



# Funding and Strategic Alignment Guidance for Infusing Small Business Innovation Research Technology Into Aeronautics Research Mission Directorate Projects for 2016

*Hung D. Nguyen and Gynelle C. Steele  
Glenn Research Center, Cleveland, Ohio*

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Glenn Research Center, Cleveland, Ohio*

National Aeronautics and  
Space Administration

Glenn Research Center  
Cleveland, Ohio 44135

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NASA STI Program  
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# **Funding and Strategic Alignment Guidance for Infusing Small Business Innovation Research Technology Into Aeronautics Research Mission Directorate Projects for 2016**

Hung D. Nguyen and Gynelle C. Steele  
National Aeronautics and Space Administration  
Glenn Research Center  
Cleveland, Ohio 44135

## **Abstract**

This report is intended to help NASA program and project managers incorporate Small Business Innovation Research (SBIR) technologies into NASA Aeronautics Research Mission Directorate (ARMD) projects. Other Government and commercial project managers interested in ARMD funding opportunities through NASA's SBIR program will find this report useful as well.

## **Introduction**

Incorporating Small Business Innovation Research (SBIR)-developed technology into NASA projects is important, especially given the Agency's limited resources for technology development. This overview of the SBIR program's targeted research areas can help small businesses and Aeronautics Research Mission Directorate (ARMD) project managers form partnerships to incorporate SBIR technologies into NASA programs and projects. For example, when ARMD program managers identify specific SBIR subtopics that are likely to generate technologies that could apply to their programs or projects, the SBIR office can provide information about previously developed technologies that could be incorporated into their work. Principal investigators (PIs) for small businesses can also benefit from understanding NASA program and project needs, increasing the likelihood that technologies developed by their small businesses will be integrated into ARMD projects. SBIR solicitations for the current fiscal year are posted at <http://sbir.gsfc.nasa.gov/solicitations>.

The SBIR program's original intent was for technologies that had completed Phase II to be ready for integration into NASA programs. Now the SBIR program supports its small business partners with three post-Phase II options that focus on creating opportunities for commercialization as well as technology integration. The Phase II Enhancement (Phase II-E), Phase II Expanded (Phase II-X), and Commercialization Readiness Program (CRP) options also provide opportunities for Phase II technologies to be integrated and tested in the NASA system platform or in the space environment. Details on Post-Phase II initiatives and opportunities, including funding options, may be found at <http://sbir.nasa.gov/content/post-phase-ii-initiatives>.

## Topics and Subtopics

### A1 Air Vehicle Technology

- A1.01 Structural Efficiency—Aeroelasticity and Aeroservoelastic Control
- A1.02 Quiet Performance—Propulsion Noise Reduction Technology
- A1.03 Low Emissions/Clean Power—Combustion Technology/Emissions Measurement Techniques
- A1.04 Aerodynamic Efficiency—Active Flow Control Actuation Concepts
- A1.05 Physics-Based Computational Tools—Stability and Control/High Lift Design Tools
- A1.06 Vertical Lift—VL Measurement Techniques and Condition-Based Maintenance
- A1.07 Propulsion Efficiency—Turbomachinery Technology for Reduced Fuel Burn
- A1.08 Aeronautics Ground Test and Measurements Technologies
- A1.09 Vehicle Safety—Inflight Icing Hazard Mitigation Technology

### A2 Integrated Flight Systems

- A2.01 Flight Test and Measurements Technologies
- A2.02 Unmanned Aircraft Systems Technology

### A3 Airspace Operations and Safety

- A3.01 Advanced Air Traffic Management Systems Concepts
- A3.02 Autonomy of the National Airspace System
- A3.03 Future Aviation Systems Safety

Figure 1.—Fiscal Year 2016 Small Business Innovation Research (SBIR) Aeronautics Research Mission Directorate (ARMD) topics and subtopics.

