NASA Academic Mission Services (NAMS)

For
Ames Research Center (ARC)

Statement of Work
January 15, 2015

National Aeronautics and Space Administration
Ames Research Center
P.O. Box 1000
Moffett Field, CA 94035

Contents

1.0 Introduction 3
2.0 Scope 3
3.0 Contract Requirements 4
3.1 ARC Programs, Projects, and Missions 5
3.1.1 Technical Organizations Supported 5
3.1.1.1 Aeronautics Directorate 5
3.1.1.2 Information Technology Directorate 6
3.1.1.3 Programs and Projects Directorate 6
3.1.1.4 Engineering Directorate 6
3.1.1.5 Science Directorate 6
3.1.1.6 Exploration Technology Directorate 9
3.1.1.7 Aeroflightdynamics Directorate 11
3.1.1.8 Office of the Director 11
3.2 General Technical Requirements 11
3.3 Organization Specific Technical Requirements 12
3.4 Management and Operations 23
4.0 Phase-In and Phase-Out 25
5.0 Acronyms 25

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 demands leading edge technical and research expertise from both student and faculty researchers. ARC is a leader within the agency in forming and nurturing innovative partnerships to further these missions and welcomes like-minded organizations.

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. The Contractor shall demonstrate capability in the formation and management of partnerships and in the pursuit of collaborations to meet Government specified requirements. Partnerships are here defined as the substantive engagement of organizations external to ARC and the Contractor contributing specifically to the accomplishment of task goals by: complementing existing internal expertise/resources, addressing identified gaps in existing internal expertise/resources, and/or extending the likelihood or impact of successful task outcomes. Collaboration is here defined as the active provision of relevant perspectives, approaches, expertise, facilities or other resources between ARC and the Contractor or any partner engaged through the Contractor's efforts.

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 Aerial Systems(UAS);

- 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

- Aeroflightdynamics – 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 (work identified within the SOW that encompasses the entire performance period of the contract and not established via task order) 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 the Core work is expected to remain stable over the life of the Contract, IDIQ technical elements may be added, deleted or modified as agency, center, programs or projects evolve. IDIQ elements will be determined at the task order level. The Core elements will be in the body of the Aeronautics directorate work, in the areas of Air Traffic Management Automation and UAS, and in the Aeroflightdynamics directorate work, in the areas of Aeromechanics, Human Systems and Flight Control. The Core work will be based upon the positions and estimated hours identified in the Pricing Template Workbook attached to the Request For Proposal (Attachment J.1.(b).4). Additional IDIQ tasks may also be developed for those areas. Core and IDIQ work may be grouped together by project for the purpose of reporting status and financial information.

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. Achieving optimal completion of requirements may involve the formation of partnerships and/or collaborative approaches. The Contractor shall document appropriate capabilities and experience in these dimensions.

The contractor must demonstrate fiscal responsibility, sustainability, the ability to engage academic environments (as appropriate), staff development, and workplace safety.

Unless otherwise designated at the project level, all background NASA software tools and functionality (other than open source software) is Government-sensitive software subject to the handling and non-disclosure requirements set forth in the contract.

3.1 ARC Programs, Projects, and Missions

3.1.1 Technical Organizations Supported

3.1.1.1 Aeronautics Directorate

NASA's Aeronautical research vision is designed to ensure that the United States will maintain its leadership in the sky and to sustain aviation so that it remains a key economic driver and cultural touchstone for the nation.

The vision embraces a future where global trends combine with emerging technologies to transform flight around the world into something unimagined today.

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 (Core)

The Aviation Systems Division 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 Operations and Safety Program (AOSP) and center personnel collaborate closely with the Federal Aviation Administration (FAA), industry, and various universities.

Unmanned Aircraft Systems in the NAS (Core)

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 is comprised 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 in 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 US Army Aviation & Missile Research, Development and Engineering Center, 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.
The three key Technical Areas (TA) covered under this Core support to AFDD are:

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

Human Systems
Human Systems TA conducts applied research into the design and testing of human interface systems, particularly with respect to fixed wing and rotorcraft Unmanned Aerial Vehicles (UAVs).

