NASA Academic Mission Services (NAMS)

For
Ames Research Center (ARC)

Statement of Work
August 22, 2013



National Aeronautics and Space Administration
Ames Research Center
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## Contents

## 1.0 Introduction

NASA Ames Research Center (ARC) is one of ten NASA centers in the country and one of only four centers with a primary focus on Research and Development (R&D). This includes fundamental scientific research, concept development, prototype testing and operations, and the creation of new technologies. The research supports both ARC's mission and NASA's overall mission and goals in Aeronautics, Science, Space Technology and Human Exploration and Operations.

ARC directorates manage various R&D science missions for NASA and collaborate with other NASA centers, academia, other Federal organizations, not for profit organizations and industry partners. Many of ARC's programs and projects span multiple technological and scientific disciplines. The success of NASA and ARC missions demand leading edge technical and research expertise from both student and faculty researchers.

## 2.0 Scope

The NASA Academic Mission Services (NAMS) Contract will provide ARC with capabilities to fulfill mission requirements from fundamental research and development through field-test deployments and operational science missions. This Contract will provide academic or university-based program and project support for science and engineering teams at the Center. The Contractor shall possess effective methods for attracting and retaining leading edge researchers and facilitating interactive participation and engagement of researchers and students with ARC employees.

NASA will address specific requirements at the task order level. The Contractor shall submit proposals for each task detailing how the work will be performed and explaining relevant additional academic resources available to enhance this work.

ARC anticipates requirements for R&D services as follows:

- Aerospace and Air Traffic Management – Aero Acoustics Engineering and Software, Air Traffic Management Automation, and Unmanned Aircraft Systems;

- Information Technology – Advanced Networking, Cloud Computing, Information and Data Systems, Cyber Security, Software Engineering and Synthesis;

- Programs and Projects – Space Flight, Program/Project Analysis, and R&D trade studies;

- Science – Space Bioscience, Space Sciences and Astrobiology, Earth Science including NASA's Earth Venture Program;

- Advanced Technological Systems – Human Systems Integration, Intelligent Systems, Supercomputing, and Entry Systems & Technology; and

- Aeroflight Dynamics – Rotorcraft Aeromechanics, Human Systems Integration, Experimental Aerodynamics,, and Flight Control and Cockpit Integration.

## 3.0 Contract Requirements

This Statement of Work (SOW) provides the over-arching description and scope of the services required by ARC. However, specific elements of program and project support will be detailed and authorized by task orders issued under the Contract.

The Contractor shall provide overall management for the accomplishment of the technical core and Indefinite Delivery Indefinite Quantity (IDIQ) elements. Most technical core elements have defined requirements, such as deliverables, significant milestone dates, budget restrictions and established performance measurement criteria. Anticipated tasks having a more basic research character will be managed using the IDIQ portion of the contract. While many core technical tasks are expected to remain stable over the life of the Contract, elements may be added, deleted or modified as agency, center, programs or projects evolve. IDIQ technical elements will be added, deleted or modified as agency, center, programs or projects evolve.

At times, quick response and rapid adaptation are necessary to accomplish emerging tasks. This may require reallocation of existing or acquisition of additional staff and new competencies. The Contractor shall be able to adjust staffing levels within reasonable time frames, as necessary to accommodate such changes, increases and/or decreases in actual workload. The Contractor shall possess, at the start of performance, significant research capabilities in ARC's technical competency areas and show realistic plans to acquire, develop, and retain high caliber research and management staff.

The contractor must demonstrate fiscal responsibility, sustainability, and workplace safety.

### 3.1 ARC Programs, Projects, and Missions

#### 3.1.1 Technical Organizations Supported

##### 3.1.1.1 Aeronautics Directorate

The technical core elements of this Contract shall include the following Aeronautics requirements.

**Aero-Acoustics Engineering and Software**

The Experimental Aero-Physics Branch, in the Wind Tunnel Division, performs research in experimental aero-acoustics through testing both at Ames and at external facilities.

Experimental projects are conducted in various facilities, including water channels and subsonic and supersonic wind tunnels located at the Fluid Mechanics Lab, Unitary Wind Tunnel, Arc-jet,

and Laser-Induced Fluorescence (LIF) facilities, as well as the National Full-Scale Aerodynamic Facility (NFAC).

**Air Traffic Management Automation**

ARC has performed research and development of Air Traffic Management (ATM) automation concepts for the United States National Airspace System (NAS) for over twenty years. From initial concept development (TRL-1) through in-situ field tests at operational ATM facilities (TRL-7), ARC researchers in the Aviation Systems Division of the Aeronautics Directorate are central contributors toward the comprehensive transformation of the NAS known as NextGen or Next Generation ATM. NextGen will allow safer, more reliable, more efficient aviation while reducing risk and negative impacts on the environment. The Aviation Systems Division at ARC performs this research under the NASA Airspace Systems Program (ASP) and center personnel collaborate closely with the Federal Aviation Administration (FAA), industry, and various universities.

**Unmanned Aircraft Systems in the NAS**

The Aviation Systems Division is currently performing research into integration of civilian Unmanned Aircraft Systems (UAS) into the National Airspace System (NAS). The UAS in the NAS project involves multiple NASA centers and is aimed at developing policy, procedures, and technologies to enable the ever increasing number of unmanned vehicles to interoperate safely with both private and commercial air traffic.

### 3.1.1.2 Information Technology Directorate

The vision of the Information Technology (IT) Directorate is aligned with that of the agency Office of the Chief Information Officer (OCIO): Be the best IT in the federal Government, contributing innovative IT solutions to ARC operations and NASA's missions. Strategically, the IT Directorate focuses on being the best innovation engine for NASA. Lastly, the business mission is to satisfy the customer's IT requirements by providing the most cost-effective, reliable, secure and innovative IT solutions.

The IT Directorate comprises of four divisions consisting of Product & Services Integration Development, IT Operations, External Projects, and IT Security.

