PERFORMANCE WORK STATEMENT—RELIANCE CONSOLIDATED MODELS DESIGN AND/OR FABRICATION OF AEROSPACE MODEL SYSTEMS AND DEVELOPMENTAL TEST HARDWARE USED FOR SPACEFLIGHT, SPACE FLIGHT DEVELOPMENT HARDWARE, & FLIGHT AND GROUND-BASED TESTS

1.0 INTRODUCTION

1.1 The Reliance Consolidated Models (RECOM) effort is a consolidation of design and/or fabrication of Aerospace Model Systems and Developmental Test Hardware used for Spaceflight, Flight, Spaceflight Development, and Ground-based tests supporting NASA Ames Research Center (ARC), Glenn Research Center (GRC), Langley Research Center (LaRC), and Marshall Space Flight Center (MSFC). These precision experimental research models and hardware may consist of both mechanical and electrical/electronic hardware elements. These models may incorporate the use of new technologies such as smart materials, or new processes such as stereolithography and rapid proto-typing using polycarbonate. The mechanical hardware elements include, but are not limited to, wind tunnel models (including, but not limited to, force/pressure, propulsion simulation, dynamically scaled, and free flight), rotorcraft models, drop models, model components, model support systems, test equipment, turbomachinery models (including, but not limited to, air turbine models, water flow pump models) aircraft flight test hardware, space flight hardware, large welded/formed structural components used in the development and validation of space flight systems, force measurement equipment (including multi-component wind tunnel balances), and structural test articles and instrumentation/devices to measure force, moments, acceleration, attitude, pressure strain and temperature. The electrical/electronic hardware elements include but are not limited to motors, actuators, sensors, control panels, printed circuit boards, data acquisition and control systems, circuit protection, connectors, fiber-optic cables and wiring, as required, to support the test hardware.

1.2 These research models and hardware may be utilized for various facilities such as NASA wind tunnels, air/water flow turbine/pump facilities, aircraft, spacecraft, and other existing and future laboratory environments.

2.0 SCOPE OF WORK

2.1 GENERAL OVERVIEW

2.1.1 The Contractor shall work from Delivery Orders (DOs) that will include drawings and specifications describing in detail all work required to satisfactorily complete each order. The Contractor shall, in response to the Delivery Order, furnish personnel, equipment, materials, and facilities necessary to perform any or all of the following: conceptual design, feasibility design studies, preliminary and detailed engineering design, stress analysis, fabrication, development and advancement of emerging technologies, instrumentation and calibration, testing, inspection, assembly, installation and check-out, packaging and transportation of Aerospace Model Systems and Developmental Hardware. The Contractor shall meet all requirements in this Performance Work Statement (PWS), particularly the requirements of LPR 1710.15, Wind-Tunnel Model Systems Criteria. The Government will not determine when fabrication should begin since overall responsibility for meeting all requirements resides with the Contractor. Performance under this contract may involve access to and/or generation of classified information, the design, analysis, and fabrication of classified hardware, and/or work in a secure area, up to the level of Secret, as stated in individual Delivery Orders.

2.1.2 The Contractor shall manage, monitor, and integrate subcontracted work at the location of performance.

2.1.3 The Contractor shall interface with the requiring Center personnel via electronic media utilizing computer codes including, but not limited to, Pro/ENGINEER, AutoCAD, Solid Works, CATIA, Nastran/Patran, ANSYS and Pro/MECHANICA formats for geometry, drawings, analysis, and reports during the design and/or fabrication process.

2.1.4 Technical skills such as welding and non-destructive tests require personnel who have been subjected to certification testing to indicate that they are capable of performing the skills required. These qualifications are identified in the NASA Standard Publications that are made a part of the Statement of Work contained in individual Delivery Orders.

2.2 DESIGN REQUIREMENTS OVERVIEW

As directed by delivery order, the Contractor shall perform design tasks including, but not limited to, the following:

2.2.1 Design and integrate mechanical and electrical/electronics packages and subsystems.

2.2.2 Provide conceptual layouts, feasibility studies, preliminary design drawings and analysis, detailed drawings, engineering analyses and appropriate computer output files which shall allow for the fabrication of mechanical hardware from a variety of materials such as metals, fiberglass, carbon fibers, wood, ceramics, polycarbonate, moldable or formable materials, or any combination of these materials.

