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SIMULATION AND AIRCRAFT SERVICES (SAS)
CURRENT TITLE: LANGLEY SIMULATION AND AIRCRAFT TECHNICAL SERVICES (LSATS)

1.0 - BACKGROUND

This statement of work describes the requirement for simulation and flight research support at the research and development facilities located at the National Aeronautics and Space Administration's (NASA) Langley Research Center (LaRC).

1.1. - Mission Description

1.1.1. The Simulation Development and Analysis Branch (SDAB) of the Research Services Directorate (RSD) provides software and hardware services utilizing the unique national research and development facilities located at NASA LaRC. These facilities are dedicated to providing researchers with high-fidelity environments in which to conduct simulation and flight research and to advance the state-of-the-art of simulation technology. The Flight Simulation Facilities (FSF) are comprised of the computing systems including the Real-Time Computer Systems, Computer Image Generation Systems, Computer Graphics Generation Systems, and Real-Time Network Systems; and the Cockpit Motion Facility (CMF), Differential Maneuvering Simulator (DMS), Development and Test Simulator (DTS), and Test and Evaluation Simulator (TES). The CMF houses a state-of-the-art six-degree-of-freedom synergistic motion system, the Research Flight Deck (RFD) Simulator, the Integration Flight Deck (IFD) Simulator, the Generic Flight Deck (GFD) Simulator, and has space for an, as yet, undefined fourth simulator. All of the simulators in the CMF are capable of operating in a fixed-base mode or installed on the motion system. The FSF also include the Uninhabited Aircraft Systems (UAS) Integration and Validation Laboratory (SIVL) and System Integration Laboratories (SIL). The flight simulators provide real-time, high fidelity (Technology Readiness Level 5 to 7), full mission, human-in-the-loop flight simulation environment and capabilities to conduct state-of-the-art, preeminent aerospace research.

1.1.2. In addition to the FSF, SDAB provides software and hardware development support to the research aircraft operated by the Research Services Directorate. These include the following aircrafts: B-200, UC-12B, SR-22, HU-25, Cessna-206, OV-10, and Columbia 300. SDAB also provides development support to other UAS within and outside LaRC.

1.1.3. The FSF and research aircraft are used by researchers from LaRC, other NASA Centers, Federal Aviation Administration (FAA), Department of Defense (DOD), other government organizations, industry, and universities. Researchers use the software and hardware services of the facilities to investigate a variety of topics ranging from the design of new aircraft/spacecraft, to new guidance and control systems, to the human factor implications of new/existing flight deck displays, control/data input devices, and airspace operations. Additionally, software and hardware services are utilized for in-house research projects and experiments that are conducted to develop new simulator systems and subsystems, improve

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existing simulation systems, develop advanced software engineering techniques to improve the fidelity and validity of simulation software programs, and incorporate the latest technology into simulator and computer systems.

1.1.4. SDAB also conducts distributive simulation experiments which include integration of flight simulations in FSF with other flight simulators and labs within and outside LaRC.

1.1.5. SDAB manages the FSF through Civil Service line managers and facility managers who are ultimately responsible for the successful performance of the mission of each facility.

1.1.6. As Project Assignments (PAs) are generated by the Contracting Officer's Representative (COR), the Contractor shall provide services to prepare, operate, maintain, improve and integrate the assigned simulators, integration labs, and aircraft research systems, and ensure that the researchers' data is collected as specified.

2.0 - SCOPE/REQUIREMENTS

2.0.1 The Contractor shall develop, integrate, test and execute projects to meet the SDAB's mission. The Contractor shall be responsible for total system operation, and to ensure the fidelity, integrity and quality of projects as tasked. Thus, it is not only important that the individual subsystems operate properly, but also, that when integrated, all elements continue to perform properly and efficiently. The Contractor shall prepare and maintain plans for coordinating this total system operation, and shall minimize the periods when the facilities are unavailable for use. When problems occur, the Contractor shall ensure that the proper corrective procedures are applied and that the response is appropriate to prevent excessive downtime.

2.0.2 The Contractor shall deliver flight simulation products and services for the various categories of simulation; (1) Real Time, Fast or Pseudo Real Time, (2) Analyses or Batch; Monte Carlo Analyses, (3) Part Task, Specific Conditions/Operations, and (4) Full Mission, End-to-End.

2.0.3 The Contractor shall provide the appropriate resources to prepare, design, develop, integrate, test and execute projects, and produce required deliverables necessary to provide the researcher with supporting documentation and data (and/or other deliverables, e.g., software and/or hardware) specified. These include resources supplied by LaRC consistent with the high-level planning conducted by LaRC Facility Managers.

2.0.4 The Contractor shall ensure the safety, quality, integrity, and maintenance of the computer systems, networks, simulators, facilities and Installation-Accountable Government Property (IAGP). In the event that a modification by the Contractor to the existing Flight Simulation and Research Aircraft Facilities impacts the safety of the test subject or workers, the Contractor shall provide the analyses required to satisfy LaRC's Human Occupancy Review Board's safety requirements.

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2.0.5 The Contractor shall prepare, operate, and maintain the simulators, integration laboratories, aircraft research systems, and any future simulators, integration laboratories, and aircraft research systems (see Flight Simulation Facilities).