### 3.1.1.3 Programs and Projects Directorate

The Programs & Projects Directorate provides ARC with an agile and entrepreneurial project management organization capable of successfully managing unique projects and satisfying customer requirements within stipulated constraints of quality, safety, schedule, budget and processes.

The Programs and Projects Directorate trains and maintains space flight project management expertise at ARC and is responsible for managing critical data on past, current and proposed space flight projects.

### 3.1.1.4 Engineering Directorate

The Engineering Directorate encompasses highly skilled and experienced engineering and technical capabilities that support the center's projects and agency's missions. Our experienced and agile staff provides innovative solutions and systems in multiple engineering areas.

The directorate provides multidisciplinary engineering design and analysis, hardware development and fabrication, and testing for ground-based, airborne, and space flight programs, projects and applications. The organization is capable of successfully executing unique projects within customer performance, schedule, budget and safety and mission assurance requirements.

### 3.1.1.5 Science Directorate

The Science Directorate at ARC conducts scientific research and technology development primarily under NASA's Science Mission Directorate and Human Exploration and Operations Mission Directorate. This Directorate has three Divisions: Space Biosciences, Space Science and Astrobiology, and Earth Science.

**Space Biosciences**

The Space Biosciences Division performs biological research, bioengineering and technology development necessary to enable NASA's long-term human exploration mission. Experiments lead to new technologies to improve astronaut health and health monitoring while making scientific discoveries and developing technologies that also benefit life on Earth. Research areas include molecular and cellular biology, gravitational biology, human physiology for space flight, radiation science, synthetic biology and biofuels.

In addition, ARC has the lead role for the agency in applying synthetic biology to space exploration and scientific discovery. The synthetic biology effort at ARC is designed to harness biology in reliable, robust, engineered systems to support NASA's exploration and science missions, to improve life on Earth, and to help define NASA's future efforts. The initiative is also intended to contribute foundational tools to the synthetic biology community. Synthetic biology in space represents a new challenge; designing organisms to perform reliable and necessary functions on which an astronaut may one day depend. The Division:

- Studies the effects of spaceflight on living systems in ground-based facilities and, in space, onboard the International Space Station (ISS) and on other platforms;
- Builds and operates specialized research facilities to support in microgravity, partial gravity and hyper-gravity investigations;
- Engineers life support technologies to sustain humans in space for long durations; and
- Develops advanced biotechnologies enabling NASA's exploration of distant destinations.

**Space Science and Astrobiology**

The Space Science and Astrobiology Division conducts research and mission-related activities relevant to the origins and evolution of stars, the interstellar medium, planetary systems, life on Earth and the potential for life elsewhere. These include some of the most fundamental questions posed by scientists and engineers concerning our place in the universe. The Division has assembled a multidisciplinary team of scientists including astronomers, astrophysicists, chemists, microbiologists, physicists, and planetary scientists.

Division personnel participate in a variety of major missions. The Kepler mission, locating hundreds of Earth-size planets around other star systems, is literally changing the text books. The Stratospheric Observatory for Infrared Astronomy (SOFIA), a partnership with the German space agency, DLR (German Aerospace Center), is the largest airborne astronomical telescope. It promises significant new findings in infrared astronomy. Division scientists have a long history of space exploration. Our scientists are currently involved with multiple spacecraft operating within the Solar System including the Cassini mission orbiting Saturn, the CRISM and HiRISE instruments on the Mars Reconnaissance Orbiter, the Mars Exploration Rovers (MER), and the Mars Curiosity rover that recently landed on Mars. Our Division scientists represent one of the largest user groups of the Spitzer Space Telescope. Division scientists are also involved in the development of the James Webb Space Telescope (JWST). The scientists participate on non-NASA missions such as the Japan Aerospace Exploration Agency (JAXA) Hayabusa mission and European Space Agency (ESA) missions such as Mars Express.

**Earth Science**

NASA pioneered the interdisciplinary field of Earth System Science—the study of the Earth as an integrated system. This approach to studying the Earth as a single complex system is essential to understanding the causes and consequences of climate change and other global environmental concerns. Space-borne instruments provide essential broad coverage, high spatial resolution, frequent sampling, and near-uniform accuracy and stability. Wide-ranging research and analysis (R&A) and Applied Sciences Programs advance science and understanding through analysis of NASA and non-NASA satellite measurements as well as data from airborne campaigns and ground-based instruments.

ARC's Earth Science Division conducts research in atmospheric science, focused on atmospheric composition and the feedbacks between composition and climate, and biospheric science, focused on terrestrial and aquatic ecosystems and their climate feedbacks. The Division has a long heritage of making observations from aircraft and is pursuing new observations using small, cost effective orbital platforms and instrumentation. It was selected in the first round of the NASA Earth Venture Suborbital program with ATTREX, the Airborne Tropical Tropopause Experiment, using the Global Hawk high altitude unmanned aircraft to investigate water vapor transport in a region of the upper atmosphere that has precious few observations. The Division also has a major Earth system modeling effort organized around a partnership with the NASA Advanced Supercomputing Division: NASA Earth Exchange (NEX).

NASA's Earth Science Division (ESD) seeks to answer the question: "How is the Earth changing and what are the consequences for life on Earth?" This mission is broken down into six science focus areas. These areas are:

- Carbon cycle and Ecosystems;

- Atmospheric Composition;
- Climate Variability and Change;
- Weather;
- Earth Surface and Interior (Geology); and
- Water and Energy cycle.

The Division at ARC conducts research in all these science focus areas with emphasis on Carbon cycle and Ecosystems and Atmospheric Composition.

To obtain the observations critical to validation of theoretical hypotheses, The Division conducts airborne science campaigns designed to study Earth's atmosphere, land surface and biosphere.