Flight Control
Flight Control TA conducts applied research into development of flight control and navigation algorithms and software for the design and testing of flight control systems, particularly rotorcraft systems. The research includes work in developing software for obstacle-field navigation (OFN) of UAVs. The developed software suite includes:

- CIFER®, a system identification tool;
- CONDUIT®, a flight control system optimization tool;
- RIPTIDE, a pilot-in-the-loop flight simulator
- libOFN, a software library for Obstacle Field Navigation
- libSLAD, a software library for Safe Landing Area Determination

3.1.1.8 Office of the Director

The Office of the Director provides ARC with strategic and operational management, facilitates coordination between Technical and Mission Support organizations, and is the home of cross-cutting functions.

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. The requirements listed in this section apply to all organizations utilizing the NAMS contract. The level of effort in each of these areas will be determined at the time the requirements are developed.

3.2.1 Academic Partnerships and Collaborations

The Contractor shall:

- Identify University research talent at all levels—undergraduate, graduate, early career, and faculty—to support NASA expertise in seeking research opportunities and thereby advance NASA's mission;
- Provide collaborative curriculum development and research to ensure that students and faculty are motivated by rich, mission-driven problems;
- Access and proactively engage a broad base of potential partners and collaborators to enable successful outcomes to meet Government-specified research goals and requirements;
- Encourage and support collaborative interactions in the implementation of task work;
- 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 funded research.

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, such as extended duty [e.g. 2 or 3 months] at remote test sites in support of Ames projects.

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 subparagraphs provide additional Aeronautics Directorate technical research requirements that support the organizational objectives set forth in Section 3.1.1.1.

Aeronautics requirements shall comprise part of the technical Core of this contract. Additional Aeronautics requirements may be determined at the task order level as IDIQ.

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. While 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 or in operational, or near-operational field settings. Deliverables include:

- validated tools/algorithms, with supporting analyses of feasibility, effectiveness, cost and benefits for defined environments;
- software developments/improvements;
- preparation/submission/presentation of publications (conference papers, journal articles, and NASA technical memoranda); and all supporting designs, plans, procedures, work processes, manuals, documentation, flowcharts, technical drawings, electronic databases and other materials which will facilitate technology transfer, as appropriate, to the FAA, airlines, or other industry partners.

The Contractor shall provide research support in the following, including, but not limited to:

- Airspace Technology Demonstrations - deliver a limited, yet impactful set of transition-able benefits for NextGen covering gate-to-gate elements. These elements may include delivery of arrival technologies for dense terminal environments employing ground and airborne systems, expansive integration of several tools for arrival, departure, and surface operations and integration of technologies for enhanced ground-based and airborne trajectory management covering domestic and oceanic en route operations.

- SMART-NAS (Shadow Mode Assessment using Realistic Technologies for the National Airspace System) Test-Bed for Safe, Trajectory-Based Operations - deliver an evaluation capability, critical to the Air Traffic Management community, allowing full NextGen and beyond NextGen concepts to be assessed and developed.
- Safe, Autonomous Systems Operations - development of concepts, requirements, and architectures to accept the broadest set of innovative concepts. This may include concepts and technologies to enable single-pilot operations, UAS (Unmanned Aircraft Systems) Traffic Management, and system architectures for maximum autonomous operations.
- 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 subparagraphs provide additional Information Technology technical research requirements that support the organizational objectives set forth 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.

Typical deliverables may include, but are not limited to: designs, plans, procedures, work processes, software developments/improvements produced, related documentation and other documents including flowcharts, technical drawings, and electronic databases.

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

3.3.3 The following subparagraphs provide additional Programs and Projects technical research requirements that support the organizational objectives set forth 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.

Typical deliverables may include, but are not limited to: designs, plans, procedures, work processes, software developments/improvements produced, related documentation and other documents including flowcharts, technical drawings, and electronic databases.

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 subparagraphs provide additional Engineering technical research requirements that support the organizational objectives set forth 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.

Typical deliverables may include, but are not limited to: designs, plans, procedures, work processes, software developments/improvements produced, related documentation and other documents including flowcharts, technical drawings, and electronic databases.

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

Science requirements shall comprise part of the technical Core of this contract. Additional Science requirements may be determined at the task order level as IDIQ.

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.

The Contractor shall deliver all hardware such as airborne remote sensing instruments and data acquisition and distribution units, and all designs, plans, prototypes, proposals, procedures, work processes, software developments/improvements produced, related manuals/documentation and other documents including flowcharts, experimental plans, reports, technical drawings, and electronic databases.