2.2.3 Incorporate a variety of functions and processes into designs, such as precision machining, welding, brazing, hand and wave soldering, riveting, heat treating, composite lay-up, vacuum bagging, wire and conventional electron discharge machining, stereolithography, rapid proto-typing using polycarbonate, and wire wrapping.

2.2.4 Design space flight hardware incorporating requirements for certifications of materials, fasteners, processes and procedures. For multiple assemblies, fabricated components shall be completely interchangeable. Specific procedures required will include the use of special materials, lubricants, and cutting fluids to prevent out-gassing in space. Proper specifications for Quality Assurance (QA) inspection of flight articles and all safety requirements shall be addressed in the design.

2.2.5 Design printed circuit boards, electrical/electronic hardware components and subsystems.

2.2.6 Design the integration of electrical/electronic hardware into final assemblies using installation and operation specifications, and providing mounting, power, wiring and circuit protection.

2.2.7 The Contractor shall design metal joints utilizing conventional as well as specialized joining processes as specified in Section 2.3.8.

2.2.8 Perform detailed thermal and dynamic/vibration analyses for mechanical hardware.

2.2.9 Perform detailed stress analysis for mechanical hardware utilizing Finite Element Analysis (FEA) programs and other software such as NASTRAN.

2.2.10 Submit and present design developments for review at various time intervals and locations, as directed by the delivery order.

2.2.11 Perform engineering design of force transducers, strain gage balances, strain gauged devices, strain gage type multi-component force measuring transducers, including single piece and multi-piece design balances. The transducers will include wind tunnel load cells, tension links, and related calibration hardware.

2.2.12 Design, analyze, and fabricate large metallic structures using specialized forming processes for both aluminum and steel sheet and plate.

2.3 FABRICATION REQUIREMENTS OVERVIEW

As directed by delivery order, the Contractor shall perform fabrication tasks including, but not limited to, the following:

2.3.1 Fabricate and assemble mechanical and electrical/electronics packages and subsystems.

2.3.2 Fabricate mechanical hardware from a variety of materials such as metals, fiberglass, carbon fibers, wood, ceramics, polycarbonate, moldable or formable materials, or any combination of these materials.

2.3.3 Fabrication shall require a variety of functions and processes such as precision machining, welding, brazing, hand and wave soldering, riveting, heat treating, composite lay-up, vacuum bagging, wire and conventional electron discharge machining, stereolithography, rapid proto-typing using polycarbonate, and wire wrapping.

2.3.4 Fabricate space flight assemblies. Fabrication of space flight hardware will impose requirements for certifications of materials, fasteners, processes and procedures. For multiple assemblies, fabricated components shall be completely interchangeable. Specific procedures required will include the use of special materials, lubricants, and cutting fluids to prevent out-gassing in space.

2.3.5 Fabricate printed circuit boards, electrical/electronic hardware components and subsystems.

2.3.6 Integrate electrical/electronic hardware into final assemblies using installation and operation specifications, and providing mounting, power, wiring and circuit protection. Inspect all work prior to delivery to ensure compliance with the delivery order. A written inspection report including material certifications shall be delivered with the completed hardware.

2.3.7 Fabricate large metallic structures using conventional and specialized forming processes on metals in various sheet, plate, and structural forms. Typical metal sheet sizes range from 0.016 inch thick to 0.250 inch thick and are 48 inches by 144 inches in size. Typical plate sizes range from 0.375 thick to 1.00 inch thick and are 48 inches by 144 inches in size. Special plates may exceed 1.00 inch in thickness. Structural forms include, but are not limited to, commercially available angle, channel, I-Beam, H-Beam, pipe, rod, and bar. Forming processes include the ability to fabricate similar structural configurations not commercially available using high capacity precision metal cutting/forming equipment, such as manual or

power shears and slip rolls, hydraulic press brakes and punches. The Contractor shall have resources for ultrasonic cleaning.

2.3.8 The Contractor shall join metals utilizing conventional as well as specialized joining processes. These include, but are not limited to, the following arc welding processes:

a. SMAW - Shielded Metal Arc Welding (Stick) various steels, alloy steels, nickels, and stainless steels. Process is used for thicker sections, structural items.
   GMAW - Gas Metal Arc Welding (Mig, solid wire) various steels, alloy steels, nickels, and stainless steels. Process is used for welding thinner sections (1/8 inch thick or less). It is also used for some thicker sections on structural items.
b. FCAW - Flux Cored Arc Welding (Mig flux cored wire) various steels, alloy steels, some nickel alloys, and stainless steels. Process is used in heavy production or structural welding.
c. GTAW - Gas Tungsten Arc Welding (Tig) Aluminum, various steels, alloy steels, tool steels, nickel alloys, precipitation hardened steels, stainless steels. Process is used in thinner applications or when weld quality must be exceptional. Can also be used in thicker sections.
d. GMAW - Gas Metal Arc Welding (Mig aluminum welding) Aluminum materials, mostly used for welding aluminum structural or thicker sections.