## Fiscal Year 2016 SBIR Subtopics and Subtopic Summaries

Figure 1 shows ARMD topics and subtopics for fiscal year 2016; SBIR descriptions for each ARMD subtopic follow here. Research topics and subtopics for all directorates are listed in Chapter 9 of the Phase I SBIR/STTR Program Solicitation for fiscal year 2016, available at <https://sbir.nasa.gov/solicit/56329/detail?data=ch9&s=56316>.

### A1.01 Structural Efficiency—Aeroelasticity and Aeroservoelastic Control

The technical discipline of aeroelasticity is a critical ingredient necessary in the design process of a flight vehicle for maintaining optimal performance while ensuring freedom from aeroelastic and aeroservoelastic instabilities. This discipline requires a thorough understanding of the complex interactions between a flexible structure and the steady and unsteady aerodynamic forces acting on the structure, with interactive control systems for flight vehicle performance and stability. This fundamental aeronautics work is focused on active/adaptive aerostructural control for lightweight flexible structures, specifically related to load distribution, flutter prediction and suppression, gust load prediction and alleviation, and aeroservoelasticity for ultra-efficient and supersonic commercial vehicles.

### A1.02 Quiet Performance—Propulsion Noise Reduction Technology

To reduce noise emissions from aircraft, tools and technologies are needed to design aircraft that are both efficient and low noise. Developments and improvements in noise reduction technology, noise prediction tools, and flow and noise diagnostic methods are necessary to mitigate the environmental impact of aircraft noise. The focus of this call is on aircraft propulsion noise, and innovations are solicited in three areas: (1) Noise Reduction, (2) Noise Prediction, and (3) Noise Diagnostics.



### **A1.03 Low Emissions/Clean Power—Combustion Technology/Emissions Measurement Techniques**

Achieving low emissions and finding new pathways to cleaner power are critical for the development of future air vehicles. Vehicles for subsonic and supersonic flight regimes will be required to operate on a variety of certified aircraft fuels and to emit extremely low amounts of gaseous and particulate emissions to satisfy increasingly stringent emissions regulations. Future vehicles will be more fuel efficient, which will result in smaller engine cores operating at higher pressures. Future combustors will also likely employ lean burn concepts, which are more susceptible to combustion instabilities. Fundamental combustion research coupled with associated physics-based model development of combustion processes will provide the foundation for technology development critical for these vehicles.

### **A1.04 Aerodynamic Efficiency—Active Flow Control Actuation Concepts**

Active flow control (AFC) technology has the potential to be a key contributor to achieving NASA's aeronautics goal of revolutionizing the energy efficiency and environmental compatibility of fixed-wing transport aircraft. AFC is the on-demand addition of energy into a boundary layer for maintaining, recovering, or improving vehicle performance. When integrated into a transport aircraft, AFC would result in smaller control surfaces, creating less drag and thereby less fuel consumption during flight. This solicitation is for robust, energy-efficient, reliable actuation systems with the control authority needed to control turbulent separation, thus improving circulation on simply hinged flaps systems and other aircraft control surfaces during the subsonic portion of the flight regime and/or to control shock-induced separation on vehicles in cruise during the transonic portion of the flight regime.

### **A1.05 Physics-Based Computational Tools—Stability and Control/High Lift Design Tools**

Developing higher-order, more accurate tools suitable for conceptual design is a difficult challenge. To perform the configuration trades and optimization typical in conceptual design, runtimes measured in seconds or minutes, instead of hours or days, are required. Additionally, because it is not possible to model every detail of the design and account for all the underlying physics in the problem formulation, it is difficult to predict the "as-built" characteristics with physics-based methods alone. Finally, the gap between the analysis capability and the maturity of the design being analyzed currently limits the usefulness of high-order analysis in conceptual design. Physics-based tools for conceptual design are needed that can rapidly and accurately predict the as-built characteristics of unconventional aircraft designs while remaining consistent with the amount of design knowledge that is available at the conceptual design stage.