3.3.6 The following subparagraphs provide additional Exploration Technology technical research requirements that support the organizational objectives set forth 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.

Typical deliverables in support of the Exploration Technology Directorate may include, but are not limited to: all designs, plans, prototypes, procedures, processes, software developments/improvements produced, related documentation and other documents, including flowcharts, technical drawings, and electronic databases.

3.3.7 The following subparagraphs provide additional Aeroflightdynamics technical research requirements that support the organizational objectives set forth in Section 3.1.1.7.

Aeroflightdynamics requirements shall comprise part of the technical Core of this contract. Additional Aeroflightdynamics requirements may be determined at the task order level as IDIQ.

3.3.7.1 Fundamental Research, Concept Development, and Experimental Support

The Contractor shall perform collaborative research to help identify, analyze and validate concepts in rotorcraft research areas deemed critical by AFDD and defined in their program plans. While the areas of research interest are defined based upon joint Government, industry,

and academia planning; they are intended to address pressing current and projected Department of Defense (DoD) and civilian rotorcraft needs. The nature of the work ranges from development of new algorithms, software development, and support of flight, simulation, and wind tunnel testing. These may include studies in which the algorithms are implemented in off-line analysis, in real-time software and presented to operators in human-in-the-loop experiments. Deliverables shall include all:

- validated tools/algorithms, prototypes, with supporting analyses of feasibility, effectiveness, cost and benefits for defined environments;
- software developments/improvements in source and object code form;
- preparation/submission/presentation of publications (conference papers, journal articles, and Army technical memoranda); and
- supporting designs, plans, procedures, flowcharts, technical drawings, manuals/ documentation enabling technology transfer, as appropriate, to the DoD and/or other industry partners.

The Contractor shall provide research support in the following areas:

- Aeromechanics TA- Basic and applied research in rotorcraft aeromechanics with the goal of providing aeromechanical expertise in support of analytical, computational and experimental research.
- Human Systems TA- Applied research into the design and testing of human interface systems, particularly with respect to fixed wing and rotorcraft UAVs.
- Flight Control TA- Applied research into development of flight control and navigation algorithms and software for the design and testing of flight control systems, particularly rotorcraft systems. The research includes work in developing software for obstacle-field navigation (OFN) of UAVs.

3.3.7.2 Product Development

The Contractor shall develop software for the existing and envisioned software systems related to the AFDD's research and development endeavors. The existing software baselines cover a range of applications, including off-line data analysis, real-time, human-in-the-loop automation tools, real-time simulation tools, modeling and simulation tools, and many analysis tool suites. In all there are several million lines of software source code across the three TA 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 AFDD procedures. The software development environment is mature, with integrated documentation, change tracking and version control

systems already in place. Languages used for development include Fortran, MATLAB/Simulink, Java, C, and C++.

3.3.7.3 Additional Knowledge Dissemination Requirements

AFDD research computer systems are on a dedicated DoD network that is separate from the NASA network, and therefore DoD specific IT policies will have to be followed. 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 the flight control tools.

Additionally, for the Flight Control TA, the Department of Defense imposes special requirements for software distribution to external user community via the Software Transfer Agreement (STA) program. The Contractor (or in collaboration with a University) shall execute the STA program, which involves interacting with external software users and collecting software transfer fees in order to support the development, tailoring, and support of on-going and future flight control software tools. The Contractor shall work with the STA user community to support the application and improvements of the integrated software tools under this STA program.

3.4 Management and Operations

The SOW provides the framework and scope of the work to be performed by the NAMS Contractor. All projects and programs supported by the Contractor shall be authorized by the Government 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 between ARC and NAMS management; and with external entities as directed.

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, partnership, 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. At times, quick response is necessary to supply adequately detailed information on costs and accomplishments. This may require rapid adaptation to incoming requests by administrative staff. The Contractor shall be able to adjust to such requests and provide quick turnaround within reasonable time frames, as necessary;

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 aligning with technical expertise in organizations other than its own in order to meet Government-specified 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 all Contractor and subcontractor staff comply fully 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
DoD	Department of Defense
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
STA	Software Transfer Agreement
TA	Technical Area
TB	Terabytes
TRL	Technology Readiness Level
UAS	Unmanned Aircraft Systems
UAV	Unmanned Aerial Vehicle

U.S.	United States