2.3.9 Fabricate and calibrate single piece and multi-piece strain gage balances and strain gauged devices.

2.4 TESTING REQUIREMENTS OVERVIEW

As directed by Delivery Order, the Contractor shall perform testing tasks including, but not limited to, the following:

2.4.1 Test mechanical and electrical/electronics packages, components, subsystems and integrated assemblies.

2.4.2 Install, test, and calibrate instrumentation such as pressure, temperature, and flow sensing devices, force measuring equipment, strain gages, and specialized data acquisition equipment as required in the Delivery Order.

2.4.3 Determine natural frequencies and mode shapes for rotating systems (e.g., rotors, turbines, turboprops) as integrated in the model test hardware.

3.0 FUNCTIONAL REQUIREMENTS

3.1 MECHANICAL AND ELECTRICAL/ELECTRONIC DESIGN

As directed by Delivery Order, the Contractor shall perform design tasks including, but not limited to, the following:

3.1.1 Mechanical and Electrical/Electronic Conceptual Design

The Contractor shall develop hardware design concepts, approaches and perform trade-off studies to demonstrate the value of each design. The output may consist of

sketches, layouts, diagrams, analyses and supporting written justification. The output shall compare all designs which could form the basis for additional feasibility studies. The conceptual design shall include identification of requirements and space allocation for electrical/electronic elements and instrumentation.

3.1.2 Mechanical and Electrical/Electronic Design Feasibility Studies

The Contractor shall conduct feasibility design studies to determine whether a chosen design approach can be used and incorporated into a successful detailed and final design, considering all analytical and fabrication constraints. The output may consist of preliminary drawings using pencil and/or Computer Aided Design (CAD) programs, supporting analyses as well as cost and schedule estimates for hardware design, fabrication and installation. The feasibility study shall include functional requirements for electrical/electronic elements. Functional requirements include but are not limited to the identification and assessment of operational objectives, volume allocation, and environmental constraints such as heat, vibration and moisture.

3.1.3 Mechanical and Electrical/Electronic Preliminary Design

3.1.3.1 The Contractor shall provide to the Contracting Officer’s Technical Representative (COTR) hardware preliminary designs that include, but are not limited to, the following: engineering layout drawings and analyses; design, fabrication and installation approaches; general specifications for subcontracted or commercially produced hardware; any special test or handling requirements; and cost and schedule estimates.

3.1.3.2 A preliminary design shall comply with the Delivery Order design requirements and describe the main components, configurations, limitations, characteristics and modes of operation.

3.1.3.3 The Contractor may be required by the Delivery Order to orally present the design at a Preliminary Design Review (PDR). The PDR may occur at the requesting Center, the Contractor's facility, or another location.

3.1.4 Mechanical and Electrical/Electronic Detailed Design

3.1.4.1 The Contractor shall provide to the COTR detailed designs that may include, but are not limited to, the following: detailed fabrication and assembly drawings; detailed engineering analyses; hardware specifications and other documents as required; computer files generated from CAD, FEA, and Contractor written executable programs. The detailed design shall conform to Section 3.3.1 "Mechanical and Electrical/Electronic Safe Design Analysis," unless otherwise stated in the Delivery Order.

3.1.4.2 The Contractor shall provide to the COTR final, detailed drawings suitable for fabrication and assembly of hardware. All final drawings shall conform to the latest revision of MIL-STD-100 and shall have NASA borders in the Design Exchange Format (DXF).

3.1.4.3 The Contractor shall have the capability to exchange CAD generated surfaces and solid models utilizing the Initial Graphic Exchange Specification (IGES) version 5.2 and other neutral formats. The Contractor shall utilize IGES files containing, but not limited to, Non-Uniform Rational B-Spline (NURBS) curve and surface representations, including trimmed surfaces.

3.2 DESIGN REVIEWS

The Contractor may be required to present and participate in periodic design reviews. Typically, design reviews occur at the following design stages: 50 percent of completion, 90 percent of completion and 100 percent of completion, and will be defined in the Delivery Order. Design review locations will be specified in the Delivery Order.