2.0.6 The Contractor shall maintain the IAGP.

2.0.7 Work under this contract includes full life cycle flight simulation software and hardware services and flight simulation hardware infrastructure support for LaRC ground-based and flight research systems and facilities. The infrastructure support requirements include, but are not limited to, mainframe processors, computer generated image (CGI) out-the-window visual scene systems, head-down graphics computers, flight management computers, flight control computers, display devices, networks and interfaces, ground-based and flight simulation cockpits, and other required physical devices. Software service requirements include, but are not limited to, analysis, design, development, integration, testing, verification, validation, research operations, data recording and post-processing, and documentation. Hardware service requirements include, but are not limited to, engineering, operations, and maintenance of the simulation hardware and software infrastructure. Infrastructure engineering services include, but are not limited to, modification of existing infrastructure, design and implementation of new infrastructure, and support for simulation operations and maintenance activities. Infrastructure operations and maintenance services are required to support the research mission.

2.1 **-** Contract-Level Program Management

2.1.1 Management/Administration

2.1.1.1 The Contractor shall provide an overall management and administrative function to ensure the proper resources are available and allocated, adequate reports and documentation are prepared, and the overall environment supports the project requirements. The Contractor shall ensure management and administrative functions to meet the requirements listed below.

2.1.1.2 The Contractor shall provide an organizational structure with clear lines of authority and clearly identified Government interfaces.

2.1.1.3 The Contractor shall ensure the facilities are available for scheduled simulation and flight projects. All work areas shall facilitate multiple work shifts depending upon facility, simulation, flight, maintenance, and development schedules and/or availability of laboratory and facility equipment.

2.1.1.4 The Contractor shall manage the resources for specific projects in a manner to ensure projects are performed in accordance with published schedules.

2.1.1.5 The Contractor shall implement a discrepancy reporting and tracking system. The Contractor shall be responsible for accepting and administering self-generated and LaRC-generated discrepancy reports. The system shall assure all discrepancies are documented and resolved, and that the history of discrepancies is reviewed for indications of systematic or recurring problems.

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The system shall provide for the daily accumulation and dissemination of facility hardware/software status (including the status of any open discrepancy reports), with information accessible to NASA via on-line computer inquiry and published monthly in the State of the Facilities and On-going Projects report.

2.1.1.6 The Contractor shall provide a monthly report of the state of the facilities and on-going projects, identifying risks and critical issues. The report shall include, but not be limited to: status information in narrative form and schedule updates; staffing data; issues and problems that may impede performance; and recommended actions for both LaRC and the Contractor. The report shall contain productivity metrics such as the reliability metric of 95% set forth in 2.1.3.1.4. The report shall also include monthly man-hours for individual projects and their respective simulators and monthly purchasing activity data.

2.1.1.7 The Contractor shall maintain and update current plans and procedures to ensure the facilities consistently meet requirements. These include equipment operating procedures such as: 1) equipment start-up procedures (power-up) normal/abnormal; 2) equipment readiness procedures and diagnostics; 3) pre-flight procedures; 4) normal/abnormal procedures for equipment in full-up mode; 5) emergency procedures to ensure safety of personnel inside and outside the simulators; and 6) post-use procedures for full-up to stand-by status/data transfer. The Contractor shall also generate and maintain contingency and off-nominal operating plans/procedures to ensure the effects of anomalies are minimized, appropriate notifications are made, and corrective actions are initiated.

2.1.1.8 The Government will make available to the Contractor plans and procedures that currently exist which the Contractor may use in performance of the contract.

2.1.1.9 The Contractor shall document and obtain concurrence from the COR for all deviations, waivers and non-compliances to the requirements of PAs.

2.1.2 Property Management

2.1.2.1 To ensure accountability for installation-provided equipment and facilities, as provided and through any upgrades or repairs, the Contractor shall comply with the requirements listed below.

2.1.2.2 The Contractor shall prepare and maintain a Property Management Plan that, at a minimum; identifies the objectives of the plan and how they will be fulfilled, defines the property management tasks that will be performed, and identifies where Government-furnished logistics, forms and procedures will be used.

2.1.2.3 The Contractor shall develop and implement procedures for maintaining within-facility stock of materials/spares, and maintain current database inventory documentation.

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2.1.3 Safety, Reliability & Quality Assurance (SR&QA)

2.1.3.1 To ensure the facilities are operated in a safe and reliable manner, with adequate quality controls, the Contractor shall meet the SR&QA requirements listed below.

2.1.3.1.1 Environmental Safety

2.1.3.1.1.1 The Contractor shall identify and keep records for all hazardous materials, and obtain permits through the Standard Practice and Environmental Engineering Branch, and Office of Safety and Mission Assurance in accordance with the Environmental and Energy Program Manual (Langley Procedural Requirement (LPR) 8500.1) and in coordination with the COR. The Contractor shall comply with the applicable regulations included in LPR 8500.1.

2.1.3.1.2 System Safety

2.1.3.1.2.1 The Contractor shall provide copies of valid certifications from vendors providing DOD or FAA parts or services.

2.1.3.1.2.2 Should a project assignment require the protection of human research subjects, the Contractor shall comply with NASA Policy Directive (NPD) 7100.8E Protection of Human Research Subjects.