### **A1.06 Vertical Lift—VL Measurement Techniques and Condition-Based Maintenance**

This subtopic is primarily interested in two areas: (1) health management of drive systems for vertical lift (VL) vehicles and (2) accurate measurements of lift systems and blade aerodynamics.

(1) Health management of drive systems for VL vehicles is critical to reliable operations and safety. Predictive Condition-Based Maintenance (CBM) improves safety, decreases maintenance costs, and increases system availability. A topic of interest in CBM includes analysis capabilities and models to simulate operating drive systems and components, including the modeling of realistic anomalies and faults that can help design and qualify CBM systems and test their utility in making maintenance decisions.

(2) Accurate measurements of lift systems and blade aerodynamics are key to developing and validating high-fidelity analyses and designing next-generation high-performance vertical lift systems. A topic of interest is instrumentation and measurement techniques for assessing blade boundary layer state (e.g., laminar flow, transition, and turbulent flow) of a rotating blade system in hover and forward flight conditions.

### **A1.07 Propulsion Efficiency—Turbomachinery Technology for Reduced Fuel Burn**

System and technology studies have indicated that advanced gas turbine propulsion will remain critical for future subsonic transports. Turbomachinery includes the rotating machinery in the high and low pressure spools, transition ducts, purge and bleed flows, casing, and hub. We are interested in traditional gas turbine turbomachinery and in innovative concepts such as exo-skeletal engines, intercooled gas turbines, cooled cooling air, and waste heat recovery. NASA is looking for improvement in aeropropulsive efficiency. Areas of interest include improved components of current architectures and cycles, novel components and cycles to improve cycle limits, and novel architectures to improve mission efficiency limits.

### **A1.08 Aeronautics Ground Test and Measurements Technologies**

NASA's ground-based test facilities play an integral role in the design, development, evaluation, and analysis of advanced aerospace technologies and vehicles. These test facilities include low speed, transonic, supersonic, and hypersonic wind tunnels; hypersonic propulsion integration test facilities; air-breathing engine test facilities; and simulation and loads laboratories. In addition to design databases, these facilities provide critical data and fundamental insight required to understand complex phenomena and support the advancement of computational tools for modeling and simulation. The primary objective of the Aeronautics Ground Test and Measurements Technologies subtopic is to develop innovative tools and technologies that can be applied in NASA's ground-based test facilities to enhance testing and measurement capability and improve utilization and efficiency.

### **A1.09 Vehicle Safety—Inflight Icing Hazard Mitigation Technology**

NASA is concerned with the prevention of encounters with hazardous in-flight conditions and the mitigation of their effects when they do occur. Under this subtopic, proposals are invited that explore new and dramatically improved icing mitigation technologies and research tools related to in-flight airframe and engine icing hazards for manned and unmanned vehicles. Technologies of interest should address the detection, measurement, and/or mitigation of the hazards of flight into supercooled liquid water clouds and flight into regions of high ice crystal density. Of particular interest are technologies that can address emerging icing issues of advanced aircraft configurations (N+2/N+3 aircraft, as well as vertical lift and unmanned systems).

## **A2.01 Flight Test and Measurements Technologies**

NASA continues to see flight research as a critical element in the maturation of technology. This includes developing test techniques that improve the control of in-flight test conditions, expanding measurement and analysis methodologies, and improving test data acquisition and management with sensors and systems that have fast response, low volume, minimal intrusion, and high accuracy and reliability. By using state-of-the-art flight test techniques along with novel measurement and data acquisition technologies, NASA and the aerospace industry will be able to conduct flight research more effectively and also meet the challenges presented by their respective cutting-edge research and development programs.