3.2.1 Informal Design Reviews

Informal preliminary design reviews shall include presentation of the preliminary design approach and the preliminary analysis, and assure that all critical areas have been analyzed by the Contractor and adequate factors of safety exist. The preliminary analysis and preliminary drawings shall be provided to the COTR, the Research Engineer, and the Standard Practice Engineer prior to the formal Preliminary Design Review.

3.2.2 Formal Design Reviews

The formal design review shall be presented to a panel and consists of a Preliminary Design Review (PDR) and a Final Design Review (FDR). The decision to require a formal design review will be determined by the COTR and will be based upon the risk or complexity associated with the fabrication of the hardware being procured.

3.3 ENGINEERING ANALYSIS

As directed by Delivery Order, the Contractor shall perform engineering analysis tasks including, but not limited to the following:

3.3.1 Mechanical and Electrical/Electronic Safe Design Analysis

3.3.1.1 The Contractor shall provide analysis verifying that all detailed hardware designs are safe for personnel and facilities. These detailed hardware requirement standards are specified in section 5.0 Standards/Codes. Provisions for alternate hardware design codes such as the "American Institute of Steel Construction" (AISC) or center specified standards may require the Contractor to verify that the hardware design is in compliance with those codes.

3.3.1.2 The Contractor shall calculate hardware loads, stresses, strains and fatigue life resulting from the following hardware design criteria: pressure, mechanical, dynamic, aerodynamic, thermal, live and dead loads. The Contractor shall determine natural frequencies and mode shapes for rotating systems (e.g., rotors, turbines, turboprops) as integrated in the model test hardware. The Contractor shall perform safety calculations for possible hardware failure in bearing, stability, bending, fatigue, weld strength, fastener strength, and other modes as required. External hardware design criteria shall be supplied in the Delivery Order. The Contractor shall submit any recommended hardware design criteria changes to the COTR for approval.

3.3.1.3 The Contractor shall provide calculations and results in a written report that is specific for each issuing Center's requirements. See Section 5.0 Standards/Codes. If the use of finite element analyses (FEA) is required, the Contractor shall provide FEA models in formats that are convertible to the NASTRAN bulk data form, or as specified by the Delivery Order. When required by the Delivery Order, electronic copies of Contractor written programs related to the hardware design shall be submitted to the Government and shall be executable using either C, C++, FORTRAN, or other mutually agreed to compilers.

3.3.1.4 The Contractor may be required to orally present results or relevant calculations described in Section 3.1 "Mechanical and Electrical/Electronic Design".

3.3.2 General Engineering Analysis

The Contractor shall perform analyses to including, but not limited to, the following disciplines:

a. Machine Design
b. Fluid Mechanics
c. Static and Dynamic
d. Vibration
e. Materials
f. Thermal Dynamics and Heat Transfer
g. Automatic Control Systems
h. Instrumentation
i. Electrical/Electronic Systems
j. General Computer Systems
k. Safety/Hazard Analyses

Pursuant to the requirements of the Delivery Order, all calculations and results shall be provided to the Government.

3.4 FABRICATION

As directed by Delivery Order, the Contractor shall perform fabrication tasks including, but not limited to the following:

The Contractor shall provide all material, equipment, facilities, transportation, and personnel to perform the fabrication described in the Delivery Order. The Delivery Order may contain hardware drawings, sketches, CAD geometry files, and/or written narratives along with any special fabrication operations, procedures, and techniques.

3.4.1 Fabrication Work Disciplines

3.4.1.1 Work disciplines shall include equipment expertise in, but not limited to the following: conventional, high-speed, and specialized machining; metalsmith fabrication; heavy metal forming/joining; soldering, brazing, torch, and arc welding; conventional and specialized wood working; lay-up, bonding, processing, and machining of composite materials; hand fairing and finishing of sculptured surfaces and contours; electrical discharge machining (wire or die sink); and tubing and instrumentation installation; and stereolithography. Specialized services shall include heat treating, Nondestructive Testing (NDT) and Nondestructive Evaluation (NDE), plating, rapid prototyping and painting.

3.4.1.2 In addition, the Contractor shall perform electronics fabrication, processes, assembly and inspection that may require the following equipment including, but not limited to, photo plotter, automatic wave reflow solder machine, solder paste dispenser, solder paste viscosity monitor, soldering stations, thermal chamber, microscopes, video inspection stations, dynamic static neutralizer and constant monitors.