2.1.3.1.3 Occupational Safety

2.1.3.1.3.1 The Contractor shall comply with safety standards consistent with NASA Procedural Requirement (NPR) 8715.1 NASA Occupational Safety and Health Programs; NPR 8715.3 NASA General Safety Program Requirements, and Langley Policy Directive (LAPD) 1700.1 Safety Program; and LAPD 1700.2 Safety Assignments and Responsibilities, for all work.

2.1.3.1.3.2 The Contractor shall furnish safety equipment required by LAPD 1700.1 to protect personnel.

2.1.3.1.4 Reliability

2.1.3.1.4.1 The Contractor shall ensure facilities are available, reliable, and maintained such that facilities, including all development systems and support equipment, are operational and available to perform requirements at least 95% of the time.

2.1.4 Configuration Management

2.1.4.1 To ensure the facilities are operated in a regular, consistent and known manner, their performance levels are measured and recorded, and a historical record of activities are maintained, the Contractor shall comply with the requirements listed below.

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2.1.4.2 The Contractor shall establish, maintain and implement a configuration management plan in accordance with the Langley Management System, Standard Operation Procedure, and Configuration Management Online (CMOL).

2.1.4.3 The Contractor shall maintain the facilities' documentation libraries and ensure the libraries are current, accurate and complete, including but not limited to:

- All operating procedures and reference manuals.
- Records of measured system performance parameters.
- Documentation recording the performance of projects including project notebooks/work files and significant repairs/upgrades.
- Manufacturer's manuals, bulletins, parts lists, and vendor source lists.
- Facility configuration controlled and non-configuration controlled documents such as drawings, procedures, and checklists

2.1.5 Software Development Plan, Project Development Data, Software Process Tracking Information and Software Products.

2.1.5.1 The Contractor shall comply with the requirements of LPR 7150.2, LaRC Software Engineering Requirements, and Center procedures (annotated as Langley Management System-Center Procedure (LMS-CP)-XXXX) for the following software classes:

2.1.5.1.1 Class C: Mission Support Software or Aeronautic Vehicles, or Major Engineering/Research Facility Software - LMS-CP-7150.4

2.1.5.1.2 Class D: Basic Science/Engineering Design and Research and Technology Software - LMS-CP-7150.5

2.1.5.1.3 Class E: Small Light Weight Design Concept and Research Technology Software - LMS-CP-7150.6

2.1.5.1.4 For Classes C and D: If the software is safety-critical, the Contractor shall also apply NASA-STD-8719.13, NASA Software Safety Standard (in lieu of complying with LMS-CP-7150.3 which includes the requirements of NASA-STD-8719.13).

2.1.5.1.5 For class C: The Contractor shall also apply NASA-STD-8739.8 NASA Software Assurance Standard

2.1.5.1.6 LMS-CP-7150.4 Class C also requires that solicitations

2.1.5.1.6.1 Require the software supplier(s)/prospective offeror to notify NASA, in the response to the solicitation, contractual agreement, or grant, as to whether Commercial-Off-The-Shelf (COTS), Government-Off-The-Shelf (GOTS), Modified-Off-The-Shelf (MOTS), reused, or open-source software will be included in code developed for the project.

2.1.5.1.6.2 That all software requirements are to be flowed down to all levels of software supplier

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2.1.5.1.7 At a minimum, the Software Development Plan shall conform to:

2.1.5.1.7.1 LMS-CP-7150.5 Appendix A1 Software Management Plan for Class D and Class E software

2.1.5.1.7.2 LMS-CP-7150.4 Appendix A1 Software Management Plan for Class C software

2.1.5.2 The following practices from the SDAB Software Development process be required:

2.1.5.2.1 Delivered source code shall conform to the SDAB Programmer's Guide.

2.1.5.2.2 Software design shall be described using a standard notation such as unified modeling language (UML).

2.1.5.2.3 The Contractor shall develop and maintain software on government provided servers running IBM Rational ClearCase in accordance with the SDAB Software Configuration Management Plan.

2.1.5.2.4 The Contract shall include SDAB personnel in peer reviews of development plans, designs, code, test plans, and test procedures.

2.1.5.2.5 The Contract shall, for each task, hold jointly with NASA a Project Kick-Off Major Milestone Review and a Production Readiness Major Milestone Review.

2.1.5.3 The Contractor shall provide Project Development Data monthly, in electronic format, for each project. At a minimum, the data shall include:

- Project schedule
- Software progress tracking measures (e.g. schedule and cost metrics)
- Software functionality measures (e.g. number of requirements implemented)
- Software quality measures (e.g. defect density, status of problem reports)
- Software characteristics (e.g. software size)

2.1.5.4 The Contractor shall provide Project Development metrics:

2.1.5.4.1 LaRC Software Metrics Collection System data as defined in LMS-CP-7150.4 Appendix A15

2.1.5.4.2 Software inventory data as defined in NPR 7150.2B SWE-122

2.1.5.5 The Contractor shall deliver Software Process Tracking Information, in electronic format, including software development and management metrics. At a minimum, the Software Process Tracking Information shall include:

- Schedules
- Time charged to projects by software staff
- Purchase orders
- Configuration status accounting

