer/Information Technology and Communications Directorate to implement IT security
Initiatives
f. Supporting users with software/hardware installation
g. Performing Help Desk functions including problem diagnosis and answering user questions regarding applications
h. Monitoring system and network security and availability
i. Repairing workstations, desktops and printers on an emergency basis
j. Data backup, archive, and retrieval

In addition to any other requirements of this contract, all individuals who perform tasks as a system administrator or have authority to perform tasks normally performed by system administrator shall be required to demonstrate knowledge appropriate to those tasks. This demonstration, referred to as the NASA System Administrator Security Certification, is a NASA funded two-tier assessment to verify that system administrators are able to –
   1. Demonstrate knowledge in system administration for the operating systems for which they have responsibility.
   2. Demonstrate knowledge in the understanding and application of Network and Internet Security.

Certification is granted upon achieving a score above the certification level on both an Operating System test and the Network and Internet Security Test. The Certification earned under this process will be valid for three years. The criteria for this skills assessment has been established by the NASA Chief Information Officer. The objectives and procedures for this certification can be obtained by contacting the IT Security Awareness and Training Center at (216) 433-2063.

A system administrator is one who provides IT services, network services, files storage, web services, etc. to someone else other than themselves and takes or assumes the responsibility for the security and administrative controls of that service or machine. A lead system administrator has responsibility for information technology security (ITS) for multiple computers or network devises represented within a system; ensuring all devices assigned to them are kept in a secure configuration (patched/mitigated); and ensuring that all other system administrators under their lead understand and perform ITS duties. An individual that has full access or arbitrative rights on a system or machine that is only servicing themselves does not constitute a "system administrator" since they are only providing or accepting responsibility for their system. An individual that is only servicing himself is not required to obtain a System Administrator Certification.

3. <u>Web Page Development and Maintenance Function</u> – The contractor shall provide web development services to help promote organizational capabilities, including:

    a. Development, maintenance, and upgrade of web sites
    b. Management of mission test facilities that require significant computer capabilities
    c. Compliance to Agency and Center policy (GSFC Webmaster) such as 508 compliance and Post 9-11 accessibility compatibility
    d. Defining with customer the look and feel of the web site, and reviewing web site requirements
    e. Developing prototype web sites for maturing web based concepts
    f. Providing maintenance services to keep web site up to date and compliant

B.   DOCUMENT SERVICES

The Contractor shall provide documentation services for all levels of hardware and software within the scope of this Statement of Work, as specified in Task Orders. Documents shall conform to applicable documents and specifications. These shall include pertinent NHBs, SMAP, quality standards, GSFC standards, documents of other NASA Centers, NOAA systems documentation and requirements, including NOAA security requirements, Federal standards, military standards, and commercial standards.

The Contractor shall provide documentation services, including instrument conceptual designs, program plans, systems analyses, illustrations, technical and implementation plans, test plans, test procedures, test scripts, software documentation, and the full range of system hardware and

software documentation. These shall also include up-to-date drawings, specifications, certifications, reports, interface control documents, and agreements.

1. <u>Document Services Specific Tasks</u> – The Contractor shall provide electronic media and document services, including:

   a. Technical writing
   b. Editing
   c. Drafting
   d. CAD/CAM
   e. Photographic
   f. Video
   g. Reproduction
   h. CD, DVD
   i. Posters and Displays

2. <u>Photo and Video Specific Tasks</u> – The Contractor shall use photos and video for maintenance, engineering, or as documentation to explain a problem. They shall become supplemental to support in unit repair or future development and maintenance. A scale shall be included to indicate relative dimensions in photographs and/or video, where appropriate.

C. MAINTENANCE SERVICES

The Contractor shall provide maintenance support, including:

1. Preventive Maintenance

The Contractor shall perform preventative maintenance on hardware and software within the scope of this Statement of Work as specified in Task Orders.