3.4.2 General Electronics

3.4.2.1 The Contractor shall provide general electronics fabrication and assembly of miscellaneous hardware including, but not limited to, printed circuit boards with surface mount technology and through hole assembly, cables, harnesses, and any associated special tooling or fixturing.

3.4.2.2 In performing the prescribed electronics fabrication services and quality assurance inspections, the Contractor shall comply with the quality provisions set forth in the NASA Procedural Requirements (NPR) 8735.2A, Management of Government Quality Assurance Functions for NASA Contracts, where applicable and/or specified in each Delivery Order.

3.4.3 General Machining

The Contractor shall perform general machining and fabrication. This work shall require a conventional and computerized numerical control (CNC) equipment to perform machining including, but not limited to, milling, turning, electrical discharge machining (EDM), drilling and grinding. The typical tolerances for general machining shall be +/- 0.005 inch.

3.4.4 Precision Machining

3.4.4.1 The Contractor shall perform precision machining and fabrication of experimental research hardware including, but not limited to, support equipment such as wind tunnel aircraft models, nacelles, engine components, single and multi-piece strain gage balances, combustors, nozzles, bearing seals, bellmouths, and flow straighteners. Dimensional tolerances ranging from +/- .0002 inches to .002 inches shall be maintained.

3.4.4.2 The Contractor shall perform precision machining of space flight and flight hardware, including, but not limited to, housings, brackets, vessels, component parts, chambers, lens and mirror mounts, positioning mechanisms, fixture plates and clamps while maintaining all flight and space flight requirements.

3.4.5 Computerized Numerical Control Machining

The Contractor shall perform CNC machining of sculptured and modeled surfaces while maintaining typical tolerances as accurate as +/- .002 inches. These models may be of various scaled sizes, complex contoured shapes and have highly cambered and twisted wings with controlled shapes and finishes.

3.4.6 Surface Finish

The Contractor shall perform hand finishing, polishing, and lapping on precision hardware, such as highly cambered and twisted wings, sculptured surfaces, and contours from CAD generated models while maintaining typical dimensional tolerances as accurate as +/-.002 inches and surface finishes as low as 2 root mean squared (rms) (micro inches).

3.4.7 Instrumentation

The Contractor shall perform instrumentation fabrication that includes, but is not limited to, devices used to detect or collect such physical conditions as: temperatures, pressure, flow, force, vibration, displacement, acceleration, and strain. The work includes fabrication of thermocouples, probes, survey rakes (temperature and/or pressure), calorimeters, and transducers. This includes working with miniature tubing assemblies, micro-miniature wiring techniques, and critical tolerances of +/-0.0005 inch to +/-0.001 inch.

3.4.7.1 Strain Gage Application

The Contractor shall apply strain gages and ancillary sensors including, but not limited to, thermocouples, temperature sensors, accelerometers, and displacement sensors on single or multicomponent transducers, single and multi-components strain gage balances, structural specimens of conventional or composite materials or other research apparatus.

3.4.7.2 Force Transducer Fabrication

The Contractor shall fabricate, modify, and repair force measuring transducers, such as single or multi-piece balances, load cells, and tension links. This includes, but is not limited to, fabricating, modifying, and repairing calibration fixtures, calibration arms, adapters, stings, cooling shields, and other related calibration hardware. The machining process may require the use of electrical discharge machining equipment.

3.4.7.3 New Force Transducer Installation and Troubleshooting

The Contractor shall install and troubleshoot strain gage force measuring transducer systems and related accessories. Requirements shall include connecting interface and wiring between force transducers and permanent wind tunnel instrumentation, performing verification checks, and troubleshooting of force-transducer-system at the test site.

3.4.8 Special Processes

3.4.8.1 The Contractor shall provide processes including, but not limited to, splicing, gear cutting, gear grinding, centerless and blanchard grinding, vacuum and conventional heat treating, stress relieving, plating, metalizing, plasma spraying, sand blasting, anodizing, engraving, painting, graphics artwork layout, silk screening and decaling of instrumentation (panels, chassis, cabinets, and printed circuit boards), and any other types of surface treatments.

3.4.8.2 The Contractor shall provide electronics processes including, but not limited to, schematic capture, photo plotting, running design rule checks and conformal coating.