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- Configuration audits
- Quality assurance audits
- Problem report status
- Status of project risks
- Status of corrective actions for project deviations from plan
- Status of change requests
- Peer review closure reports

2.1.5.6 Software Products include, but are not limited to the following:

- Requirements document(s)
- Requirements traceability matrix
- Architecture and design documents
- Source code, data, and makefiles
- Build and installation instructions
- Configuration record of the executable (if product is built within ClearCase) but not the executable itself
- Test plan and, if class C software, Test procedures
- Test results and, if Class C software, Test reports
- User's manual
- Compliance Matrix for the software class
- Interface documents
- Software Version Descriptions

2.2 - Core Requirements and Functional Capabilities

2.2.1 Aeronautical/Aerospace Engineering and Applications Programming

2.2.1.1 The Contractor shall provide the following core requirements and functional capabilities in order to meet the requirements of this PWS. The Contractor shall ensure that these core requirements and functional capabilities shall be capable of supporting at least 50 aeronautics and space exploration research projects simultaneously for various categories of simulation including real-time, batch or Monte Carlo, and full-mission simulation, while at the same time, operating real-time, high fidelity flight simulation production/operation for at least five research and development simulation studies and providing development and operation efforts for at least three aircraft flight research experiments simultaneously.

2.2.1.2 The Contractor shall perform aeronautical and aerospace engineering and applications software programming to complete the software analysis, design, development, modification, installation, checkout, verification, validation, integration, maintenance, and documentation of all real-time mathematical models (e.g., mathematical models of advanced and existing aircraft/spacecraft for real-time computation). The software products generated shall employ these essential, state-of-the-art elements:

- Design and development of methodologies and tools
- Software languages and development environments
- Relevant software processes to generate, operate, and maintain products that are highly reusable, scalable, portable, re-configurable, maintainable,

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and cost effective for different aerospace vehicles operating in their respective simulated environments

2.2.1.3 The Contractor shall perform aeronautical and aerospace engineering and applications programming including, but not limited to:

- Aircraft/spacecraft dynamic equations of motion
- Aeronautical/Aerospace vehicle databases
- Geodesy and gravitation models
- Atmospheric and turbulence models
- Landing gear/ground reactions and ground handling models
- Primary and secondary flight control systems
- Auto flight systems
- Avionics systems including error modeling and fault systems
- Propulsion systems
- Fuel Systems
- Hydraulic systems
- On-board auxiliary systems
- Air conditioning/pressurization systems
- Navigation systems programs
- Detection/communication systems
- Thermal control systems
- Power systems
- Maintenance and/or creation of new navigational data bases (e.g., terrain profiles, radio facilities)
- Translation of Simulink or other similar commercial off-the-shelf software diagrams into real-time software code

2.2.2 Systems Software/Device Drivers/Imbedded Software

2.2.2.1 The Contractor shall:

- Provide specialized systems software including real-time schedulers, debug packages, program development tools, input/output routines, special device handlers, networks, and hardware diagnostics.
- Provide data reduction software.
- Perform systems analysis and recommendations for redesign of systems software.
- Coordinate systems software development with hardware engineering.
- Train and consult with system users regarding new hardware/software.
- Provide requirements and specification studies.
- Maintain current system configuration control library, including subcontractor supplied software and equipment.
- Implement/maintain a system of programming standards, design, coding, and documentation methods.
- Provide systems administration support for host computers, graphics computers, and image generation computer systems.

2.2.3 Graphics Programming - The Contractor shall complete the design, development, modification, installation, checkout and documentation of all graphics and text display software, which may include, but are not limited to the creation and maintenance of real-time graphics software and the creation and maintenance of text and graphics displays for simulation and flight heads-down and heads-up

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display units, electronics flight bags, experimenter/researcher control display units, and any other research related display systems.

2.2.4 Real-Time Visual Displays/Visual Scene Models Programming for Image Generation Systems - The Contractor shall create and maintain real-time visual scene databases and visual scene models for image generation computer systems.

2.2.5 Research Solutions Based Systems Engineering - The Contractor shall provide system engineering services to ensure the continuing operation and evolutionary improvement of the flight simulation and research aircraft facilities. Such services may include, but are not limited to:

2.2.5.1 Definition and development of facility upgrades and capabilities, including development of new ground-based and in-flight simulators which may include providing structural modifications to existing systems and facilities, performing systems analyses and conceiving designs for simulator systems/subsystems, and providing the implementation planning, integration and testing for new simulation systems.

2.2.5.2 Design, fabricate, install, integrate, build, and test a new “FAA level D equivalent” research flight simulator capable of fixed and motion based operations.

2.2.5.3 Make or procure major real-time, high fidelity (Technology Readiness Level 5 to 7), and full mission flight simulator state-of-the-art electrical components and integrate them into existing flight simulators. Major components include but not limited to mainframe processors, computer generated image (CGI) out-the-window visual scene systems, head-down graphics computers, flight management computers, flight control computers, display devices, control display units, electronics flight bags, networks and interfaces, ground-based and flight simulation cockpits, other required physical devices, and avionics systems.

2.2.5.4 Design, development, and integration of advanced technology into simulation systems (i.e., advanced controls/displays). This may also include developing advanced engineering techniques to improve fidelity/validity of simulations.