The Division is expanding into Earth observation from space. In particular, ARC is interested in exploring smaller, more cost effective platforms and instruments. NASA would like to have access to university science and instrumentation expertise with application for Earth observation in support of NASA science priorities and particularly to compete for Principle Investigator (PI) led Earth Venture orbital and Earth Venture instrumentation mission opportunities.

#### 3.1.1.6 Exploration Technology Directorate

**Human Systems Integration Division**

The Human Systems Integration Division advances human-centered design of aerospace systems through analysis, experimentation, and modeling. As a result, Division scientists help enable dramatic improvements in safety, efficiency, and mission success. The Human-Machine Interaction Group contributes to the development of measurably better NASA software through the careful application of human-computer interface methods. The Human Performance Group aims to maximize the health, productivity, and safety of crew members in space by modeling human performance and creating countermeasures to mitigate performance deficits. The Integration and Training Group develops and evaluates methodologies for the integration of human factors principles into aviation safety and training.

**Intelligent Systems Division**

The Intelligent Systems Division conducts research in selected sub-fields of computer science, develops software systems and technologies for aerospace applications, builds software- and systems-engineering applications, and deploys advanced IT in support of NASA missions, other Government agencies, and the United States (U.S.) aerospace industry. The Division has four technology areas:

- The Robust Software Engineering (RSE) technical area focuses on advances in theory, methodology, and implementation needed to meet the software requirements of NASA's space missions and of NextGen airspace operations. RSE draws on many techniques from computer science and applies them to the verification and validation of software and to model-based code generation. Technologies developed include automated software analysis, automated test-case generation, certifiable code generation, and risk/cost analysis tools;

- The Discovery and Systems Health (DaSH) technical area focuses on challenges in understanding engineering and science data. Engineering data understanding centers on Integrated Systems Health Management (ISHM), including cyber-physical systems and physics-based modeling. Scientific data understanding targets large-scale data analysis problems in data-rich domains such as Earth science and cosmology. Resident expertise includes machine learning, data and text mining, statistical pattern recognition, exploratory data analysis, physics, and quantum computing;

- The Autonomous Systems and Robotics (ASR) technical area has unique and long-standing expertise in building deployable autonomous systems for NASA missions. NASA's future exploration missions will require closer cooperation among humans and robots than ever before. ASR develops the component technologies required, integrates and tests systems, and delivers them for aeronautics, spaceflight missions, and terrestrial demonstrations; and

- The R&D goal in Collaborative and Assistant Systems (CAS) is to design, develop, and deliver IT and collaboration tools that enable a new generation of engineers, scientists, and mission experts to collaborate across distributed work settings. The research activities in this area focus on implementing information management, artificial intelligence, and computer-supported cooperative systems that augment human cognition, and generating and integrating the specialized work-systems of distributed teams in aerospace missions.

**NASA Advanced Supercomputing Division**

The NASA Advanced Supercomputing (NAS) Division has two primary roles within NASA: as the agency lead for advanced computing, including high-end computing (HEC) and as a key provider of experts in high-fidelity modeling and simulation (M&S), especially for aerospace research and applications. In Advanced Computing, NAS operates the agency's primary supercomputing facility, providing world-class HEC resources and services to meet the high-fidelity M&S needs of programs from all NASA Mission Directorates, the Office of the Chief Technologist (OCT), and NASA Engineering and Safety Center (NESC), including Earth and space science, space exploration, and aeronautics. This facility serves users across the country from all NASA centers, academia, and industry. NAS also provides comprehensive user services: application porting and performance optimization, large-scale data analysis and visualization, network support, and user environment customization. In High-Fidelity Modeling and Simulation, NAS employs leading researchers, tool developers, and practitioners in disciplines including computational fluid dynamics (CFD), aerothermodynamics, aeroelasticity, computational chemistry, engineering risk assessment, Earth sciences, heliophysics, and others. In addition, NAS expertise has been applied to research in solar physics, astrophysics, and other NASA mission areas.

**Entry Systems & Technology Division**

The Entry Systems & Technology Division supports NASA Mission Directorates in the research and development of advanced entry system designs and thermal protection systems for entry

probes, including both crewed and robotic missions. The Division's entry systems capability includes Aerothermodynamics, Entry System and Vehicle Development, Thermal Protection Materials, and Thermo-Physics Test Facilities. Aerothermodynamics provides integrated modeling, simulation, and testing capabilities for aerothermodynamics, hypersonic and high enthalpy fluid dynamics, shock layer radiation and aerodynamic configuration design. Entry System and Vehicle Development performs and coordinates system level integration for existing and future atmospheric entry vehicles. Such research principally furthers technologies and capabilities to analyze, design, develop, test, evaluate, manufacture, certify, and operate atmospheric entry vehicles and systems. Thermal Protection Materials focuses on advancing and improving existing materials. It includes methods and techniques for characterizing materials, as well as analyzing and designing models required to understand material behaviors and predict and guide thermal protection system development. Thermo-Physics Test Facilities operate hyper-velocity ground testing environments, each providing unique atmospheric high-speed flight conditions essential for technology development and flight system validation.

#### 3.1.1.7 Aeroflightdynamics Directorate

The Aeroflightdynamics Directorate (AFDD) is a division of the U.S. Army Civilian Service Corps co-located at ARC. AFDD advances knowledge and innovative technology in rotorcraft aeromechanics and human-system integration, providing a decisive advantage for Allied forces in aviation missions worldwide and enhancing U.S. rotorcraft competitiveness.

AFDD conducts basic and applied research in rotorcraft aeromechanics with the goal of providing aeromechanical expertise in support of analytical, computational and experimental research.

**Flight Control and Cockpit Integration Division**

The Division produces software for the design and testing of flight control systems, particularly rotorcraft systems. Examples of this software include:

- CIFER®, a system identification tool;
- CONDUIT®, a flight control system optimization tool;
- RIPTIDE, a pilot-in-the-loop flight simulator; and
- Data Management (TRENDS/FIDGET/SMACK).