3.4.9 Sheet Metal & Metal Plate Fabrication

The Contractor shall provide sheet metal work that includes, but is not limited to, bending, forming, punching, shearing, brazing, rolling, riveting, and welding. The Contractor shall fabricate large metallic structures using conventional and specialized forming processes on metals in various sheet, plate, and structural forms. Typical metal sheet sizes range from 0.016 inch thick to 0.250 inch thick and are 48 inches by 144 inches in size. Typical plate sizes range from 0.375 thick to 1.00 inch thick and are 48 inches by 144 inches in size. Special plates may exceed 1.00 inch in thickness. Structural forms include, but are not limited to, commercially available angle, channel, I-Beam, H-Beam, pipe, rod, and bar. Forming processes include, but are not limited to, the ability to fabricate similar structural configurations not commercially available using high capacity precision metal cutting/forming equipment, such as manual or power shears and slip rolls, hydraulic press brakes and punches.

(a) General fabrication with tolerances of +/- 0.060 inch unless otherwise specified.

(b) Precision fabrication with tolerances of +/-.0.030 inch unless otherwise specified.

(c) Space flight hardware tolerances shall be in accordance with MSFC- STD-156 unless otherwise specified.

3.4.10 Composites

The Contractor shall perform fabrication of experimental research hardware including, but not limited to, drop models, flutter models, free flight models, and turbine and rotor blades utilizing composite materials. This work will include development of molds, performing hand lay- ups, vacuum bagging, autoclave curing, machining and finishing composites.

3.4.11 Materials

The Contractor shall use a variety of materials including, but not limited to, ferrous metals, non-ferrous metals (including super and high temperature alloys), ceramics, composites, plastics, wood, Teflon, foam, honeycomb, metals and composites, and smart materials.

3.5 QUALITY ASSURANCE

As directed by Delivery Order, the Contractor shall perform quality assurance tasks including, but not limited to, the following:

3.5.1 Quality Management System

The Contractor shall utilize a quality assurance program that is compliant with the requirements of the current ANSI/ISO/ASQC Q ISO 9001 standard, *Quality Management Systems Requirements,* and ASO 9100 standard, *Quality Management Systems – Aerospace – Requirements*.

3.5.2 Configuration Control

The Contractor shall establish and utilize a configuration control program that assures components are fabricated to the latest drawing release and no deviations from approved drawings are permitted without notification of and prior approval from the COTR.

3.5.3 Inspection

3.5.3.1 The Contractor shall develop and submit to the COTR a fabrication inspection plan for approval prior to fabrication, if required by the Delivery Order. This plan shall be included in the Contractor’s Delivery Order plan as described in Section 4.1, Design Submittals. The inspection plan shall address any unique hardware features and incorporate specific inspection instructions or requirements that may be included in the Delivery Order.

3.5.3.2 The Contractor shall furnish, as required, written certification for processes and materials including, but not limited to, chemical and physical tests, material composition, x- ray and ultrasonic inspections, dye penetrant inspections, heat treatment, welding, and welder qualifications.

3.5.3.3 Final hardware inspection, assembly, and check-out of all configurations shall be performed by the Contractor at the contractor's facility prior to shipment. A Government inspector or designated representative shall be present during final inspection. A final inspection report, as described in Section 4.2.4, Inspection Reports, shall be submitted to

the COTR at the completion of the Delivery Order. Final acceptance of deliverables shall be conducted with the COTR present in accordance with the requirements in the Delivery Order.

3.5.3.4 Final hardware inspection shall be performed while the hardware has the same fixity as it will experience during testing. Inspection shall be performed on aerodynamic components while in a rigged, free state condition or as stated in the Delivery Order.

3.5.4 Nondestructive Evaluation

The Contractor shall perform all nondestructive examinations (NDE) and tests as required for fabrication, assembly and checkout. NDE personnel shall be qualified and certified in accordance with the recommended standard practice of The American Society for Nondestructive Testing (ASNT) Standard for Qualification and Certification of Nondestructive Evaluation Personnel – ANSI/ASNT-CP-189 (most current edition). All NDEs shall be performed using written procedures. The Contractor shall submit to the COTR all NDE procedures for government NDE-Level-II review and acceptance before performing the examination. The Contractor shall submit to the COTR all examination reports, X-Ray film and film interpretation reports for government NDE-Level-II review and acceptance as soon as practical after completion of the examination. The Government NDE-Level-II has the final approval authority for acceptance of all NDE results. NDE personnel certifications shall be subject to review by the Government NDE Level II and NDE examinations shall be subject to witnessing by the Government NDE-Level-II at Centers that participate in NDE Level II.

3.5.5 Nonconformances

3.5.5.1 The Contractor shall notify the COTR of any nonconformances to the Delivery Order criteria found during in-process or final inspection prior to shipping. Nonconformances shall be classified as Type I or Type II.