## **A2.02 Unmanned Aircraft Systems Technology**

Multiple technological barriers restrict greater use and application of Unmanned Aircraft Systems (UAS) in NASA research and in civil aviation. These barriers include, but are not limited to, a lack of methods, architectures, and tools that enable (1) verification, validation, and certification of complex and/or nondeterministic systems; (2) operation of multiple UAS with minimal human oversight; (3) multi-vehicle cooperation and interoperability; (4) high-level machine perception, cognition, and decision making; and (5) inexpensive, secure, and reliable communications. This solicitation is intended to break through these and other barriers with innovative and high-risk research.

## **A3.01 Advanced Air Traffic Management Systems Concepts**

This subtopic addresses user needs and performance capabilities, trajectory-based operations, and the optimal assignment of humans and automation to air transportation system functions, gate-to-gate concepts, and technologies to increase capacity and throughput of the National Airspace System (NAS). Related concepts and technologies will seek to achieve high efficiency in using aircraft, airports, and en-route and terminal airspace resources while accommodating an increasing variety of missions and vehicle types, including full integration of Unmanned Aerial Systems (UAS) operations.

## **A3.02 Autonomy of the National Airspace Systems**

This subtopic encourages the development of concepts or technologies focused on increasing the efficiency of the air transportation system within the midterm operational paradigm (2025 to 2035 timeframe) in areas that would culminate in autonomy products to improve mobility, scalability, efficiency, safety, and cost-competitiveness. Proposals in product-oriented research and development are sought in (but not limited to) the following areas: (1) autonomous and safe Unmanned Aerial Vehicle (UAV) operations for the last and first 50 ft under diverse weather conditions; (2) autonomous or increasing levels of autonomy for networked cockpit management, traffic flow management, airport management, or metroplex management; (3) autonomy-based (or self-management-based) architectures for the entirety, or parts, of airspace operations; and (4) autonomous systems.

### A3.03 Future Aviation Systems Safety

The Aeronautics Research Mission Directorate (ARMD) has concluded the successful Aviation Safety Program (AvSP). The Airspace Operations and Safety Program (AOSP) is succeeding AvSP’s significant achievements and stepping up to lead the ARMD research in the area of Real-Time System-Wide Safety Assurance (RSSA). ARMD sees its future safety-related research focused in a forward-looking, more comprehensive, and system-wide direction. ARMD’s RSSA will focus on the current and future National Airspace System (NAS), toward a gate-to-gate trajectory-based system capability that satisfies a full vision for the Next Generation Air Transportation System (NextGen) and beyond. The ultimate vision for RSSA would enable the delivery of a progression of capabilities that accelerate the detection, prognosis, and resolution of system-wide threats.

### Phase I Contract Awards

Figure 2 indicates the number of ARMD-associated Phase I contracts awarded in fiscal year 2016.

SBIR ARMD Topics and Subtopics <sup>a</sup>	2016 Awards
<b>A1 Air Vehicle Technology</b>	
A1.01 Structural Efficiency	5
A1.02 Quiet Performance	4
A1.03 Low Emissions/Clean Power	3
A1.04 Aerodynamic Efficiency	4
A1.05 Physics-Based Computational Tools	3
A1.06 Vertical Lift	3
A1.07 Propulsion Efficiency	4
A1.08 Aeronautics Ground Test and Measurements Technologies	4
A1.09 Vehicle Safety	4
<b>A2 Integrated Flight Systems</b>	
A2.01 Flight Test and Measurements Technologies	9
A2.02 Unmanned Aircraft Systems Technology	9
<b>A3 Airspace Operations and Safety</b>	
A3.01 Advanced Air Traffic Management Systems Concepts	5
A3.02 Autonomy of the National Airspace System	8
A3.03 Future Aviation Systems Safety	6

<sup>a</sup>See Appendix A for contract titles.

Figure 2.—Fiscal year 2016 Phase I contract awards associated with the Aeronautics Research Mission Directorate (ARMD).