2.2.5.5 Systems analyses and providing recommendations for redesign of software and hardware systems including networks.

2.2.5.6 Development and modification of advanced aircraft/spacecraft models for real-time computation.

2.2.5.7 Determination of methods to provide effective visual/motion cues to simulator pilots.

2.2.5.8 Operate and maintain classified simulators with appropriate level of control on both hardware and software systems. Provide or obtain personnel with Security Clearances to the Secret level.

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2.2.6 Research Solutions Based Hardware and Mechanical Systems Engineering (NOTE: Hardware and mechanical systems can be separate systems or several sub-systems interconnected as a larger system.) The Contractor shall:

2.2.6.1 Design, fabricate, modify, assemble, and integrate hardware and equipment for simulation and flight research projects and discrete projects. Specific projects may include fabrication of original equipment from design drawings or sketches and/or modification or changes to existing hardware and systems. Sample projects are flight deck instrument panels and consoles, floor panels, seats, visual display support structures, sheet metal assemblies, pilot control devices such as sticks, grips, surface controls, and power management mechanisms.

2.2.6.2 Design, develop, maintain, operate, and modify simulation mechanical, hydraulic, electrical/electronic, and servo systems.

2.2.6.3 Design, fabricate and/or modify electronic chassis, assemblies and subassemblies, and cables.

2.2.6.4 Design and perform structural analyses of the mechanical structures supporting major flight simulator electrical components.

2.2.6.5 Provide specialized simulation related services such as heating, ventilating, and air conditioning (HVAC), hydraulics system, electrical power systems, fire detection and prevention system, computer aid drafting, scaffolding, and rigger services.

2.2.6.6 Develop/maintain equipment operations and maintenance logs for usage/configuration and availability, including discrepancy reports.

2.2.6.7 Understand/manage diverse hardware/software environments.

2.2.6.8 Provide integration of new hardware/software systems.

2.2.7 Simulation-to-Flight Research Support - The Contractor shall analyze, design, develop, verify, validate, operate, maintain, modify, and integrate research hardware and software systems for a seamless, efficient, and cost effective transition of research experiments from a real-time, high fidelity (Technology Readiness Level 5 to 7), full mission ground flight simulator to a an aircraft in order to perform Simulation-to-Flight concept flight research. The verification and validation of flight hardware and software shall be conducted in an integration laboratory when required.

2.3 **-** Research Projects

2.3.1 Research projects cover a variety of topics including but not limited to the design of new aircraft/spacecraft, new guidance and control systems, the human factor implications of new/existing flight deck displays, control/data input devices, and airspace operations. The Contractor shall be capable of designing, developing, testing, and operating real-time, high fidelity flight simulations for at least 50 aeronautics and space exploration research projects simultaneously for various

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categories of simulation including real-time, batch or Monte Carlo, and full-mission simulation, while at the same time, operating real-time, high fidelity flight simulation production/operation for at least five research and development simulation studies and providing development and operation efforts for at least three aircraft flight research experiments simultaneously.

2.3.2 The COR will generate PAs for research projects support. The successful performance of research projects is one of the primary functions of the Simulation and Flight Facilities. The process cycle for a successful research project includes planning, preparation, operations and post-operation activities. The Contractor shall document and obtain concurrence of the COR for all deviations, waivers and non-compliances to the requirements of PAs. The Contractor shall use the functional capabilities defined in section 2.2, as necessary to achieve the goals of each research project. The specific requirements applicable to each phase of the process cycle are defined below.

2.3.3 Project Planning

2.3.3.1 Project planning focuses on the development of the technical and management approaches, technical objectives, risk allocation, and performance metrics that identify key actions/deliverables to be used to assess the success (or failure) of Contractor performance. In response to a PA, the Contractor shall:

2.3.3.2 Define, develop, operate and maintain a project resource control system for the resources that are allocated for the specific project, which tracks the project schedule, finances and configuration.

2.3.3.3 Generate a Project Management Plan (PMP) that outlines the Contractor's approach to the technical objectives throughout the preparation, operations and post-operations phases. The PMP shall require approval by the COR shall:

- Define the tasks necessary to perform the project, the associated required resources, the estimate to perform the PA, and the schedule.
- Address special matters pertaining to SR&QA, configuration management, maintenance, potential environmental impacts (complete Langley Form (LF) 461, Environmental Project Planning Form), facilities integrity, and IAGP.
- Address any known technical, resource, and schedule risks associated with the proposed approach.

2.3.4 Project Preparation

2.3.4.1 With the planning phase complete, preparation for the project is required. While the extent, complexity and duration of preparation activities vary from project to project, for a nominal project, hardware, systems software, applications programming, electrical, electronic and mechanical development shall be provided by the Contractor in order to prepare all facets of a project. This phase includes all activities from completion of project-specific planning to the beginning of the actual research phase of the project.

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2.3.4.2 The Contractor shall implement project preparation in accordance with the approved PMP. The Contractor shall:

2.3.4.2.1 Generate project operations plans and procedures, along with foreseeable contingencies, as described in the PMP.

2.3.4.2.2 Complete the design, development, fabrication, installation, integration and checkout of all mechanical, electrical and hardware systems necessary for the performance of the project.