3.5.5.2 A Type I nonconformance is defined as an out-of-tolerance condition that will affect the performance, durability, interchangeability, reliability, safety, effective use, weight or appearance of the item(s). A Type I nonconformance typically will require repair of or remaking the item.

3.5.5.3 A Type II nonconformance is defined as an out-of-tolerance condition that will not likely materially reduce the usability of the item(s) for its intended purpose. A Type II nonconformance will require written approval by the COTR to use as is. No items with open Nonconformance Reports (NCRs) are to be delivered.

3.6 CALIBRATION, TESTING, ASSEMBLY, AND INSTALLATION

As directed by Delivery Order, the Contractor shall perform tasks including, but not limited to, the following:

3.6.1 The Contractor shall provide calibration, proof testing, dynamic balancing and integrated operation of rotating and non-rotating systems, and functional checkout of fabricated systems and components as specified in Delivery Order. Acceptance testing shall include, but not be limited to, proof pressure/hydrodynamic testing or pressurized components, spin proof tests of rotating components, and electrical continuity checks.

3.6.2 The Contractor may be required to perform fit and function checks with the mating parts at specified NASA facilities. Specific Delivery Orders may require assembly, installation and system checkout in specified NASA facilities.

3.6.3 The Contractor shall provide calibration services for single and multi-piece strain gage balances.

4.0 DOCUMENTATION AND REPORTING

The Contractor shall provide documentation and reports in accordance with the Delivery Order. The following paragraphs describe the documentation and reporting requirements.

4.1 DESIGN SUBMITTALS

The Contractor shall provide the following items, as specified in the Delivery Order:

4.1.1 For hardware design tasks, the Contractor shall provide to the COTR three (3) copies of the hardware design for review according to the schedule specified in the Delivery Order. The Delivery Order shall detail the submittal requirements and may include some or all of the following: engineering layout drawings, preliminary analyses, general specifications for subcontracted or commercially produced hardware, design, fabrication/installation and inspection approaches/plans, any special test or handling requirements, and cost and schedule estimates.

4.1.2 In cases where PDRs and Critical Design Reviews (CDRs) are required, the Contractor shall first obtain authorization to commence fabrication.

4.1.3 The design submittal for the PDR/CDR shall contain: detailed fabrication and assembly drawings, detailed analyses, equipment specifications, any computer generated files, and cost and schedule estimates.

4.1.4 Upon approval by the Design Review Committee, the Contractor may commence fabrication without further delay.

4.2 ENGINEERING AND FABRICATION DELIVERABLES

The Contractor shall provide the following items, as specified in the Delivery Order:

4.2.1 Drawings

4.2.1.1 The Contractor shall provide to the COTR three (3) copies of the design drawings for review unless otherwise specified. The Contractor shall provide reproducible originals and three (3) copies, unless otherwise specified, of each approved drawing at the completion of the job. CAD drawings and all related geometry, part, and assembly files shall be provided in accordance with LPR 7320.1, Engineering Drawing System.

4.2.1.2 The drawings shall contain the required border and shall be no larger than D-size unless otherwise specified in the Delivery Order. Drawings must meet MIL-STD-100E or the most current version and MIL-T-31 000.

4.2.1.3 For work that includes both design and fabrication, the final Contractor generated drawings shall exhibit all changes incurred during fabrication and reflect "as-built" designs.

4.2.2 Model Systems Report

The Contractor shall provide to the COTR three (3) copies, unless otherwise specified, of the Model Systems Report as part of the hardware design submittals. The Model Systems Report shall contain all applicable as-built (reduced size) drawings, sketches, design loads, stress analysis reports, stability reports, inspection reports and test reports, deviation requests, and design review documents that were performed to ensure the hardware meets specifications described in the Delivery Order, and all applicable other documentation listed in the requesting Center's criteria. The report shall state the results of the analysis and indicate compliance and/or deviations from the Delivery Order specifications.

4.2.3 Specifications

The Contractor shall provide to the COTR three (3) copies of maintenance manuals, operation manuals, manufacturers' specifications, and specifications for fabricated equipment. The Contractor shall provide to the COTR three (3) copies of the hardware assembly, installation and change procedures. To permit model configuration changes during a test program, the change procedures shall include, but not be limited to, assembly, sequential steps, torque values, alignment criteria, installation instructions and requirements to checkout.