## ARMD Program and Project Summaries

ARMD topics and subtopics strategically align with ARMD programs and projects and support the Directorate’s current needs and objectives. Figure 3 illustrates how SBIR subtopics are mapped to ARMD programs and projects for fiscal year 2016. This is followed by descriptions of each ARMD program and project (arranged alphabetically). Understanding how ARMD topics and subtopics are being addressed in ARMD programs and projects will be useful for small business principal investigators (PIs) and ARMD project managers.



Figure 3.—Fiscal year 2016 Small Business Innovation Research (SBIR) Aeronautics Research Mission Directorate (ARMD) subtopics mapped to ARMD programs and projects.



Figure 3.—Concluded.

### Advanced Air Transport Technology Project

The Advanced Air Transport Technology (AATT) Project explores and develops technologies for advanced fixed-wing transport aircraft with revolutionary energy efficiency. These technologies are critical to reduce the environmental impact of aviation as the industry continues to grow. AATT studies focus on the future, targeting vehicles that are three generations beyond the current state of the art that require mature technology solutions in the 2035 to 2045 timeframe.

### Advanced Air Vehicle Program

More environmentally friendly next-generation fixed-wing and vertical lift aircraft will be needed as growth accelerates in both domestic and international air transportation. NASA’s Advanced Air Vehicle Program (AAVP) studies, evaluates, and develops technologies and capabilities that can be integrated into these aircraft systems and explores far-future concepts that hold promise for revolutionary improvements to air travel.

## **Advanced Composites Project**

The Advanced Composites (AC) Project focuses on the development and use of high-fidelity and rigorous computational methods, improved test protocols, standardized inspection techniques, and manufacturing process simulation to shorten the timeline to bring innovative composite materials and structures to market. The AC Project engages key players from Government, industry, and academia to mature and verify methodology; ensure effective transition to industry; and assure safety through certification authorities such as the Federal Aviation Administration.

## **Aeronautics Evaluation and Test Capabilities Project**

The Aeronautics Evaluation and Test Capabilities (AETC) Project sets the strategic direction for NASA's versatile and comprehensive portfolio of ground test aeronautics research capabilities. Its integrated approach to asset planning, use, and management considers the complementary high-end computing capabilities necessary for advanced analyses in conjunction with the ground experimentation capabilities.

## **Airspace Operations and Safety Program**

The Airspace Operations and Safety Program (AOSP) creates technologies to help the Next Generation Air Transportation System (NextGen) fulfill its promise by working with the Federal Aviation Administration, industry, and academic partners to develop NextGen technologies to improve the intrinsic safety of current and future aircraft.

## **Airspace Technology Demonstrations Project**

The Airspace Technology Demonstrations (ATD) Project comprises a collection of critical technology development and demonstration activities geared toward delivery of near-term benefits to air transportation system stakeholders. Activities under this effort include (1) Terminal Sequencing and Spacing—Flight Deck Interval Management, (2) Integrated Arrival/Departure/Surface, (3) Applied Traffic Flow Management, and (4) Technologies for Airplane State Awareness (Energy and Attitude).

## **Commercial Supersonic Technology Project**

The Commercial Supersonic Technology (CST) Project addresses the development of tools, technologies, and methods to address challenges facing practical commercial supersonic flight, including fuel efficiency, airport community noise, high-altitude emissions, structural weight and flexibility, and airspace operations, with a primary focus on sonic boom reduction methods and approaches.

## **Convergent Aeronautics Solutions Project**

The Convergent Aeronautics Solutions (CAS) Project merges traditional aeronautics disciplines with advancements driven by the nonaeronautics world to improve capabilities in commercial aviation. CAS teams conduct initial feasibility studies, perform experiments, try out new ideas, identify failures, and then review whether developed solutions have met their goals and whether they are feasible options in the real world.

## **Environmentally Responsible Aviation Project**

The Environmentally Responsible Aviation (ERA) Project explores and documents the feasibility, benefits, and technical risk of vehicle concepts and enabling technologies to reduce aviation's impact on the environment. The ERA Project assesses new vehicle concepts and enabling technologies through system-level experimentation to simultaneously reduce fuel burn, noise, and emissions.