Additionally, the Division is actively involved in obstacle-field navigation (OFN) research for Unmanned Aerial Vehicles (UAVs).

The Human Systems Lab within the Division performs research into the design and testing of human interface systems, particularly with respect to fixed wing and rotorcraft UAVs.

### 3.2 General Technical Requirements

The Contractor shall possess capabilities to support work in each core and IDIQ technical area. For IDIQ technical requirements, capabilities may be demonstrated by detailing appropriate

breadth and depth of scientific and engineering expertise and/or by clearly explaining an ability to reach out to external collaborators to address gaps in expertise

### 3.2.1 Academic Collaborations

The Contractor shall:

- Identify University research talent at all levels—undergraduate, graduate, early career, and faculty—to advance NASA's mission;
- Provide collaborative curriculum development and research to ensure that students and faculty are motivated by rich, mission-driven problems;
- Engage a broad base of expertise external to the Contractor organization leveraging partnerships and proactively seeking out collaborations in order to fill disciplinary gaps;
- Incorporate students and laboratories from a range of academic areas to support research areas of this Contract; and
- Support visiting professors/early career/students, leveraging their academic teaching and community service requirements, and the periodic influx of interns and visitors.

### 3.2.2 Knowledge dissemination

The Contractor shall provide support for outreach and education, and dissemination of research results in accordance with current NASA Data Handling, Data Rights, Export Control and ITAR policies and requirements, including:

- Preparation of publications, presentations, credentials, recognitions as required including presentation and participation in technical meetings and conferences;
- Transfer of technology to external Government agencies and commercial partners;
- Publish conference proceedings, refereed professional journals, NASA technical publications, and other materials, as appropriate;
- Support demonstrations and presentations of results and tools to visitors and technical delegates; and
- University collaboration in teaching, and development of teaching/tutorial material for research and development products and capabilities developed by NASA or NASA-university research funding.

### 3.2.3 Travel

The Contractor shall travel as required to support research, development, laboratory or in-field experiments, and dissemination/presentation of research results including potential long-term off-site assignments in the domain of exploration technologies.

## 3.3 Organization Specific Technical Requirements

Definition of contract tasks awaits identification and funding of specific projects and programs. Cross-disciplinary research cutting across topics is expected. Tasks in additional areas may arise

throughout the contract period of performance. Potential areas include, but are not limited to, those listed below:

**3.3.1** The following Aeronautics technical research requirements are presented in the context of the organizational objectives in Section 3.1.1.1.

The technical core elements of this Contract shall comprise of the Aeronautics requirements.

**3.3.1.1 Fundamental Research/Concept Development**

ATM Concept Development

The Contractor shall perform collaborative research to help identify, analyze and validate ATM automation concepts in research areas deemed critical by NASA and defined in its program plans. The areas of research interest are defined based upon joint Government, industry, and academia planning; they are intended to address pressing current and projected NAS performance issues. The nature of the work ranges from highly theoretical, using notional ATM data and environments to specifically applied, using real ATM data and actual environments. The latter may include studies in which the algorithms are implemented in real-time software and presented to operators in human-in-the-loop experiments. Deliverables include:

- validated algorithms, with supporting analyses of feasibility, effectiveness, cost and benefits for defined environments;
- preparation/submission/presentation of publications (conference papers, journal articles, and NASA technical memoranda); and
- all supporting materials enabling technology transfer, as appropriate, to the FAA, airlines, or other industry partners.

The Contractor shall provide research support in the following areas:

- Separation Assurance – automation and decision support tools to detect potential aircraft flight path intersections and to advise the safest, most efficient actions required to avoid loss of separation. Improves on existing operational conflict prediction and resolution tools in use by air traffic controllers;
- Super-Density Operations – automation and decision support tools to safely and efficiently schedule and control the ever-increasing levels of U.S. air traffic expected in the coming decades. Generates schedules and advisories based upon accurate models of aircraft trajectories, generated in real-time. Includes integration of ground-based controller tools with cockpit enhancements and emerging navigation technologies and procedures;
- Surface Operations – decision support tools to optimize usage of the many airport surface areas: gate areas, ramps, taxiways, and runways. Integrates with advanced surface radar and shares information across the many authorities that control airport surface movement;

- System and Portfolio Analysis – high-fidelity simulation and modeling tools that represent all aspects of the NAS for purposes of predicting the system-wide effects of changes in automation or procedures;
- Traffic Flow Management – automation tools to enhance the overall efficiency of use of the complex U.S. airspace environment, especially in the en-route altitudes. Addresses both the projected increase in traffic levels and the challenges of efficient operations in the presence of severe weather interruptions of normal operations; and
- Unmanned Aircraft Systems (UAS) - The Contractor shall support engineering, software development, integration, experimentation, and analysis of proposed concepts for UAS integration. The work will emphasize modeling of UAS aircraft performance in several existing ATM tools, simulating existing Separation Assurance/Sense-and-Avoid Interoperability (SSI) algorithms in NASA ATM tools, and implementing NASA SSI enhancements.

**3.3.1.2 Product Development**

ATM Software Development/Testing

The Contractor shall develop software for the existing and envisioned software systems related to the Aviation Systems Division's research and development endeavors. The existing software baselines cover a range of applications, including real-time, human-in-the-loop automation tools, real-time simulation tools, fast-time and NAS-wide modeling and simulation tools, and many analysis tool suites. In all there are several million lines of software source code across approximately six separate major programs. The Contractor will perform the majority of the design, implementation, and testing phases of the software lifecycle in response to requirements submitted by a variety of sources. The software development is conducted in accordance with NASA procedures. The NASA classification for the software ranges from C to E depending on the program and its intended environment. Most of the software is Class D, while software for use in operational environments may be classified Class C, depending on potential risk. The software development environment is mature, with integrated documentation, change tracking and version control systems already in place. Languages used for development include Java, C, C++, and Python.