2. Emergency Repair Services

The Contractor shall provide expeditious emergency repair services for hardware and software within the scope of this Statement of Work, as specified in Task Orders. The Contractor shall respond to the Government within four hours of notification to determine and implement a mutually agreeable course of action. In some cases, there shall be 24-hour coverage during flight hardware and software evaluation, verification, and test. This service shall comprise of repair, modification, or replacement of components, codes, subassemblies, and assemblies. Documentation updates shall be required as a result of any design change.

D. SUSTAINING ENGINEERING SERVICES

The Contractor shall provide sustaining engineering services for hardware and software within the scope of this Statement of Work, including:

1. Modifications of hardware/firmware, including installation of circuits for improved reliability and/or performance

2. Modifications of wiring to improve circuit performance

3. Fabrication, assembly, wiring, and testing of printed circuit assemblies where necessary to update old circuitry or improve reliability

4. Engineering, fabrication, testing of assemblies or sub-assemblies to replace outdated circuitry to eliminate component or circuit failures

5. Engineering, fabrication, assembly, and testing of engineering circuits to correct problems encountered

6. Modifications of mechanical assemblies, structures, and mechanisms to correct or improve the design

7. Update of drawings, manuals, and technical data to reflect current status at the time of modifications

E. DEMONSTRATION, PRESENTATION AND CONFERENCE SERVICES

The Contractor shall provide technology services for hardware and software demonstrations, technical/project/conference presentations, and conference planning/implementation for items within the scope of this Statement of Work, including:

1. Demonstration Specific Tasks – The Contractor shall provide hardware, software, support equipment, and technical services for onsite and offsite demonstrations.
2. Presentation Specific Tasks – The Contractor shall provide materials for inclusion in technical/project/conference presentations, including viewgraphs, information, photographs, etc. In addition, the Contractor shall perform the presentation.
3. Conference Specific Tasks – The Contractor shall support the Government by providing services in the planning and implementation of conferences.

F. EDUCATION SERVICES

The Contractor shall provide education services, including:

1. Supporting ETD mini-course series
2. Supporting GSFC's partnership with the University of Maryland Aerospace Department to teach courses in satellite design
3. Supporting the NASA Engineering Training (NET) activity
4. Supporting programs with universities and NASA headquarters

G. STANDARDS AND PROCESS

The Contractor shall provide support for engineering standards work and engineering process work, including:

1. ISO documentation and process generation
2. Engineering standards documentation and review
3. Engineering process documentation
4. Activities in support of engineering process improvement

H. PROCUREMENT SYSTEM

The contractor shall have an established procurement system. Items to be purchased include both non-flight and flight hardware.

I. ROBOTICS ENGINEERING AND INFRASTRUCTURE SUPPORT

The contractor shall provide engineering, technical, and procurement support to allow for the daily operations of the robotic simulation platform facilities in Greenbelt, Maryland and Fairmont, West Virginia within the scope of this Statement of Work, including

1. Managing, maintaining, controlling, and ensuring all robotic system safety procedures and policies are maintained and followed as per ANSI/RIA 15.06-2012 (Safety Requirements for Industrial Robots and Robot Systems) and ISO 12100:2010 (Safety of Machinery – General Principles for Design – Risk Assessment and Risk Reduction).
2. Providing procurement support to acquire the systems and components needed to support the operations of the team including, but not limited to, robotic systems, computer systems, metrology equipment, and infrastructure equipment.
3. Providing electrical/mechanical fabrication and assembly support to the robotics team.

APPLICABLE DOCUMENTS AND SPECIFICATIONS

General:
NPR 7120.5E, "NASA Space Flight Program and Project Management Requirements"
NASA SP-2007-6105 Rev1, NASA Systems Engineering Handbook December 2007
NPR-7150.2B, "NASA Software Engineering Requirements"
NASA-STD-8719.13, "NASA Software Safety Standard"
NASA-STD-8739.8, "Software Assurance Standard"
GPR 8070.4C, "Administration and Application of the Goddard Rules for the Design, Development, Verification and Operation of Flight Systems"
GSFC-STD-1000F, "Rules for the Design, Development, Verification, and Operation of Flight Systems."