2.3.4.2.3 Complete the development of specialized systems software necessary for the performance of the project.

2.3.4.2.4 Perform application programming, database modeling and graphics to complete the design, development, modification, installation, checkout and documentation necessary for the performance of the project.

2.3.4.2.5 Develop the data collection process to support the project, including, but not limited to, the definition of the parameters, data rate and volume, and data format.

2.3.5 Project Operations

2.3.5.1 The operations phase is the period of activities that occur from the start of the actual research experiment through its completion. This is the period where pilots evaluate the aircraft or scenario and data is collected and stored. The Contractor shall implement project operations in accordance with the approved PMP. As part of the project operations, the Contractor shall:

2.3.5.2 Operate the simulation in accordance with written plans/procedures, and shall provide the flexibility to modify research experiment parameters contingent upon interim research experiment results.

2.3.5.3 Ensure integrity of the facilities prior to each day's research experiment runs. The Contractor shall document the setup, operation, and performance of each project in a consistent format.

2.3.5.4 Conduct data collection, verification and any post-processing required for each project.

2.3.5.5 Record system discrepancies and ensure they are resolved in an appropriate manner. The Contractor shall also log changes in systems status for each research experiment run (e.g., electrical/electronic, mechanical, hardware/software, and spares).

2.3.6 Post-Project Operations

2.3.6.1 Subsequent to research experiment completion, the Contractor shall complete all documentation and deliverables.

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2.3.6.2 The Contractor shall implement post-project operations in accordance with the approved PMP. The Contractor shall provide required outputs in accordance with project requirements, which may include but are not limited to:

- Data distribution and analysis per the PMP.
- Project summary report including documentation of all modifications made to software/hardware to support the research experiment.
- Recommend what software/hardware data to retain for future use/reference and capture the configuration to ensure the project can be repeated at a future time.
- Record lessons learned and update the current project documentation, a copy of which shall be provided to the COR.

2.4 - Discrete Projects

2.4.1 The COR will generate PAs for discrete projects that fall outside the bounds of research projects, maintenance, and routine support functions. Such projects may include proof of concept, demonstrations, facility enhancements, or other facility projects. As with the research project activities of section 2.3, discrete projects shall follow the standard process cycle including planning, preparation, operation and post-operation activities, and shall meet the same requirements delineated in section 2.1. The Contractor shall use the functional capabilities defined in section 2.2, as necessary, to achieve the goals of each discrete project.

2.4.2 Discrete projects encompass analyses, design, acquisition, modification, installation, and checkout of Flight Simulation and Research Aircraft Facilities software and hardware, including, but not limited to, computer systems, real-time data I/O systems, simulators, simulator subsystems, and aircraft subsystems.

2.4.3 The Contractor shall analyze and recommend solutions in the areas identified in paragraph 2.4.2 above that may lead to acquisition of off-the-shelf solutions or in-house development and modifications. Follow-on activities shall include system level installation and checkout of these solutions.

2.4.4 The Contractor shall document and obtain concurrence of the COR for all deviations, waivers and non-compliance to the requirements of PAs.

2.4.5 Examples of solution based discrete projects under this PWS include but are not limited to:

- Design and development of the Langley Standard Real-Time Simulation (LaSRS) Methodology and the C++ Object-Oriented Software Implementation (LaSRS++) of this methodology.
- Software and hardware design, development and systems integration of advanced aircraft or spacecraft simulation systems.
- Software design and development of computer generated image airport visual data bases for research studies.
- Design, development and systems integration of research data acquisition systems for simulation and flight.
- Design, development and systems integration of major subsystems for RFD Simulator, IFD Simulator, GFD Simulator, DMS, DTS, TES, SIVL, and SIL.

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- Final outfitting and testing of RFD Simulator, IFD Simulator, GFD Simulator, DMS, DTS, TES, SIVL, and SIL.

2.5 **-** Hardware and Software Maintenance

2.5.1 The Contractor shall maintain the simulators, integration laboratories, and any future simulators and integration laboratories (see Flight Simulation Facilities).

2.5.2 The Contractor shall use the functional capabilities defined in section 2.2 to accomplish the hardware and software maintenance requirements.

2.6 **-** Preventive Maintenance

2.6.1 The Contractor shall provide all services necessary to maintain the Flight Simulation Facilities specified in paragraph 2.5.1 above.

2.6.2 Unless otherwise provided by the Government, the Contractor shall provide spare parts to support routine maintenance/anticipated failures, and tools required to maintain assigned equipment, unless such tools are listed in the IAGP.

2.6.3 The Contractor shall prepare preventive maintenance plans for assigned facilities, systems, and equipment to minimize system downtime.

2.6.4 The Contractor shall perform functions to ensure proper maintenance of facility systems, including but not limited to:

- Provide mechanical maintenance in accordance with operations manuals, manufacturer's service information and standard industry practices.
- Clean, lubricate, service, adjust, and tune equipment to support flight simulation and research aircraft schedules as required.
- Maintain analog and digital systems with associated peripherals, networks and interfaces.
- Maintain hardware, such as real-time control consoles, and real-time I/O systems.
- Maintain real-time graphics generation systems used to generate heads-down and heads-up cockpit displays.
- Maintain visual and graphics display systems, including, but not limited to, high-resolution cathode ray tube (CRT) and high-resolution liquid crystal displays.
- Maintain electric and hydraulic control loaders and hydraulic power units.
- Maintain communications and audio systems, such as aircraft sound systems.
- Develop/maintain equipment operations and maintenance logs for usage/configuration and availability, including discrepancy reports.