**3.3.1.3 Experimental Support**

Simulation Development

The Contractor shall study and predict the broad effects of new ATM concepts, using sophisticated NAS-wide, gate-to-gate modeling and simulation systems. The purpose of the testing may include assuring an automation concept intended to increase the efficiency of certain operations will not have negative side effects on other domains within the NAS, or quantifying expected benefits of a concept over many varying conditions of traffic or weather.

The modeling and simulation software is complex, component based, and runs on suites of servers in non-real-time.

The Contractor will participate significantly in validation of a new modeling software system that NASA plans to develop externally during the period of performance. This system will have far more sophisticated models of existing NAS systems, and will be capable of plug-and-play integration with actual systems.

ATM Lab support

The Contractor shall support and maintain all facilities and hardware necessary for the management of associated complex IT system, data acquisition, concept development and analysis, software verification, human-in-the-loop experiments, and post-experiment analysis and documentation.

ATM Field Site Support

The Contractor shall staff and support the operation and enhancement of the North Texas Research Station (NTX), located at the Fort Worth Air Route Traffic Control Center (ARTCC) near Dallas-Fort Worth (DFW) airport. NASA has developed research partnerships with the air traffic control facilities, various airlines, and the DFW Airport Board to leverage NTX's proximity to these air transportation assets. In addition, NTX has nurtured a close partnership with the FAA Southwest Region, headquartered in Fort Worth, and has an ongoing collaboration with faculty and students at the University of Texas at Arlington. NTX personnel, including a permanent civil servant presence and Contract staff, support research led from ARC and complete their own research projects with a focus on high-TRL experiments that take advantage of NTX's unique capabilities.

Aero-physics Support

The Contractor shall support activities including the design, development, implementation, and utilization of research facilities, measurement systems, control systems, and monitoring systems for tests in the associated facilities. This effort will also include data acquisition, analysis, and reporting of experimental results.

The Contractor shall provide engineering support for aero-acoustics measurements in wind tunnels and at outdoor rocket testing facilities. Support activities include the design, development, installation, and operation of novel and unique acoustic measurement systems and affiliated hardware within the test facilities. The Contractor will at times serve as the acoustic measurement principal investigator. The Contractor shall provide operational hardware and software, data analyses, and reports.

The Contractor shall apply advanced embedded system technologies to explore and propose improvements to force and moment measuring systems, including wind tunnel balances. The

Contractor shall identify promising concepts based on state-of-the-art commercial technologies and demonstrate these for possible further development

**3.3.1.4 Analysis**

ATM Data Collection

The Contractor shall maintain and enhance the current ATM-related data collection activities of the ATM research area. A broad array of flight and weather data are collected continuously and placed into an Oracle-based data warehouse. A web-based interface provides a variety of access, query, and analysis tools specified by NASA and Contractor analysts and researchers. The data warehouse continues to grow at a rate of about 4 TB per year, and this rate may increase as more data sources are added to the system.

**3.3.1.5 Additional Knowledge Dissemination**

The Contractor shall update user manuals or related documentation, as necessary and/or as directed, adhering to NASA-developed change control requirements.

**3.3.2** The following Information Technology technical research requirements are presented in the context of the organizational objectives in Section 3.1.1.2.

**3.3.2.1 Fundamental Research, Experimental Support, and Product Development**

Definition of Contract tasks awaits identification and funding of specific projects and programs. Cross-disciplinary research cutting across topics is encouraged. Tasks in additional technical areas may arise throughout the Contract period of performance. Potential areas of emphasis include, but are not limited to:

- Advanced Networking;
- Cloud and Distributed Computing;
- Collaborative Information and Data Systems;
- Cyber Security, Information Assurance, Software Assurance, and Systems Security Engineering;
- Knowledge Discovery and Data Mining; and
- Software Engineering and Synthesis.

**3.3.2.2 Analysis**

As tasks are identified, the Contractor shall assist the Principal Investigator, or act as the Principal Investigator, in analysis, evaluation, and presentation of research results (see also Knowledge Dissemination, below).

**3.3.2.3 Additional Knowledge Dissemination Requirements**

The Contractor shall update user manuals or related documentation, as necessary and/or as directed, adhering to NASA-developed change control requirements.

**3.3.3** The following Programs and Projects technical research requirements are presented in the context of the organizational objectives in Section 3.1.1.3.

**3.3.3.1 Fundamental Research and Concept Development**

The Contractor shall provide technical support of the Directorate's advocacy of ARC projects and support agency interfaces with the ARC project and programs.

The Contractor shall provide technical support of the Directorate's advocacy of ARC project and program proposals and advanced concepts.

The Contractor shall perform systems studies on technical and scientific concepts, flights, and missions to determine feasibility, cost, and risk. The concepts can range from conventional spacecraft/instruments to state of the art, radical concepts.

**3.3.3.2 Product Development**

The Contractor shall create and maintain a project database at ARC that documents and puts into a usable format the history and key performance information of ARC projects as assigned. The format of the database shall be optimized for use in developing new proposals and as a resource for projects facing problems similar to those that have occurred in the past.

**3.3.3.3 Experimental Support**

The Contractor shall provide support and expertise in the management of major experimental space flight projects and programs at ARC in the areas of:

- Provide necessary data for the development, implementation, performance, and oversight of Earned Value Management systems, as required;
- Supplement, assist, and review projects bringing to bear space flight project technical disciplines expertise, as necessary; and
- Comprehensive technical support to project management, including schedules, earned value, budget control, and cost estimation.

**3.3.3.4 Analysis**

The Contractor shall maintain critical data on past, current, and proposed space flight projects for the continuous improvement of:

- ARC space flight projects and programs management capabilities; and
- ARC space flight projects and programs proposal submissions, with specific emphasis on Management sections, confidence in the accuracy of Cost and Schedule estimation (including prediction of appropriate reserves), and Risk Assessments.