4.2.4 Inspection Reports

The Contractor shall provide to the COTR three (3) copies of the final inspection reports at the end of the requested job. The final inspection report shall contain certifications of the materials, fasteners, components and processes used for the hardware. Certifications shall meet the specifications of the Delivery Order and NASA Procedural Requirements (NPR) 8735.2A, Management of Government Quality Assurance Functions for NASA Contracts. The final inspection report shall also include the results from the inspection of the hardware and their tolerances, and any Nonconformance Reports (NCRs).

5.0 STANDARDS/CODES

The nature of the research work at the ARC, LaRC and GRC and MSFC is such that conformance to various standards and codes shall be specified if required. Those that are applicable will be specified in each Delivery Order. Typical standards and codes that may be required of the Contractor are the following:

ALL CENTERS

- American National Standards Institute (ANSI) Power Piping Codes as sponsored by ASME
- AS9100 Quality Management System Standard
- American Society of Mechanical Engineers Boiler (ASME) and Pressure Vessel Code
- American Society for Testing Material (ASTM) Standards
- American Society for Nondestructive Testing (ASNT) Standard for Qualification and Certification of Nondestructive Evaluation Personnel ANSI/ASNT-CP-189
-ASNT Standard SNT-TC-1 A
- American Welding Society (AWS)
- Department of Transportation Regulations
- Institute of Electrical and Electronics Engineers (IEEE)
- International Standard 1940: Mechanical Vibration – Balance Quality Requirements for Rotors in a Constant (Rigid) State
- Instrument Society of America (ISA)
- ISO 9001 Quality Management System Standard
- MIL-HDBK-17-1F, Composite Materials Handbook
- MIL- Specs/ Standards

- NASA Standards and Handbooks
- National Electrical Manufacturers Association (NEMA)
- The Society of Automotive Engineering (SAE)
- Space Flight Specifications/Standards

ARC:

- Guidelines for Preparing Design/Safety Analysis Documentation (currently undergoing revision)

LaRC:

- Wind-Tunnel Model Systems Criteria (LPR 1710.15) (July 2004)
- Calibration and Evaluation of Multicomponent Strain Gage Balances (March 1964)
- NASA Technical Memorandum (TM) 2004-213017, Suggested Procedures for Installing Strain Gauges on Langley Research Center Wind Tunnel Balances, Custom Force Measuring Transducers, Metallic and Composite Structural Test Articles (May 2004)
- Safety Clearance Procedures for the Control of Hazardous Energy (Lockout/Tagout) (LPR 1710.10) (January 2005)
- Engineering Drawing System (LPR 7320.1) (July 2004)
- NASA TM 84625, Fabrication Division Ultrasonic Inspection Specification for Critically Stressed Components
-Space Product Assurance (LPR 5300.1) (January 2005)
-Aviation Operations and Safety Manual (LPR 1710.16) (May 2005)
-Acceptable Methods of Aircraft Repair Manual (FAA AC 43.13-1B/2A)

GRC:

-NASA TM 106565, NASA Lewis Wind Tunnel Model Systems Criteria
-NASA TM 106569, NASA Lewis Propulsion Systems Laboratory Customer Guide Manual
-NASA TM 106589, NASA Lewis Propulsion Systems Laboratory Test Article Systems Criteria

MSFC:

-NASA TM X-64624, The George C. Marshall Space Flight Center's 14 X 14-Inch Trisonic Wind Tunnel Technical Handbook
- Marshall Space Flight Center Standard 156 (April 2, 1962)

The Contractor shall adhere to the latest edition or supplements as published in effect at the date of delivery order award when utilizing the standards or codes set forth above.

6.0 GLOSSARY

AISC	American Institute of Steel Construction
ARC	Ames Research Center
ASNT	American Society for Nondestructive Testing
ASTM	American Society for Testing Material
CAD	Computer Aided Design
CDR	Critical Design Review
CNC	Computerized Numerical Control

COTR	Contracting Officer's Technical Representative
DO	Delivery Order
DOD	Department of Defense
DXF	Design Exchange Format
FEA	Finite Element Analysis
GRC	Glenn Research Center
IGES	Initial Graphic Exchange Specification
LaRC	Langley Research Center
MSFC	Marshall Space Flight Center
NASA	National Aeronautics and Space Administration
NCR	Nonconformance Report
NURBS	Non-Uniform Rational B-Spline
PDR	Preliminary Design Review
PWS	Performance Work Statement
rms	root mean square (Surface Height Rating)

[END OF SECTION]