## **Flight Demonstrations and Capabilities Project**

The Flight Demonstrations and Capabilities (FDC) Project conducts complex and integrated small-scale flight research demonstrations in support of ARMD programs. In addition, FDC operates, sustains, and enhances those specific flight research and test capabilities necessary to address and achieve the ARMD Strategic Plan, ARMD program and project activities, other NASA mission directorate activities, and national strategic needs.

## **Integrated Aviation System Program**

The Integrated Aviation System Program (IASP) conducts flight-oriented, integrated, system-level research and technology development that supports the flight research needs across the ARMD strategies, programs, and projects. The IASP focuses on highly complex flight tests and related experiments.

## **Revolutionary Vertical Lift Technology Project**

Revolutionary Vertical Lift Technology (RVLT) improves unique vertical capabilities by reducing noise and improving safety and fuel efficiency. RVLT research develops tools, technologies, and concepts that overcome performance barriers. These new technologies increase speed, range, and payload and decrease noise, vibration, fuel burn, and emissions by using improved computer-based prediction methods.

## **Safe Autonomous Systems Operations Project**

To address the needs of future air transportation and airspace operations, the Safe Autonomous Systems Operations (SASO) Project identifies and develops the maximum possible autonomous capabilities. Once the Next Generation Air Transportation System (NextGen) is implemented, airborne autonomy will likely expand. Operational complexity will increase to enable and sustain significant growth in passengers and cargo. The SASO Project's goal is to seek ways to safely integrate the highest justifiable level of automation within the National Airspace System, but not to explore automation simply for automation's sake.

## **Shadow Mode Assessment Using Realistic Technologies for the National Airspace System**

The Shadow Mode Assessment using Realistic Technologies for the National Airspace System (SMART-NAS) Project develops an air traffic management simulation capability to integrate alternative concepts, technologies, and architectures into the NAS. Simulations will take actual operational input from the NAS by employing advanced prognostics, data mining, and data analytics for enhanced decisionmaking and system assessments.



## **Subsonic Fixed Wing Project**

The Subsonic Fixed Wing Project addresses the comprehensive challenge of enabling energy-efficiency improvements in subsonic transport aircraft combined with dramatic reductions in harmful emissions and perceived noise to allow sustained growth of the air transportation system. Multidisciplinary advances are required in aerodynamic efficiency to reduce drag, structural efficiency to reduce aircraft empty weight, and propulsive and thermal efficiency to reduce thrust-specific energy consumption (TSEC) for overall system benefit.

## **Transformative Aeronautics Concepts Program**

The Transformative Aeronautics Concepts Program (TACP) cultivates multidisciplinary, innovative concepts to transform aviation. Although its emphasis is on sharply focused research, the TACP provides flexibility for innovators to explore technology feasibility and provides the knowledge base for radical transformation. The program solicits and encourages revolutionary concepts, creates an environment for researchers to experiment with new ideas, performs ground and small-scale flight tests, allows failures and learns from them, and drives rapid turnover into potential future concepts.

## **Transformational Tools and Technologies Project**

The Transformational Tools and Technologies (TTT) Project develops new computer-based tools, models, and associated scientific knowledge that will provide first-of-a-kind capabilities to analyze, understand, and predict performance for a wide variety of aviation concepts. Examples of research areas include predicting flow around vehicles and improving the understanding of strong and lightweight materials for aviation.

## **Unmanned Aircraft Systems Integration in the National Airspace System Project**

The Unmanned Aircraft Systems (UAS) Integration in the National Airspace System (NAS) Project provides research findings to reduce technical barriers associated with integrating UAS into the NAS. Project research addresses technical challenges in the following areas: sense-and-avoid concepts and technologies that can operate within the NAS, robust communication technologies, robust human systems integration, and standardized safety and certification guidelines.