**3.3.3.5 Additional Knowledge Dissemination Requirements**

The Contractor shall provide training and certification, as well as maintain associated documentation, within the Program and Projects Directorate in the areas of:

- Space flight project/program management;
- Space flight project/program schedule, cost estimation, budget management, and earned value; and
- Space flight project/program risk assessment, mitigation, and problem anticipation and solving.

**3.3.4** The following Engineering technical research requirements are presented in the context of the organizational objectives in Section 3.1.1.4.

**3.3.4.1 Fundamental Research and Concept Development**

The contractor shall conduct basic research into the science of imaging earth-like exosolar planets. The scope of this work will be, at a minimum, the successful assembly and performance verification of a working Phase-Induced Amplitude Apodization Coronagraph (PIAA-C).

The contractor shall support in the design, development and operation of a precision high contrast imaging testbed to demonstrate the capabilities of an end-to-end imaging system featuring a new PIAA-C in a stabilized atmosphere. The testbed system design activity will include aspects of the optomechanical design and layout, procurement of optics, mounts, masks, error budgeting, and performance modeling. The contractor shall design the testbed to include a state-of-the-art wavefront sensing and control system that includes micro-electronic mechanical structures, deformable mirrors, and a wavefront sensing and control system, including developing algorithms and electronics.

**3.3.5** The following Science technical research requirements are presented in the context of the organizational objectives in Section 3.1.1.5.

**3.3.5.1 Fundamental Research and Concept Development**

The Contractor shall:

- Provide scientific support to space biology missions including: experiment formulation, development, implementation, measurement and data collection, data analysis, archival and dissemination and subsequent presentation and publication of results and analysis. Research includes, but is not limited to, fundamental biological experiments in the microgravity environment. Experiments are conducted in Earth-based laboratories, airborne assets, and space platforms;
- Collaborate closely with ARC bioscientists and engineers;
- Provide access to strong fundamental research and technology expertise and to specialized facilities strengthening the competitiveness of the Science Directorate's proposals and its ability to successfully accomplish selected projects;

- Capably integrate multiple disciplines within teams supporting NASA research relevant to Earth-based, airborne and space flight missions and in the development of enabling technologies;
- Support NASA personnel in proposal submission; and
- Support Space Synthetic Biology (SSB) work including analytic, experimental, development, and prototyping activities focused on harnessing the capabilities of synthetic biology to provide tools for astronaut crews.

**3.3.5.2 Product development**

The Contractor shall support the NASA Airborne Science Program with sensor development and mission support including:

- Development, implementation, installation, and maintenance of *in situ* and remote sensing instrumentation on NASA operated and non-NASA aircraft for Earth observing;
- Development, operation, calibration, and maintenance of sensor suites, acquiring, archiving, and disseminating their data products. Current sensors include multi- and hyperspectral imagers invisible to thermal infrared (IR) spectral bands, high resolution digital cameras, navigation and atmospheric state sensors. The contractor should support fundamental advances in sensor technology from conception through design, fabrication, calibration, test and operation;
- Adaptation of sensing hardware to optimize acquisition of ground-based and/or airborne measurements. Sensor selection and customization criteria include precision as well as life-cycle cost;
- Calibration of all radiometric and spectral measurements to standard established by the National Institute of Standards and Technology (NIST);
- Support for the development of cross-cutting science infrastructure for NASA-operated and other aircraft. Airborne science platforms in use include uninhabited as well as inhabited aircraft. Work involves the design and implementation of hardware and software for the new Sensor Network Initiative in the Airborne Science Program;
- Development of integrated hardware and software systems to enable standardization for airborne science platforms. Systems may include those enabling experimenters across the airborne science fleet to interface data acquisition and dissemination systems and payload controls. Supporting installed commercial Inmarsat satellite communications systems is part of this work;
- Development, operation, enhancements and maintenance to software for current and future sensors. Software includes data retrieval and analysis programs;
- Support website creation, enhancement and maintenance enabling outreach by the Earth Science community; and
- Support for the implementation of a new web-based archive for navigation data from all Earth Science aircraft flying the new data acquisition and distribution systems.

**3.3.5.3 Facilities**

The Contractor shall maintain the existing Calibration Lab to NIST standards. Other facility requirements may arise as program priorities and budgets evolve.

**3.3.5.4 Additional Travel Requirements**

The Contractor shall travel, as necessary, to provide full and comprehensive support to the NASA Airborne Science Program's engineering test flights including sensor testing, validation of unique prototype systems and the collection of associated scientific data. Such support shall be provided for various NASA-operated platforms and others. Flights will be conducted in collaboration with larger NASA Airborne Science campaigns and may occasionally be located in diverse, remote locations. This mission support may involve extensive travel, including international locations, with extremely demanding mission work schedules. Flight activities may occur with very little advance notice and support efforts may be required 24 hours a day and/or seven days a week during certain periods. The Contractor shall be capable of providing appropriate staffing levels and logistical support to enable such activities when required.

**3.3.6** The following Exploration Technology technical research requirements are presented in the context of the organizational objectives in Section 3.1.1.6.

**3.3.6.1 Fundamental Research and Concept Development**

Definition of Contract tasks awaits identification and funding of specific projects and programs. Cross-disciplinary research cutting across topics is encouraged. Tasks in additional technical areas may arise throughout the Contract period of performance. Potential areas of emphasis include, but are not limited to:

- Human-centered design of aerospace systems;
- Optimizing the health, productivity, and safety of crew members in space by modeling human performance and creating countermeasures to mitigate performance deficits;
- Development and evaluation of methodologies for the integration of human factors principles into aviation safety and training;
- Advancing theory, methodology, and implementation that are needed to meet the software requirements of NASA's space missions and of next-generation airspace operations;
- Creating autonomous systems, including robotic assistants, capable of adapting their behavior to complex, rapidly changing, and incompletely understood environments;
- Exploration and exploitation of advanced computing architectures, collaborative computing environments (e.g., the NASA Earth Exchange), big data analytics and knowledge discovery, cloud computing, and quantum computing systems and applications;
- Enhancement of computer science techniques including program verification, automated reasoning, model checking, static analysis, symbolic evaluation, and machine learning;

- Design, development, and delivery of IT and collaboration tools that enable a new generation of engineers, scientists, and mission experts to collaborate across distributed work settings; and
- Developing world-class High End Computing resources and services to meet the high-fidelity modeling and simulation needs of programs from all NASA Mission Directorates.