Launch Vehicles:
NASA-STD 8719.24 (with Annex), NASA Expendable Launch Vehicle Payload Safety Requirements,
JMR 002, Launch Vehicle Payload Safety Requirements,
NPR 8715.7, ELV Payload Safety Program,
MIL-STD-882E, Standard Practice for System Safety, Appendix B.
NASA-STD-8719.13, "NASA Software Safety Standard"
NASA-STD-8739.8, "Software Assurance Standard"
NPR 8715.7, "Expendable Launch Vehicle Payload Safety Program", Launch Site Facility-specific Safety Requirements, as applicable
 NASA-STD 8719.24 (with Annex) NASA Expendable Launch Vehicle Payload Safety Requirements,
 KNPR 8715.3, "KSC Safety Practices Procedural Requirements" applicable at KSC property, KSC-controlled property, and offsite facility areas where KSC has operational responsibility

Conformal Coating and Staking:
NASA-STD-8739.1A with change 2, "Workmanship Standard for Polymeric Application on Electronic Assemblies"

Soldering – Flight, Surface Mount Technology:
J-STD-001FS ""Workmanship Standard for Surface Mount Technology"

Soldering – Flight, Manual (hand):
 J-STD-001FS, "Soldered Electrical Connections"

Soldering – Ground Systems:
J-STD-001FS, Space Applications Electronic Hardware Addendum to IPC-J-STD-001F "Requirements for Soldered Electrical and Electronic Assemblies"

Electronic Assemblies – Ground Systems:
IPC-A-610F, "Acceptability of Electronic Assemblies"

Crimping, Wiring, and Harnessing:
NASA-STD-8739.4, with Change 6 "Crimping, Interconnecting Cables, Harnesses, and Wiring"
GSFC-733-HARN-01, "Design and Manufacturing Standard for Electrical Harnesses"
565-PG-8700.2.1C,"Design and Development Guidelines for Spaceflight Electrical Harnesses"

Electro-Static Discharge (ESD) Control:
ANSI/ESD S20.20- 2014, "Protection of Electrical and Electronic Parts, Assemblies and Equipment" (Excluding Electrically Initiated Explosive Devices)

Printed Wiring Board (PWB) Design:
500-PG-8700.2.2C, Electronics Design and Development Guidelines
500-PG-8700.2.4F, Mechanical Design and Development Guidelines,
500-PG-8700.2.5C, "Engineering Drawing Requirements Manual"
IPC-2221, "Generic Standard on Printed Wiring Board Design"
IPC-2222, "Sectional Standard on Rigid Printed Wiring Boards Design"
IPC-2223C, "Sectional Design Standard for Flexible Printed Boards"

EEE Parts
GSFC 311-INST-002, "Instructions for EEE Parts Selection, Screening, Qualification, and Derating"

PWB Manufacture:
IPC A-600, "Acceptability of Printed Boards"
IPC-6011, "Generic Performance Specification for Printed Boards"
IPC-6012, "Qualification and Performance Specification for Rigid Printed Boards"
Flight Applications – Supplemented with: GSFC/S312-P-003, Procurement Specification for Rigid Printed Boards for Space Applications and Other High Reliability Uses
IPC-6013 "Qualification and Performance Specification for Flexible Printed Boards"
IPC-6018 "Microwave End Product Board Inspection and Test"

Section 508 EIT Standards
- 1194.21 Software Applications and Operating Systems
- 1194.22 Web-based Intranet and Internet Information and Applications
- 1194.24 Video and Multimedia Products

Mechanical Design
541-PG-8072.1.2B, "GSFC Fastener Integrity Requirements".