2.6.5 The Contractor shall perform the following functions to ensure proper maintenance of systems software for all assigned computer systems:

- Maintain, integrate, test and install software for each assigned computer system.
- Maintain documentation for these computer systems.
- Incorporate modifications to solve reported problems, and incorporate and document approved design changes.
- Test and report on all new/modified systems software (accept/reject).
- Archive software and associated documentation.

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- Perform system/subsystem testing, diagnostics, and reporting on new hardware.
- Provide programming and software capabilities assistance to systems users.

2.7 **-** Corrective Maintenance

2.7.1 The Contractor shall follow the standard process cycle for corrective maintenance. This includes planning, preparation, operation and post-operation activities and shall meet the same requirements delineated in section 2.1, although in an expedited fashion because corrective maintenance is likely to be time critical.

2.7.2 Examples of items that fall under this category may include but are not limited to: emergency purchase of replacement equipment, repair of malfunctioning heads-down display units, and replacement of boards for computer systems.

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FLIGHT SIMULATION FACILITIES

1. The Langley Flight Simulation Facilities are a portfolio of the NASA Agency Strategic Capabilities Assets Program (SCAP) and include the Cockpit Motion Facility, the Differential Maneuvering Simulator, the Test and Evaluation Simulator, the Development and Test Simulator, Uninhabited Aircraft Systems (UAS) Integration and Validation Laboratory (SIVL), the System Integration Laboratory (allows flight hardware to be tied into the simulators), centralized real-time computer systems, centralized image generator systems, centralized graphics display systems, and centralized data and communications networks.

2. The Cockpit Motion Facility (CMF), located in Building 1268D, is made up of one motion system site and four fixed-base sites. The motion system site contains a six-degree-of-freedom state-of-the-art synergistic motion base with 76-inch extension actuators. The four fixed-base sites provide homes for the simulator cockpits when they are not resident on the motion system. The cockpits are fully operational when located in the fixed-base sites and run totally independent of each other and the motion system site. When a research study requires use of the motion system, the appropriate cockpit is moved from its fixed-base site to the motion system by use of an overhead facility crane system and lifting rig. Each fixed-base site and the motion system site are equipped with quick disconnect features for power, air conditioning, hydraulics, video, audio, data communication and fire detection to allow for rapid changeover. The four cockpits are the Research Flight Deck Simulator, the Integration Flight Deck Simulator, the Generic Flight Deck Simulator, and a future, undefined simulator.

3. The Research Flight Deck (RFD) Simulator, located in the CMF in Building 1268D, is an advanced all-glass jet transport simulator. The simulator is currently driven by a Boeing 757-200 aircraft dynamics mathematical model which has been enhanced through data obtained in Langley's wind tunnels. The mathematical model can be changed to any vehicle for which data is available. The cockpit main instrument panel is completely glass with all instrumentation generated by computer graphics. All displays can be changed to meet researchers' requirements. There is a heads-up display mounted in front of each pilot, and there is a center aisle stand mounted between the two pilots. There are two control display units located in the center aisle stand mounted between the pilots. Each pilot has a two-axis side stick control loader system for pitch/roll control and a set of hydraulic control loaded rudder pedals. The pilot's side stick controller is mounted on the left side, and the copilot's side stick controller is mounted on the right side. The cockpit's visual system is a collimated panorama system, which provides 200 degrees horizontal field-of-view and 40 degrees vertical field-of-view. The visual system is driven by a state-of-the-art computer generated image system. A number of very high detailed terminal area and surrounding area visual data bases are available to the researcher. The RFD is considered equivalent to an FAA certified Level D simulator.

4. The Integration Flight Deck (IFD) Simulator, located in the CMF in Building 1268D, is a Boeing 737-800W research simulator cockpit. The simulator is driven by a Boeing 737-800W aircraft dynamics mathematical model. The mathematical model can be changed to any vehicle for which data is available. The cockpit includes standard ship's instruments representative of a line operations Boeing 737-800W aircraft. There is a heads-up display mounted in front of the pilot. There are two control display units located in a center aisle stand mounted between the two pilots. Each pilot has a hydraulic or electric column/wheel control loader system for pitch/roll control and a set of electric control loaded rudder pedals. The cockpit's visual system is a collimated panorama system, which provides 200 degrees horizontal field-of-view and 40 degrees vertical field-of-view. The visual system is driven by a state-of-the-art computer

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generated image system and has the same visual data bases available as does the RFD Simulator. The IFD is considered equivalent to the Federal Aviation Administration (FAA) certified Level D simulator.