**3.3.6.2 Product Development**

Product development activities within this research area may include, and the Contractor shall, as directed, support:

- Development of verification and validation software and model-based code-generation tools;
- Development of integrated systems health models, systems engineering methods, prognostic life estimation tools, approaches for uncertainty management, model-based diagnostics, failure recovery, decision support, machine learning, methods for learning from partial or incomplete models, stochastic nonlinear model identification, Bayesian and other statistical and model-based learning methods;
- Development of deployable autonomous systems and integration/test systems for NASA missions, including the component technologies required;
- Research and development of adaptive control technologies, agent architectures, embedded decision systems, evolvable systems, intelligent robotics, adjustable autonomy, distributed and multi-agent systems, goal-level commanding, and planning and scheduling; and
- Development of tools and methods for information management, artificial intelligence, and computer-supported cooperative systems that augment human cognition, and generating and integrating the specialized work-systems of distributed teams in aerospace missions.

**3.3.6.3 Experimental Support**

The Contractor shall provide support, as directed, for:

- Laboratories and simulators focusing on virtual environments, acoustic displays, human cognition, performance modeling, psychophysiology, and vision science;
- Laboratories and simulators associated with flight deck procedures, cockpit displays, air traffic management, air-ground systems, and team decision-making; and
- Computational laboratory environments serving users across the country from all NASA centers, academia, and industry in disciplines including computational fluid dynamics (CFD), aerothermodynamics, aeroelasticity, computational chemistry, engineering risk assessment, Earth sciences, heliophysics, and others.

**3.3.6.4 Analysis (data products analysis)**

The Contractor shall provide support, as directed, for:

- Application porting and performance optimization, large-scale data analysis and visualization, network support, and user environment customization;

- Analysis of research data from laboratories investigating virtual environments, acoustic displays, human cognition, performance modeling, psychophysiology, and vision science;
- Extraction of actionable insights from very large sets of engineering and science data including cyber-physical systems and physics-based models;
- Automated software analysis and test-case generation, certifiable code-generation, and the development of risk/cost analysis tools;
- Data analysis problems in data-rich domains, such as Earth science and cosmology; and
- Analysis and mining of large heterogeneous datasets residing in NASA's aeronautics and exploration technology programs. Resident expertise should include machine learning, data and text mining, statistical pattern recognition, exploratory data analysis, physics, and quantum computing.

**3.3.7** The following Aeroflightdynamics technical research requirements are presented in the context of the organizational objectives in Section 3.1.1.6.

**3.3.7.1 Fundamental Research, Concept Development, and Experimental Support**

The Contractor shall support experimental aerodynamics research in the Army 7- by 10-Foot Wind Tunnel at ARC and in other facilities. Work requires familiarity with and use of existing software models and experimental aircraft.

The Contractor shall participate in joint-industry manned and unmanned flight control research projects utilizing integrated tools developed within Code YH, Flight Control and Cockpit Integration Division.

The Contractor shall provide technical support for existing mechanical systems used by AFDD.

**3.3.7.2 Product Development**

The Contractor shall continue development of the integrated software system for the design and testing of flight control systems. This integrated system will address the specification, design, simulation, development, and flight test evaluation aspects of flight control system development.

**3.3.7.3 Analysis**

The Contractor shall assist the Principal Investigator, or act as the Principal Investigator, in the design, planning, conducting, and analyzing of experimental measurements related to rotorcraft (see also Knowledge Dissemination, below).

**3.3.7.4 Additional Knowledge Dissemination Requirements**

Additional Export Control and ITAR policies, as dictated by the U.S. Army, may apply.

The Contractor shall update user manuals or related documentation as necessary and /or as directed, for each advance in flight control tools.

The Contractor shall work with user community to support application of the integrated software system and the OFN software system.

### 3.4 Management and Operations

The SOW provides the framework and scope of the work to be performed by the NAMS. All projects and programs shall be authorized individually by task orders in accordance with the provisions of this Contract.

The Contractor shall, in accordance with the provisions of this Contract,

3.4.1 Establish and provide the intellectual leadership and management expertise necessary and appropriate to manage, operate, and staff the NASA Academic Mission Services (NAMS) organization co-located at ARC.

3.4.2 Establish and maintain scientific and technical partnerships with ARC, the NAMS management, and external entities.

3.4.3 In performing the Contract work, the Contractor shall implement appropriate management systems to:

3.4.3.1 Establish an efficient management structure that enables the fulfillment of NAMS research, outreach, and educational goals;

3.4.3.2 Develop integrated, multidisciplinary plans and schedules within and across tasks to achieve program objectives, incorporating input from ARC;

3.4.3.3 Provide management and administrative functions necessary to manage and to track the labor hours, materials, and associated costs to perform the technical core elements and IDIQ task orders under this Contract. This Contract will require the simultaneous performance tracking of technical and financial milestones of all individual elements in this Contract consistent with existing NASA requirements;

3.4.3.4 Maintain sufficient technical breadth and depth to manage task activities and projects throughout their lifecycle and manage the resources allocated by NASA for specific elements in a manner to ensure project and management goals are accomplished in accordance with agreed upon milestones;