Environmental Testing
GSFC-STD-7000 "General Environmental Verification Standard (GEVS)"

Robot Systems
ANSI/RIA 15.06-2012 (Safety Requirements for Industrial Robots and Robot Systems)

ISO 12100:2010 (Safety of Machinery – General Principles for Design – Risk Assessment and Risk Reduction)

Appendix I: Acronyms

64QAM	64 Quadrature Amplitude Modulation
8PSK	8 Phase Shift Keying
AR&C	Autonomous Rendezvous and Capture
AR&C	Autonomous Rendezvous & Capture
ASIC	application-specific integrated circuit
BPSK	Binary phase-shift keying
CAD	Computer-aided design
CAM	computer-aided manufacturing
CD	Computer Disk
CDMA	Code division multiple access
CM	Configuration Management
CMMI	Capability Maturity Model Integration
CO	Contracting Officer
ConOps	Mission Operations Concept
COTS	commercial off-the-shelf
CPL	Capillary Pumped Loop
CPU	Center Processing Unit
CSO	Mission Assurance Officer
dc-dc	Direct Current to Direct Current
DCIDs	Director of Central Intelligence Directives
DM	Documentation Management
DoD	Department of Defense
DPA	Destructive Physical Analysis
DVD	Digital Video Disk
E-M	Electro-Magnetic
EED	Electrical Engineering Division
EEE	Electrical, Electromechanical and Electronic
EIT	Electronic and Information Technology
ETD	Engineering and Technology Directorate
ELV	Expendable Launch Vehicle
EMI	Electromagnetic Interference
EMI/EMC	Electromagnetic Interference and Electromagnetic Compatibility
EP	electrical propulsion
ESD	Electrostatic Discharge
ETR	Eastern Test Range
FEMAP/TCON	Finite Element Modeling and Post-processing
FFTB	Formation Flying Test Bed
FMEA	Failure Modes and Effects Analysis

FPGA	field-programmable gate array
FSW	Flight Software
FTA	Fault Tree Analysis
GEVS	General Environmental Verification Standard
GHz	Giga hertz
GIDEP	Government and Industry Data Exchange Program
GN	Ground Network
GN&C	Guidance, Navigation and Control
GOTS	government off-the-shelf
GPIB	General Purpose Interface Bus
GPS	Global Positioning Satellite
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
GUI	graphical user interface
HDL	hardware description language
Hz	Hertz
I/O	Input/Output
ICD	Interfaces and Interface Control Document
IMDC	Integrated Mission Design Center
ISO	International Organization for Standardization
ISTD	Instrument Systems and Technology Division
IT	Information Technology
ITS	information technology security
JPSS	Joint Polar Satellite System
Li	Lithium
MEMS	Micro Electromechanical Systems
MESA	Mission Engineering and Systems Analysis Division
MIMO	multiple-input and multiple-output
MOLEKIT	Molecular Kinetics
MSD	Mechanical Systems Division
NASA	National Aeronautics and Space Administration
NDE	Non-destructive Evaluation
NET	NASA Engineering Training
NExIS	NASA's Exploration and In-space Services Projects Division
NHB	NASA Handbook
NISPOM	National Industrial Security Program Operating Manual
NSTS	National Space Transportation Systems
OMES	Omnibus Multi-Discipline Engineering Services
PRA	Probability Risk Assessment
PWB	Printed Wiring Board
QCM	Quality Control Management
QPSK	Quadrature Phase Shift Keying

REA	Radiation Effects and Analysis
RF	Radio Frequency
RISC	Reduced instruction set computing
RPODU	Rendezvous Proximity Operations, Docking, Undocking
S/C	Space Craft
SCI	Sensitive Compartmented Information
SED	Software Engineering Division
SEMP	System Engineering Management Plans
SINDA	Systems Improved Numerical Differencing Analyzer
SISO	Single-input single-output
SMAP	Soil Moisture Active Passive
SN	Space Network
SNE	Space Network Expansion
SOW	Statement of Work
SSPTA	Simplified Space Payload Thermal Analyzer
STS	Space Transportation System
TDRS	Tracking and Data Relay Satellite
TMG	Thermal Model Generator
TRASYS	Thermal Radiation Analyzer System
TRL	technology readiness level
TSS	Thermal Synthesizer Systems
UAV	Unmanned Aerial Vehicle
UV	Ultra Violet
V&V	Verification and Validation
VHDL	VHSIC Hardware Description Language
WSC	White Sands Complex
WTR	Western Test Range