5. The Generic Flight Deck (GFD) Simulator, located in the CMF in Building 1268D, is an advanced all-glass generic simulator which can be used to represent a wide range of vehicle types including conventional and advanced transports, such as the Boeing 757 Aircraft and the Blended Wing Body Aircraft, and spacecraft, such as the HL-20, the Orion Crew Exploration Vehicle, the Altair Lunar Lander, and a generic Planetary Lander. The simulator is driven by the appropriate vehicle dynamics mathematical model for the class of vehicle under study. The main instrument panel is completely glass supporting three large Liquid Crystal Display (LCD). There is a center aisle stand, which also contains two LCD units, mounted between the two pilots. The LCD units are equipped with touch panel overlays. The cockpit is designed such that different types of control inceptors can be utilized depending on the particular research being conducted, and are designed for rapid changeout. Presently, each pilot position can be configured to have one of three types of control loaded inceptors: (1) column/wheel/rudders, (2) side stick/rudders, and (3) pedestal mounted center stick/rudders. The cockpit's visual system is also flexible and can be configured in two different ways: (1) four collimated window systems (two forward and two side units), and (2) two direct view forward windows and two collimated side windows. The visual system is driven by a state-of-the-art computer generated image system and has the same visual data bases as do the RFD and IFD Simulators. International Space Station and lunar data bases are also available.

6. The Differential Maneuvering Simulator (DMS), located in Building 1268A, is a twin-dome air-combat simulator capable of providing a 360-degree field-of-view computer-generated visual environment and projection of up to two target aircraft for each dome. The cockpits provide an all-glass instrument environment, each with three heads-down displays, one heads-up display and several small backup instruments. Each cockpit includes a three-axis control loader system and an audio cue system for engine sounds, weapon systems, etc. This simulator is used to examine future aircraft designs, modifications to existing aircraft, aircraft handling qualities, control system design, display system design, etc. The DMS can be configured for fighter aircraft and UAS simulations, and space-related simulations including rendezvous and docking, lunar landings, and surface operations of a rover vehicle and/or humans on the Moon and Mars.

7. The Development and Test Simulator (DTS), located in B1268A, is an advanced all-glass jet transport simulator and was originally a research cockpit mounted inside the former NASA Langley Boeing 757-200 aircraft. With the decommissioning of the aircraft, the research cockpit was removed and reconstructed in the Flight Simulation Facilities and renamed the DTS. The simulator is currently driven by a Boeing 757-200 aircraft dynamics mathematical model which has been enhanced through data obtained in Langley's wind tunnels. The mathematical model can be changed to any vehicle for which data is available. In one configuration, the cockpit main instrument panel includes eight ARINC D size displays on which primary flight information, navigation/map information, engine information, and other specified system parameters are displayed. In a second configuration the cockpit main instrument panel is completely glass with all instrumentation generated by computer graphics. All displays can be changed to meet researchers' requirements. There are provisions for a heads-up display mounted in front of the pilot. There are two control display units located in the center aisle stand mounted between the two pilots. Each pilot has a two-axis electric side stick control loader system for pitch/roll control and a set of rudder pedals. The pilot's side stick controller is mounted on the left side, and the copilot's side stick controller is mounted on the right side. The cockpit's visual system is a non-collimated panorama system, which provides 210 degrees horizontal field-of-view and 45

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degrees vertical field-of-view. The visual system is driven by a state-of-the-art computer generated image system.

8. The Test and Evaluation Simulator (TES), located in B1268A, is a reconfigurable simulator and can be configured to represent any type of vehicle for piloted aircraft, UAS, or any planetary research. The visual system is a panorama system, which provides a 135 degrees horizontal field-of-view and a 67.5 degrees vertical field-of-view. The visual system is driven by a state-of-the-art computer generated image system. A high detailed International Space Station database and a lunar database of the Lunar South Pole and Shackleton Crater area are available to the researcher. The flight deck contains two large heads down display units, a three-axis rotational hand controller, and a three-axis translational hand controller. For UAS research, simulated airspace included the scenes Fort Pickett, Surry Nuclear Power Plant, and all other major airports in the U.S. were also available for aeronautics research.

9. UAS Systems Integration and Validation Laboratory (SIVL) provides a UAS-systems integration, validation, and diagnostics hardware-in-the-loop (HWITL) simulation capability for UAS to address airworthiness and certification requirements. The core of the capability would be a software representation of an uninhabited vehicle, including all of the relevant avionics and flight control system components. The software representation of specific system elements could be replaced with hardware representations where desired to provide Hardware-in-the-Loop (HWITL) test and evaluation capability. SIVL provides a robust and flexible simulation framework that permits the study of failure modes, effects, propagation paths, criticality, and mitigation strategies to help develop safety, reliability, and design data that can assist, for example, with the development of certification standards, means of compliance, and design best practices for civil UAS. Software representations of different types of UAS having a wide range of performance capabilities are included in the capability along with commonly-used hardware interfaces. Existing network interfaces enable the integration of SIVL with other large scale simulations.

10. The System Integration Laboratory (SIL) is a ground-based facility used in the development and validation of flight/simulation experiments prior to implementation in the research aircraft and/or simulators. The SIL configurations, to the extent practical, match that of the aircraft/spacecraft system to maximize efficiency of the simulation-to-flight process. The SIL includes flight control computers, flight management computers, experimental electronics systems, data link systems, etc. The SIL serves principally as a development facility and is located within the Cockpit Motion Facility (CMF). Research software that supports simulation-to-flight experiments is developed and tested at the various simulators in conjunction with the SIL before actual flight validation.

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