3.4.3.5 Utilize appropriate technologies to reduce costs and improve performance;

3.4.3.6 Promote sustainability in all aspects of contract performance including overall technical objectives, management continuity, environmental considerations, health and safety, transparency of task and financial reporting, interoperability, and life-cycle costs;

3.4.3.7 Identify NAMS on-site, remote, and/or virtual facilities necessary to promote close collaboration and cost-effectively accomplish assigned tasks, management functions, and collaborative work conducted at remote field sites;

3.4.3.8 The Contractor shall conduct an integrated safety management program, in cooperation with NASA and ARC, including oversight for NAMS subcontractor operations. The Contractor co-located staff shall comply with all Federal, State and local environmental regulations and ARC environmental, safety, and health policies and procedures;

3.4.3.9 Provide oversight and management of all subcontractors required for completion of requirements;

3.4.3.10 Provide a management and administrative structure that provides a single point of contact for interface to the Contracting Officer (CO) and the Contracting Officer's Representative (COR). Provide transparent procedures and accountable management supervision to ensure compliance with applicable Government policies, regulations, and contractual requirements for all work performed under this Contract. As technical work areas change, the Contractor shall provide points of contact for each NASA element requester;

3.4.3.11 Provide overall management and oversight of all resources, facilitating the sharing of expertise across ARC projects and programs ensuring that the proper resources are available and correctly allocated within and across the elements. The Contractor shall identify conflicting and/or complementary needs among all elements, and propose innovative and efficient ways of leveraging resources to ensure that conflicts are resolved and that needs are met. The Contractor shall have an objective means for identifying and leveraging technical expertise in organizations other than its own in order to meet task order requirements;

3.4.3.12 Attend relevant training, provided by the Government, as required for all employees;

3.4.3.13 Ensure that the Government has insight into the technical, schedule, cost, and sustainability risks associated with the Contractor's ability to accomplish tasks. The Contractor shall identify all risks that could impact the budget or completion time period of the tasks and develop mitigation plans for all such identified risks as specified in the Contract Data Requirements List (CDRL) requirements;

3.4.3.14 The Contractor shall utilize facilities furnished by ARC as identified in each task order. The Contractor is responsible for ensuring that all Contractor and subcontractor staff comply with the operational policies and procedures for all ARC facilities;

3.4.3.15 Provide property management to ensure accountability for Government Furnished Property and Government Furnished Equipment and be responsible for annual inventory surveys and accountability verification forms;

3.4.3.16 Coordinate travel as required in the performance of Contract elements. All foreign travel by Contractors must conform to relevant Government policies and procedures;

3.4.3.17 Acquire resources (equipment, supplies) as needed, not otherwise provided by the Government, to support the successful completion of all work.

## 4.0 Phase-In and Phase-Out

4.1 Phase-In

The Contractor shall accomplish the phase-in process as expeditiously as possible, with a maximum phase-in time of 60 days.

During the Phase-In period, the Contractor shall assess the needs of the requirements such that, on the first day of the contract base period after phase-in, qualified Contractor personnel are performing the work at an acceptable level.

The Contractor shall meet weekly with the CO and COR to discuss phase-in plan implementation status.

4.2 Phase-Out

Upon completion of this contract, the outgoing Contractor shall provide for the orderly transfer of duties and records to the incoming Contractor.

The Contractor shall accomplish the phase-out process in an expeditious manner consistent with the incoming contractor's phase-in schedule, with minimal impact on ongoing task orders.

The Contractor shall submit a phase-out plan no later than 60 days before the end of the contract for Government review and approval.

## 5.0 Acronyms

| | |
|---|---|
| AFDD | Aero-Flight Dynamics Directorate |
| AO | Announcement of Opportunity |
| ARC | Ames Research Center |
| ARTCC | Air Route Traffic Control Center |
| ASP | NASA Airspace Systems Program |
| ASR | Autonomous Systems and Robotics |
| ATM | Air Traffic Management |
| ATTREX | Airborne Tropical Tropopause Experiment |

| | |
|---|---|
| CFD | Computational Fluid Dynamics |
| CRISM | Compact Reconnaissance Imaging Spectrometer for Mars |
| DaSH | Discovery and Systems Health |
| DFW | Dallas/Fort Worth Airport |
| DLR | German Aerospace Center |
| EAS | European Space Agency |
| EIP | Experimenter Interface Panel |
| ESD | Earth Science Division |
| FAA | Federal Aviation Administration |
| FAR | Federal Acquisition Regulations |
| GHOC | Global Hawk Operations Center |
| HEC | High-End Computing |
| HiRISE | High Resolution Imaging Science Experiment |
| ISHM | Integrated Systems Health Management |
| IT | Information Technology |
| IR | Infrared |
| ITAR | International Traffic in Arms Regulation |
| JAXA | Japan Aerospace Exploration Agency |
| JWST | James Webb Space Telescope |
| MER | Mars Exploration Rovers |
| NAS | United States National Airspace System |
| NASA | National Aeronautics and Space Administration |
| NASDAT | NASA Airborne Science Data and Telemetry system |
| NESC | NASA Engineering and Safety Center |

| | |
|---|---|
| NRA | NASA Research Announcement |
| NEX | NASA Earth Exchange |
| NFAC | National Full-Scale Aerodynamics Facility |
| NIST | National Institute of Standards and Technology |
| NPG | NASA Policy Guidelines |
| NPR | NASA Procedural Requirements |
| NTX | North Texas Research Station |
| OCIO | Office of the Chief Information Officer |
| OCT | Office of the Chief Technologist |
| OFN | Obstacle-Field Navigation |
| PIAA-C | Phase-Induced Amplitude Apodization Coronagraph |
| R&D | Research and Development |
| SSI | Separation Assurance/Sense-and-Avoid Interoperability |
| TB | Terabytes |
| TRL | Technology Readiness Level |
| UAS | Unmanned Aircraft Systems |
| UAV | Unmanned Aerial Vehicle |
| U.S. | United States |