## **Unmanned Aircraft System Traffic Management Program**

There is currently no established infrastructure to enable and safely manage the widespread use of low-altitude airspace and Unmanned Aircraft Systems (UAS) operations. Building on its legacy of work in air traffic management for crewed aircraft, NASA is researching prototype technologies for a UAS Traffic Management (UTM) system that could develop airspace integration requirements for enabling safe, efficient low-altitude operations.



## Appendix A.—Fiscal Year 2016 Phase I Contract Titles

Abstracts of these Phase I contracts below are posted at <http://sbir.gsfc.nasa.gov/SBIR/abstracts/16-1.html>

A1.01-7107	Distributed Sensing, Computing, and Actuation Architecture for Aeroservoelastic Control
A1.01-7111	Reduced Order Nonlinear Dynamic Aeroservoelasticity
A1.01-7636	Reduced Order Modeling for Aeroservoelastic Control and Analysis (RACA)
A1.01-8122	Dynamic Flight Simulation Utilizing High Fidelity CFD-Based Nonlinear Reduced Order Model
A1.01-8553	Physics-based Models for Aeroservoelasticity Prediction and Control
A1.02-7568	Low Profile, Low Frequency, Adaptively-Tuned Acoustic Liner
A1.02-7604	Advanced Analytical Tools for the Characterization of Fundamental Jet Noise Sources and Structures
A1.02-8281	Validation of Standing Wave Liner Impedance Measurement Method
A1.02-8366	Continuous-Scan Phased Array Measurement Methods for Turbofan Engine Acoustic Testing
A1.03-7624	Fluidic Fuel Flow Modulation for Active Combustion Control
A1.03-8199	Spatially and Temporally Resolved Diagnostics of Dense Sprays Using Gated, Femtosecond, Digital Holography
A1.03-8523	Electrometric Aviation Soot Monitor
A1.04-7639	Flow Control on a High Lift Airfoil Using High-Bandwidth Microactuators
A1.04-7670	Colliding-Jet Fluidic Actuators for Active Flow Control
A1.04-8270	Cyclotronic Plasma Actuator with Arc-Magnet for Active Flow Control
A1.04-8579	Analysis of Active Flow Control Concepts Using the 3D LES VorCat Software
A1.05-7521	Robust Prediction of High Lift Using Surface Vorticity
A1.05-7880	Physics-Based Conceptual Design Flying Qualities Analysis Using OpenVSP and VSPAero
A1.05-8105	Defining Handling Qualities of Unmanned Aerial Systems
A1.06-7988	Rapid In-Place Composite Rotor Damage Detection
A1.06-8213	Predictive Condition-Based Maintenance for Vertical Lift Vehicles
A1.06-8494	Distributed Contact Solver for 3D Dynamics Simulation of Drive Systems with Defects
A1.07-7705	Injector-Integrated Fuel-Air Heat Exchanger Module
A1.07-8365	Improved Efficiency of Small Core Turbines Through Tip Leakage and Secondary Flow Mitigation
A1.07-8447	Fan Duct Heat Exchanger for Turbine Cooling Air
A1.07-8448	Design Concepts for Low Aspect Ratio High Pressure Turbines for High Bypass Ratio Turbofans
A1.08-7188	Small Sub-Micron-Particle Position-Resolving Laser-Doppler Velocimeter for High-Speed Flows
A1.08-7805	Development of an Elastomeric Force Balance
A1.08-8296	High-Repetition-Rate Interferometric Rayleigh Scattering for Velocity, Density, and Temperature Measurements
A1.08-8552	Plenoptic Attitude Monitoring System
A1.09-7073	Thin-Film Hybrid Coating for Ice Mitigation on Aircraft
A1.09-7646	Durable Icephobic Cellulose Nanopaper Composite for Aircraft Icing Mitigation

