PERFORMANCE WORK STATEMENT
FLIGHT CRITICAL SYSTEMS RESEARCH

1.0 Background/Introduction

The mission of NASA Langley's Research Directorate (RD) is to conduct research and develop advanced technology to support the research and technology objectives of NASA's Aeronautics Research Mission, Human Exploration and Operations Mission, Space Technology Program, and Science Mission. This statement of work (SOW) defines the requirements for Flight Critical Systems Research to assist NASA in fulfilling this mission, and will evolve as the Agency's mission evolves. Flight Critical Systems Research addresses aviation systems technology gaps that are exposed by the operational challenges of the Next Generation Air Transportation System (NextGen), trans-atmospheric flight, and extra-terrestrial planetary flight. Such operations are characterized by increasing complexity and innerconnectivity; distributed control; system of systems, continuous vehicle health management; remote-piloting and autonomy (e.g., unmanned aircraft systems operations); blurring of system boundaries; escalating and ubiquitous automation and computing; and increasing verification, validation, and certification challenges.

2.0 Scope

The Contractor shall conduct basic and applied research, technology development, and systems analyses in airborne and ground-based systems critical to flight safety, management, and control. The work to be performed will be defined in performance based Task Orders issued by the Contracting Officer in accordance with Section H, H.6 TASK ORDERING PROCEDURE (NFS 1852.216-80) (October 1996). The Contractor shall be responsible for defining operational and system requirements, and for delivering engineering and research results that meet the specific technical requirements defined in the SOW of each Task Order. The Contractor shall furnish all personnel, facilities, equipment, material, supplies, and services to perform the work as outlined in each Task Order, with the exception of the items designated as Government furnished. The general Work Areas to be performed under the Task Orders are outlined below.

3.0 Crew Systems and Aviation Operations

This Work Area includes, but is not limited to: integrated flight deck systems; aircraft self-separation and distributed air traffic management; atmospheric hazard awareness and avoidance; situation awareness assessment; synthetic vision; human-machine interface; and human-centered design. These research areas investigate aviation safety and airspace capacity issues such as controlled flight into terrain (CFIT), loss of control in flight, runway incursions, high density air traffic operations, air and ground-based traffic management, all-weather operations, terrain-impacted navigation, detection and accommodation of wake turbulence and other atmospheric hazards to aviation, and operation of remotely piloted and autonomous aircraft.

3.1 Situation Awareness – Flight Crew

The Contractor shall investigate, develop, and evaluate technologies, methods and procedures to improve flight crew situation awareness for Next Generation Air Transportation System (NextGen) operations.

3.1.1 Real-time Information: The Contractor shall develop technologies and methods that provide real-time information electronically, to flight crews (airborne or ground-based) to improve their situation awareness. Types of real-time information include, but are not limited to: current position in four dimensional space; traffic locations and identity; terrain and obstacle locations; hazardous weather location and type; flight path or surface route information; air traffic control (ATC) instructions; and alerts of impending/potential hazardous situations.

3.1.2 Flight Deck Displays and Interface Concept: The Contractor shall investigate, develop, and evaluate display concepts and human machine interfaces that reduce uncertainties associated with real-time information presentation. A human centered design approach shall be employed.

3.1.3 Communication, Navigation, and Surveillance Infrastructure Technologies: The Contractor shall develop communication, navigation, and surveillance infrastructure technologies required to acquire, process, and disseminate situation awareness information.

3.1.4 Human-in-the-loop Experimentation: The Contractor shall design and conduct human-in-the-loop (HITL) experiments in simulation and in flight test environments, including data analysis and publication of results.

3.2 Situation Awareness – Air Traffic Control (ATC)

The Contractor shall investigate and develop technologies and methods to increase air traffic control situation awareness including, but not limited to, strategic and tactical collaborative decision making; seamless surveillance; controller-pilot data link communications (CPDLC); and alerting of flight crew path/route deviations.

3.3 Requirements for Human Subject Experimentation

The Contractor shall complete all documentation and meet all requirements to conduct experimentation with human subjects, in accordance with NASA Procedural Requirement 7100.1 “Protection of Human Research Subjects” (available at the NASA Online Directives Information System http://nodis.hq.nasa.gov/)and the NASA Langley Research Center Institutional Review Board (IRB). For flight testing, the Contractor shall perform all analyses and develop all documentation necessary to obtain safety authority approval as determined by the LaRC Airworthiness and Safety Review Board (ASRB). This includes experiments flown on NASA aircraft, or Contractor-owned and university-owned aircraft funded by NASA.

4.0 Safety-Critical Aviation Systems

The Contractor shall develop and demonstrate methods, techniques, and tools for the design, verification, validation, and certification of safety-critical systems. This Work Area includes, but is not limited to: mathematical proof of safety properties for software and hardware; formal safety analysis; formal verification; hardware and software verification; system and subsystem validation; system safety assurance; fault tolerance; fault modeling and emulation; architecture concepts to improve system robustness to disturbances; vehicle health management; commercial-off-the-shelf technology in safety-critical systems; complexity modeling and management; integrated modular avionics; requirements analysis for strategic and tactical

decision making among distributed computational and/or human elements; and airworthiness and system safety for unmanned aircraft, autonomous, and robotic systems.

4.1 Design Integrity
The Contractor shall develop and demonstrate methods, techniques, and tools for the design, verification, integration, validation, and certification of complex and highly integrated mission and life critical systems. This research area includes, but is not limited to: Formal Methods (theorem proving, model checking, and static analysis); safety assurance of complex systems; and design and assessment methods and techniques for the Validation & Verification of complex systems (compositional verification, static analysis methods, model-based development, and numerical analysis).

4.2 System Safety Assurance
The Contractor shall develop and demonstrate methods, techniques, and tools that provide a consistent and comprehensive approach to system safety for software-intensive systems, regardless of domain (airborne/ground-based/space-based, manned/unmanned). This research includes, but is not limited to: identification and assessment of safety-related requirements; software assurance and certification; safety-related arguments and evidence; airworthiness and systems safety; and the integration of formal, semi-formal, and informal evidence within coherent safety arguments.

4.3 Operational Integrity
The Contractor shall develop and demonstrate new analytical, architectural, and testing capabilities necessary to meet the high level of integrity required for safely deploying complex system of systems technologies. This research includes, but is not limited to: architectural principles for redundancy management and fault-tolerance; modeling of faults, failures, disturbances, and degradation; and integrated systems health management.

5.0 Flight Critical Systems Analysis and Assessment
This work area includes, but is not limited to, performance of systems analysis and assessment, and participation on working groups and standards-setting committees in support of airborne and ground-based systems that are critical to flight safety, management, and control.

5.1 The Contractor shall conduct systems analysis, conceptual design studies, trade studies, and technology assessments for flight critical aerospace systems. This work area includes, but is not limited to, requirements analysis, design and analysis of systems concepts, assessment of alternatives, cost-benefit studies, experimental system design, system verification and validation, life-cycle planning, assessment of technical alternatives, flight testing and simulation, and the defining of technology requirements. The Contractor shall perform all analyses and develop all documentation necessary to obtain safety authority approval as determined by the LaRC Airworthiness and ASRB. This includes experimental flight system(s) flown on NASA aircraft, or Contractor-owned and university-owned aircraft funded by NASA.

5.2 The contractor shall provide technical interchange in working groups and special committees for purposes of ensuring NASA research is relevant to emerging national and/or international standards. This work area includes, but is not limited to, participation and contribution to special committees, working groups, and technical forums; providing input on drafting of standards documents, including minimum operational performance standards and interoperability guidelines; and arranging for Government/industry/academia workshops.