A1.09-8166 Performance Enhancement of Deicing Systems with the Use of an Anti-Ice Nano-Coating  
 A1.09-8557 In-Flight Ice Accretion Hazard Mitigation with Low Surface Roughness Aluminum Airfoil  
 A2.01-7127 RF Emission-Based Health Monitoring for Hybrid and/or All-Electric Aircraft  
 Distributed Propulsion S  
 A2.01-7475 Inexpensive, Rugged, and Compact Tunable Laser with Simple Tuning Control for  
 Airborne Fiber Optic Sensor (FOS) Interrogators  
 A2.01-7500 Cloud-Based Electronic Test Procedures  
 A2.01-7589 A Battery Management and Control System using a Universal Reconfigurable Architecture  
 for Extended Health of Batteries in Hybrid and/or All-Electric Propulsion Systems  
 A2.01-7618 Automated Tools and Technologies for Enhancing Long-Range Imagery  
 A2.01-7801 Runtime Assurance for Flight Test Research Aircraft  
 A2.01-7848 MATE: Modern Software Technology for Flight Test Automation and Orchestration  
 A2.01-8005 Aircraft Chemical Sensor Arrays for Onboard Engine and Bleed Air Monitoring  
 A2.01-8364 Optimal Realtime Damage Identification in Composite Structures  
 A2.02-7076 Core Flight Software for Unmanned Aircraft Systems  
 A2.02-7563 Run-Time Assurance for Safe UAS Operations with Reduced Human Oversight  
 A2.02-7580 Autonomous Contingency Detection and Reaction for Unmanned Aircraft  
 A2.02-7634 Safety Analysis For Evaluating (SAFE) sUAS  
 A2.02-7689 Self-Directed and Informed Forced-Landing System for UAV Avoidance of On-Ground  
 Persons, Vehicles, and Structures  
 A2.02-8065 Tool for Collaborative Autonomy  
 A2.02-8094 Smart Coordination of UAV Teams (SCOUT)  
 A2.02-8241 Low SWaP-C FAA Compliant UAV Navigation  
 A2.02-8328 Compact High Power 3D LiDAR System for (UAS) Unmanned Aircraft Systems  
 A3.01-7271 Simulation-Based Tool for Traffic Management Training  
 A3.01-7346 Integrated Technologies Supporting Seamless Oceanic Transitions  
 A3.01-7633 Stakeholder Web-based Interrogable Federated Toolkit (SWIFT)  
 A3.01-7729 Weather Scenario Generator for ATM Simulation and Testing Systems  
 A3.01-8505 Integrated Multi-Mode Automation for Trajectory Based Operations  
 A3.02-7084 Hiawatha Aircraft Anti-Collision System  
 A3.02-7176 SDR-Based MicroADS-B for Low Altitude Small UAS Operations  
 A3.02-7644 Autonomous Air Traffic Reporting and Operations for UAS  
 A3.02-7738 Landside-Aware Air Traffic Management  
 A3.02-8018 Increasingly Autonomous Traffic Flow Management Under Uncertainty  
 A3.02-8204 IR Beacon System for Assisted or Automated Landing of Aircraft  
 A3.02-8235 Avionic for Low Altitude High Density SUAS—Dynamic Configurable Dual ADS-B  
 with Interrogation  
 A3.02-8237 Innovation in the Sky  
 A3.03-7315 Integration of 4D Airline Operation Control Systems into NextGen and the NAS  
 A3.03-7366 Plug-and-Play ATM-Centric Speech-Enabled Agent for SMART-NAS Testbed  
 A3.03-7397 Intelligent Information Processing for Enhanced Safety in the NAS  
 A3.03-7425 Monitoring Real-Time NAS Safety with State-Dependent Risk Models  
 A3.03-7631 DAAS: Data Analytics for Assurance of Safety  
 A3.03-8048 Automated Real-Time Clearance Analyzer (ARCA)



